Children's Employment Commission.

REPORT by CHARLES BARHAM, ESQ M.D.,

on the Employment of Children and Young Persons in the Mines of Cornwall and Devonshire, and on the State, Condition, and Treatment of such Children and Young Persons.

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TO HER MAJESTY'S COMMISSIONERS.

GENTLEMEN,

1. The Mining District of the West of England, concerned in the following Report, extends from the South-Eastern borders of Dartmoor in Devonshire to the Land's-End in Cornwall, a distance of about 100 miles. Its breadth is very variable, but the principal mines constitute, through the greater part of this distance, a narrow chain, the links of which are separated here and there by short intervening spaces of an exclusively agricultural character. For the purposes of this inquiry it will, however, be convenient to associate these mines in four distinct groups, which may be designated respectively, the Devonshire District, and the Eastern, Central, and Western Cornwall Districts. It is in the extreme peninsula of England, within 30 miles from the Land's-End, that the mines are aggregated the most closely.

2. The condition of the children and young persons engaged in mining labour is the immediate subject of this Report; but their condition is too intimately mixed up with that of the adult miners to be well understood without some preliminary consideration of the latter. This will again be greatly assisted by a knowledge of the physical conditions of the mines and minerals, the places in which, and the materials on which, both classes are employed. These subjects shall therefore be first noticed, in the order now indicated.

3. The mining district of the West of England may be considered to commence at Dartmoor, and terminate at the Land's-End. The surface is gently undulating, the loftiest hills rarely exceeding 1000 feet above the sea, whilst the greater number of them range from 500 to 700, and the plains at their bases are in general from 100 to 200 feet above high water.

4. The highest peaks are for the most part granite, whilst the lower hills and most of the plains consist of various descriptions of slate. The granite may be considered to present six patches of large dimensions, viz., Dartmoor, the neighbourhood of Rough-tor and Brownwilly, the Hengsbarrow [sic] district, the Cairn Brea [sic] range, which is separated from that of Wendron merely by a narrow slip of slate near Pendarves, and lastly, the western tract, which extends from St. Ives to the Land's-End. There are, however, three minor bodies of granite, namely; Kit-hill, Breage, and St. Michael's Mount - in addition to the six larger, besides small specks of the same rock, in two or three other localities. All the other parts of Cornwall (except the Lizard district, which is of serpentine) may be considered to consist of slate of various kinds.

5. The granite is, in general, coarse-grained, and of porphyritic structure; its constituents are felspar, quartz, and mica; but in some places the mica is replaced by talc, and the rock is then often removed as china-stone, or the felspathic portions of that which is decomposed are washed out and prepared as porcelain-earth* for the manufacture of earthenware. In some of the granite schorl abounds.

6. The slates are in general felspathic, and near the granite their structure is often compact, whilst at greater distances they become lamellar and schistose in their structure, and still farther off they become fissile, and make excellent roofing-slates; among these last organic remains are sometimes found.

7. The laminae of the slates usually dip from the granite, round the flanks of which they are thus somewhat symmetrically arranged ; and it has been well ob-

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* In the year 1838 about 28,000 tons of china-stone and porcelain-clay were exported from Cornwall to the Potteries.

served that the granitic peaks rise like islands in an ocean of slate. The range or bearing of the masses of granite is somewhat about north-east and south-west, and the mines occur on both sides of it.

8. Both the granitic tracts and the slates in their vicinity are intersected by veins or dykes of a porphyritic felspar rock (provincially called *elvan).* These veins have in a few cases been traced for miles, and they pass uninterruptedly through both granite and slate; their usual direction is about 20 degrees south of west, and they are generally several fathoms in width. Where they fall in contact with the veins, their general comportment is much as if they had been portions of the strata.

9. The more schistose varieties of the slate formation, at considerable distances from the granite, frequently contain beds of limestone; these sometimes coincide in position with the slaty laminae, but they are more generally irregular and uncomformable.

10. The metalliferous veins (or *lodes* as they are provincially called) have an average direction of four degrees south of (true) west; but the general bearings are not quite the same in various parts of Cornwall; those of St. Just, for example, run about 35 degrees north of west. Indeed in the same district, and even in the same mine (as at Dolcoath, East Wheal Crofty, &c.), there are often two series of *lodes*, one of which bears nearly east and west, whilst the other (usually called *counter-lodes*) bears about south-east and north-west.

11. The dip or inclination of the *lodes* may, on an average, be about 60 or 70 degrees (from the horizon), and perhaps four out of six of them incline towards the nearest mass of granite; it also appears that the *lodes* near Dartmoor are for the most part flatter than those in the west of Cornwall. Taken on the whole, the *lodes* appear tolerably straight, both in direction and also in inclination; but when they are examined in detail, it will be found that they exhibit almost continual curvatures or irregularities in both respects; still, however, these flexures seem projected on certain lines, which have considerable constancy.

12. The width of the *lodes* is on the average about three feet and a half, but in this respect there are very great irregularities; from a mere line to 40 or 50 feet, and sometimes even more. But though there are great and rapid fluctuations, each *lode* seems to have a sort of natural or usual breadth of its own.

13. The compositions of the *lodes* are as variable as the natures of the rocks through which they pass. By far the greatest part of them is, however, earthy matter, of the nature of the contiguous rock, but also containing large quantities of quartz. These ingredients are sometimes in separate veins, but for the most part they are mixed without regularity or order, and through them the metallic ores are dispersed; sometimes very thickly, or in large irregular lumps, connected with each other by small veins of ore; in other cases the ore is very sparingly sprinkled through the whole of the earthy matter of the vein, and in some rare instances the ore forms the larger part of its contents. The masses of ore in the *lodes* usually dip from the granite, and the deepest parts of the mines are therefore in general farthest from where that rock appears at the surface.*

14. There is a second series of veins which run nearly at right angles to the *lodes*, and which are called *cross-courses* when they are composed of quartz, and *flucans* when of clay. The general directions of these cross-veins are somewhere about south-east and north-west. Their dimensions are variable, being perhaps on an average about two feet: their dip too fluctuates, but as a general rule it is greater (from the horizon) than that of the *lodes*. It has been already mentioned that quartz and clay form the larger part of their ingredients: this clay is invariably of the same character as the contiguous rocks. Tin and copper ores are occasionally found in small quantities in the *cross-veins*, and in two or three instances silver and its ores have occurred to some amount. The chief metallic produce, however, of this class of veins, is lead-ore, but this they seldom yield in the neighbourhood of *lodes* which have been productive of other metals. Indeed it is a general law in Cornwall that two series of veins at right angles to each other are seldom found productive in the same district.

15. Both the *lodes* and cross-veins ramify and divide; and whilst the part which in one place is large will sometimes within a short distance dwindle and die away, the portion which is small where the other is rich will often within a small space enlarge and become productive.

*In a large proportion of cases, the upper part of fissures in which metalliferous veins occur is, or has been, occupied by an iron-ochreous substance named *gossan,* often containing tin, and commonly having certain characteristic appearances, from which the experienced miner infers the quality of the copper lode on the top or *back* of which this gossan lies.

16. As these two series of veins run at right angles to each other, they of course frequently meet and intersect. There are a few cases of the *lodes* traversing the *cross-veins,* but in by very far the larger number of instances the *cross-veins* cut through the *lodes.* Occasionally the *cross-vein* simply intersects the *lode;* but more generally a displacement attends their contact: the separated portions of the *lodes* not occurring exactly opposite to each other on both sides of the *cross-vein.* These displacements are provincially called *heaves,* and though they are usually for only a few feet or fathoms, yet some cases are on record where the discordances are 20, 30, and 40 fathoms, and in one instance so much as 72 fathoms. It is not easy to lay down a rule for the discovery of the second portion, but it is perhaps rather more frequent to discover it on the side of the obtuse angle formed at the intersection than on the acute. It is obvious that, on whichever portion or the *lode* we approach the *cross-vein,* the other part will be found towards the same hand; the separated portions are perhaps more commonly found towards the right hand than the left. These *heaves* are the most intricate and baffling phenomena with which the Cornish miners have to contend.

17. There is also a third series of veins (bearing parallel to the *lodes),* which are generally of small size, and consist of clay, which are called *slides.* These are confined to the slate districts, and are seldom metalliferous. They intersect the *lodes* on the lines of their inclinations, and seem to cut off their lower from the upper parts, and produce similar displacements vertically to those which the cross-veins occasion horizontally.

18. Taking the granite and slate with the *lodes* which traverse them on a large scale, it appears that by very far the largest part of the tin-ore obtained in the West of England is from *lodes* in the granite, and that of copper-ore from veins in the slate. It however appears that the richest individual masses of tin-ore yet discovered have been in slate, whilst the *bunches* of copper ore which have been found in the granite have in a few instances been as large as the very largest which have occurred in slate.

19. It is a prevailing and apparently well-founded opinion among practical miners that the *lodes* are usually most productive near the junction of the granite and slate rocks. Accordingly the mines, instead of being irregularly distributed over the face of the country, are clustered together near the lines of these junctions, and the heaps of worthless rubbish separated from the ores may be traced in such situations for considerable distances on the lines of the chief *lodes,* rising in some cases amid rich fields, and destroying the vegetation "like streams of lava from a volcano."

20. The St. Just mines form one group near the Land's End, those near St. Ives another, at the opposite ends of the same granitic mass; those of Breage a third, subordinate to the granite of Godolphin and Tregoning hills. The Crowan and Gwinear mines stand at the western extremity of the Cairn Brea [sic] and Wendron granite; whilst those of Camborne and Redruth skirt it on the north, and those of Wendron on the south; and the Gwennap district occupies its eastern flank. In like manner, the St. Agnes mines are many of them located near a small patch of granite at Cligger Point, those of St. Austell are grouped on the skirts of the Hengsborough [sic] granite; whilst, the mines near Callington and Tavistock are contiguous to the Kit-hill and Dartmoor ranges.*

21. Tin-ore is also found in deposits, generally considered diluvial, mixed with the debris of different rocks, and often covered with an alluvial bed. Repeated washing, by means of running water, being the chief process to which such tin is subjected, the designation of *stream-work* is commonly applied to this method of obtaining the ore. In a solitary instance at Carnon (Evidence p 836, 1. 7), this stratum of tin-stuff is removed by subterraneous excavation; the alluvial bank, or overburthen, which is usually taken off from the surface, being in this case too thick to admit of such a process, and being likewise covered by the sea at high water.

22. Mines of iron† and manganese,‡ giving employment to a considerable number of persons, fall also within the district above defined. Of the iron-mines those

* I am indebted for the foregoing account of the mining district to Mr. *W.*J.Henwood, F.R.S., a gentleman whose investigations into the details of the physical conditions of the mines concerned have been probably more minute and accurate than those of any other individual. For a more particular statement of the peculiarities of the lodes in the different districts we may refer to Mr. De La Beche's *Report on the Geology of Cornwall, &c.,*1839.

† The quantity of iron-ore raised in Cornwall was calculated three years ago to be about 30,000 tons annually: it has since increased.

‡ The quantity of manganese raised in Cornwall has been recently computed at from 700 to 1000 tons per annum. The price of average ores about *£7* per ton. A larger quantity is probably raised in the mines in Devonshire.

near Lostwithiel are the most important. The ore lies in a vein which is nearly vertical, and of an average thickness of ten feet. The greater part of this mine is worked open to the surface, and the access to the underground part is by levels. The greatest depth does not exceed 50 fathoms. The manganese-mines, which are chiefly situated on the borders of the two counties, are likewise very superficial; the workings being seldom carried more than from 20 to 30 fathoms from the surface. Antimony has also been raised to some extent, but the foreign ores of this metal have of late years almost monopolised the market, and it is believed that very few children or young persons are now employed in its production.*

23. The mines of tin, copper, and lead, with the latter of which metals silver is generally united, are those which present the characteristic features of the mining of the West of England, and they employ at least nineteen-twentieths of the young people who are engaged in this kind of labour. The following introductory remarks will therefore be chiefly descriptive of the works for the raising of those metals.

24. When it is known or is thought probable that a lode which will repay the cost of working exists in a particular locality, the usual course of proceeding is to sink a shaft vertically to a certain depth in the first place. In so doing the lode may be met with, or as it is termed "cut." If this is not the case, a gallery, or "level", is excavated (driven) at right angles to the shaft, in the assumed direction of the lode, and continued till it is reached. In either case, when the lode is reached, a level is driven horizontally along its course, and the miner then works upwards, and removes it from above. It must depend on the thickness of the vein, and also in some measure on its inclination, whether it is necessary to excavate any of the adjoining rock, and to what extent. Meantime, the shaft being sunk still deeper, another gallery or level is carried along the vein or lode, usually about ten fathoms below the former one, and the metalliferous stone intervening between the two levels is subsequently removed. This process is repeated again and again; and as the workings become more extensive in length, additional shafts become necessary in that direction. Horse and water power are employed for effecting the earlier operations, but the steam-engine is soon requisite in most of these mines, and as they increase in depth and extent more powerful machinery is needed to raise the excavated rock and the water. Shorter shafts, called *winzes,* are also formed at intervals between the levels, chiefly for the purpose of ventilation. It is clear that in proportion to the dip or inclination of the vein there will be an advance in a horizontal direction, as the depth of the workings increases; and this may also render necessary communications from the lower levels to the surface more direct than can be furnished by the shafts originally adapted to the shallower ones.

25. At a very early stage of this progress a separation is established between the shafts by which the men pass to and from their work and those in which machinery is employed. This separation is in the first place effected by the boarded division of a single shaft, and subsequently by the devoting distinct shafts to these distinct purposes. Excepting the occasional raising of men and boys in buckets through short distances, ladders are the universal means of ascent and descent in these mines. Many of the shorter shafts (winzes) are provided with ladders, so that the course taken by the miner is commonly not one of continuous descent and ascent, but varied by his traversing at different intervals a considerable length of horizontal galleries.

26. The particulars of these arrangements will be much more clearly understood by a reference to the Plans (Nos. 1 and 2) than from verbal description. The dark patches show the portions of the lode which have been removed in the working of the mine. The excavation in these parts may be either still progressive, or it may have been discontinued from the poverty of the lode, whether absolutely, or relatively to the price of ores in the market, or comparatively with the quality of what can be obtained in other parts of the mine.†

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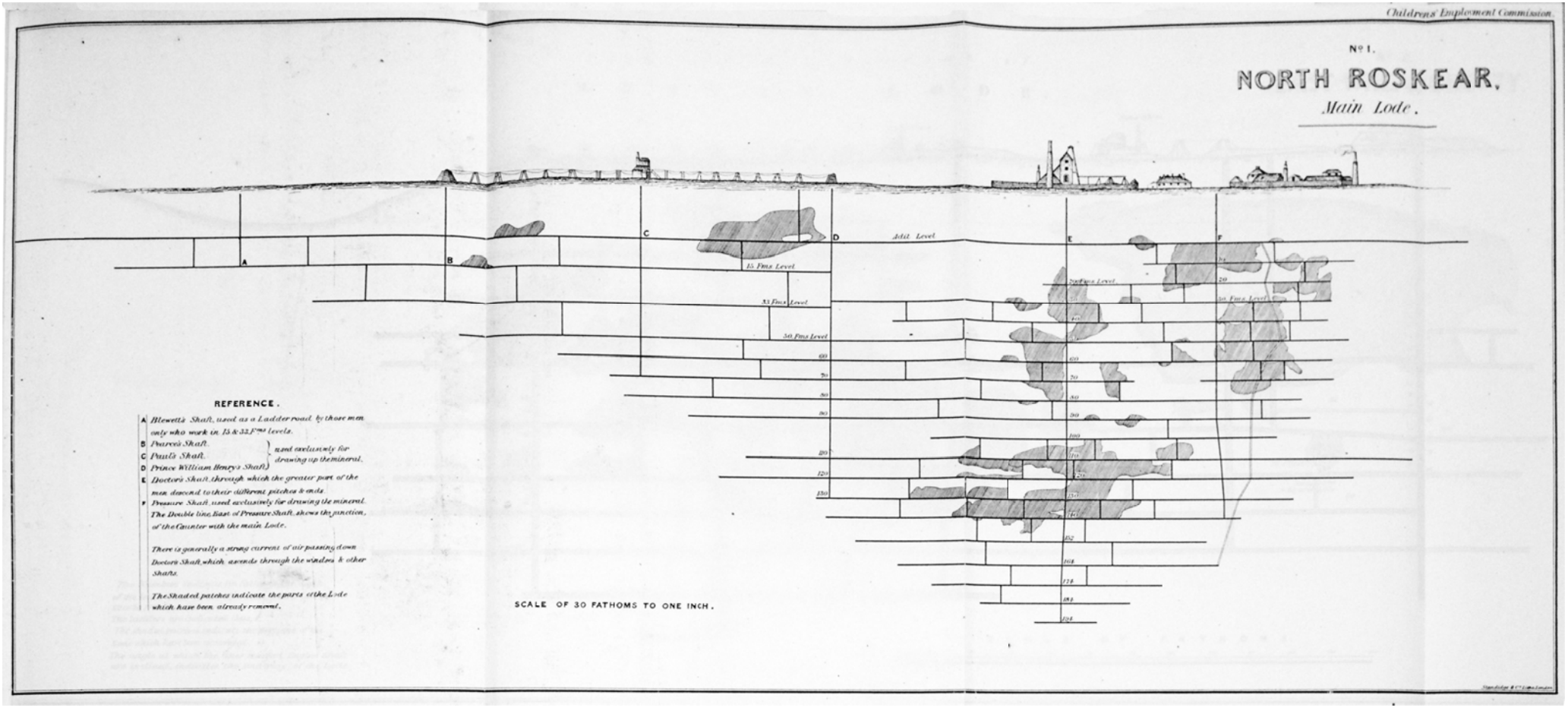
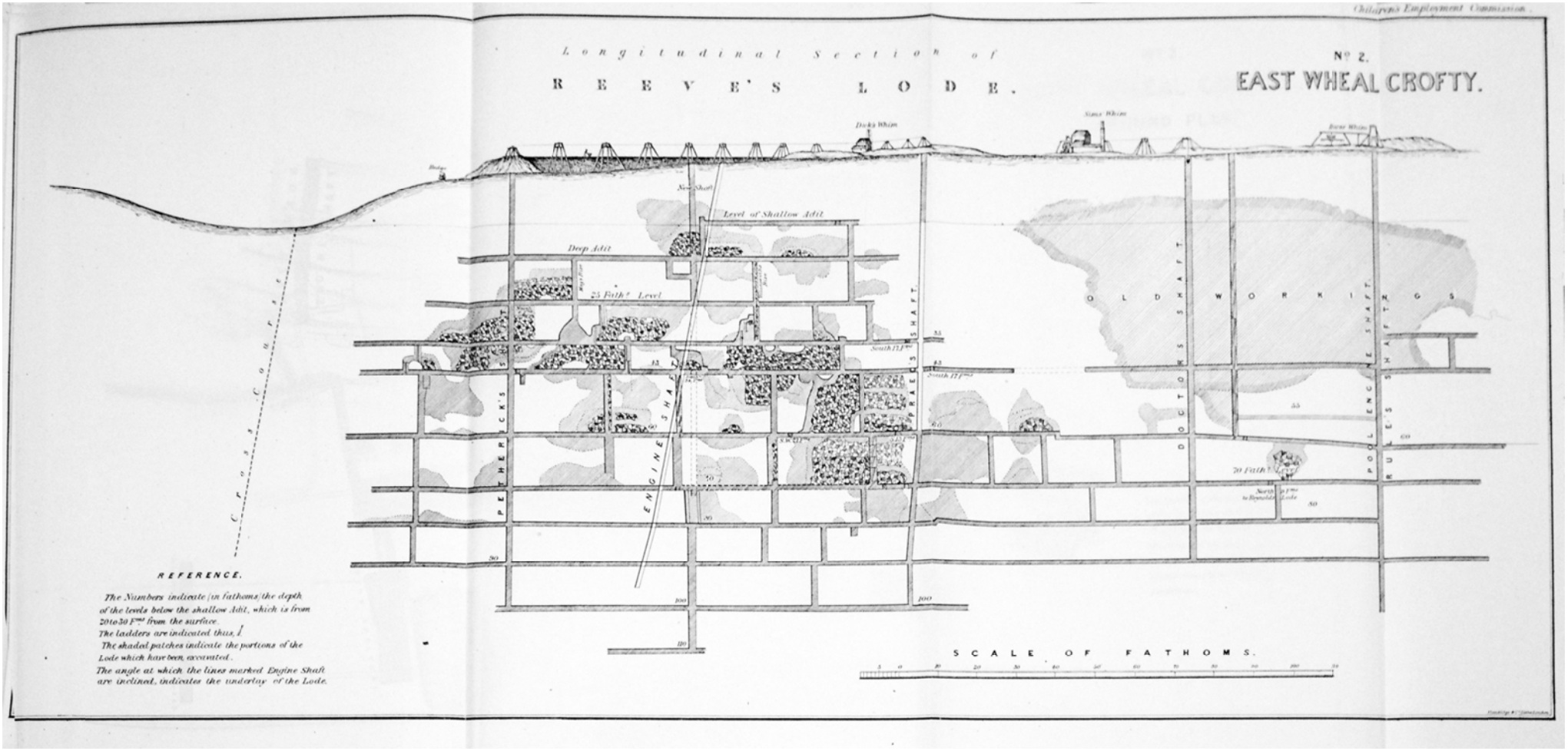
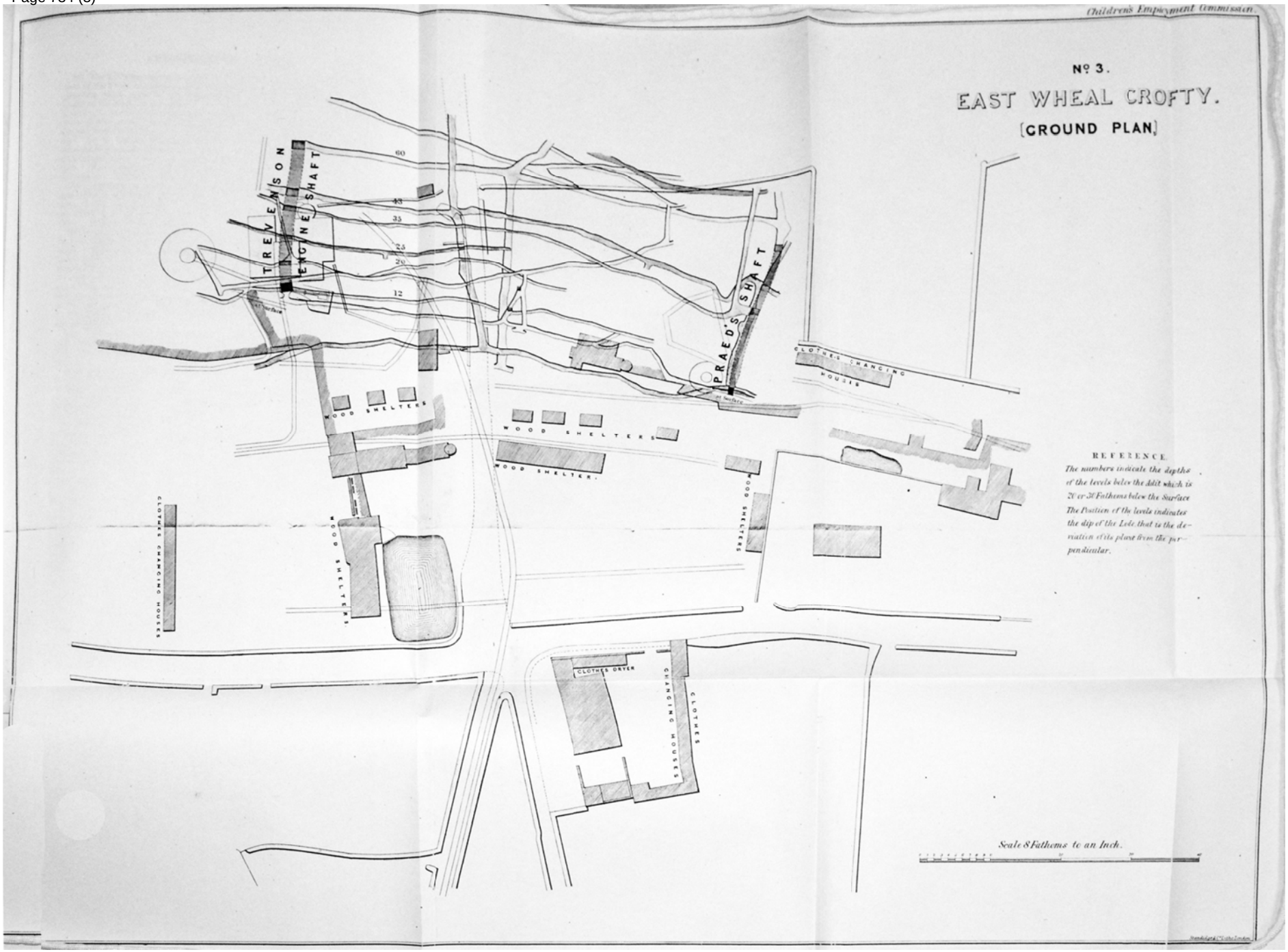
* Mr. De La Beche, in his *Geological Report,* has estimated the mineral exported produce of Cornwall and Devon, in 1837, as follows:

Copper	£952,855
Tin	415,518
Manganese	40,000
Lead	3,600
China-Stone and Clay	43,000
Granite	24,500
Total .	£1,478,973

† It is a common practice, in the larger mines especially, to leave portions of good ore here and there unexcavated. Such patches, often termed "the eyes of the mine" may be had recourse to when the produce from other parts is deficient, or when the market is favourable. They constitute, in fact, a sort of


Childrens' Employment Commission.
Nº 1.
NORTH ROSKEAR.
Main Lode.
A
B
C
D
E
F
Adit Level
15 Fms Level
33 Fms Level
50 Fms Level
60
70
80
90
100
110
120
130
140
152
168
178
184
194
REFERENCE.
A Blewett's Shaft, used as a Ladder road, by those men only who work in 15 & 32 Fms levels.
B Pearce's Shaft. } used exclusively for
C Paul's Shaft. } drawing up the mineral.
D Prince William Henry's Shaft.
E Doctor's Shaft, through which the greater part of the men descend, to their different pitches & ends.
F Pressure Shaft, used exclusively for drawing the mineral. The Double line, East of Pressure Shaft, shows the junction of the Counter with the main Lode.
There is generally a strong current of air passing down Doctor's Shaft, which ascends through the windlass & other Shafts.
The Shaded patches indicate the parts of the Lode which have been already removed.
SCALE OF 30 FATHOMS TO ONE INCH.


Children's Employment Commission.
Longitudinal Section of
REEVE'S LODE.
No 2.
EAST WHEAL CROFTY.
Dicky Whim
Deep Adit
Level of Shallow Adit
25 Fath.m Level
PETHERICK'S SHAFT
ENGINE SHAFT
PRAED'S SHAFT
DOCTOR'S SHAFT
POLLENCE SHAFT
RULE'S SHAFT
OLD WORKINGS
70 Fath.m Level
Cross Course
REFERENCE.
The Numbers indicate (in fathoms) the depth of the levels below the shallow Adit, which is from 20 to 30 Fms from the surface.
The ladders are indicated thus,
The shaded patches indicate the portions of the Lode which have been excavated.
The angle at which the lines marked Engine Shaft are inclined, indicates the underlay of the Lode.
SCALE OF FATHOMS.


Children's Employment Commission.
Nº 3.
EAST WHEAL CROFTY.
(GROUND PLAN.)
TREVENSON ENGINE SHAFT
PRAED'S SHAFT
60
43
33
23
20
12
WOOD SHELTERS
WOOD SHELTER.
CLOTHES CHANGING HOUSES
CLOTHES DRYER
CLOTHING WORKS
CLOTHES
REFERENCE.
The numbers indicate the depths of the levels below the Adit which is 20 or 30 Fathoms below the Surface
The Position of the levels indicates the dip of the Lode that is the deviation of its plane from the perpendicular.
Scale 8 Fathoms to an Inch.

27. The following answers to the printed queries will serve to show the dimensions of the levels in different mines, and the method of excavating the ores. The questions which apply to this department are:

5. What is the smallest height of the levels in your mine?
6. What is the thickness of your bed or vein of ore?
7. Are your workings, heads, or ends of the same depth with the beds or veins of ore, or do you cut away any of the top and bottom?
8. How many fathoms from the surface of the ground or from the adit is the ore you are working?

(*a*) In Carnon Mine, from which a horizontal diluvial bed of tin-stuff is removed, two parallel galleries have been driven on the course of the bed, and communications between these, at right angles, have been made by levels here and there. The answers are:

5. Five feet.
6. Three feet.
7. Cut away both top and bottom.
8. Thirteen fathoms from the surface of the ground.

As a specimen of another shallow mine, Restormel iron-mine (*b*), which has been already mentioned, may be brought forward. The answers are:

5. Six feet.
6. Ten feet (average).
7. The vein is nearly perpendicular; the levels are driven on it, and the back (the part towards the surface) and bottom taken away.
8. From 10 to 50 fathoms.

But these are exceptions among the West of England mines. The returns from St. Ives Consols *(c)* will illustrate the character of the greater part of the tin-mines in these particular respects:

5. Seldom less than 6 feet.
6. From a few inches to 10 feet, and sometimes more than double that width.
7. The lodes in this district enter the rock at the surface or thereabout, at an angle of 50, 60, or 70 degrees from the horizon, and sometimes almost vertical, and the lodes, or veins of ore, from any given level to another, if productive, are regularly cut away, after first supporting the sides and roof of the level with framework fitted to the angle of the lode, which in few cases proves otherwise than completely safe and secure.
8. Working at the 30, 40, 50, &c., and downwards to the 147 fathoms level. The adit 20 fathoms.

The Charlestown tin-mines (*d*) will furnish an example from the Eastern Cornwall District:

5. Seven feet high.
6. From 3 to 10 feet wide.
7. Drive the levels first and afterwards take down the back.
8. At the adit, and 75 fathoms below.

Some examples of copper-mines may now be given. In the Central District the answers for the United Mines *(e)* are as follows:

5. The levels in the ancient working of the mine do not exceed 5 feet high by 2 feet wide; but those made more recently are about 7 feet high and 4 feet wide.
6. The veins are nearly perpendicular, and vary from one inch to 9 feet wide.
8. The ores are got from between 40 and 220 fathoms of the surface.

For the Consolidated Mines (*f*), in the same district, the deepest of any, the returns are these:

5. Six feet high and 2½ feet wide. The openings in the platform from one ladder to the other 18 inches by one foot.
6. Varies very considerably; sometimes 8 feet, at others a few inches only.
7. Our veins do not incline much from the perpendicular; consequently we drive our levels 6 feet high, and work the ground above afterwards.
8. Sometimes ore is found much nearer the surface than the adit level. In general we are working for ore from 20 fathoms to the surface to the 260 fathom level below the adit; the deepest point being nearly 300 fathoms from the surface.

From the Levant (*g*), the largest copper-mine in the Western district, the answers are:

5. Height of all our levels is 6 feet; and from thence to the next level is 10 fathoms or 60 feet.
6. Thickness or width of the whole vein wherein the ore is found is on an average about 4 feet.
7. Our vein is almost perpendicular, a small declination only, and we work by the side of it first, then take it down afterwards.
8. Adit, or sea-level, 30 fathoms under surface. Under adit we are working from 70 to 230 fathoms deep.

In the Eastern Cornwall District the Fowey Consols *(h)* is the most considerable copper-mine; the answers are these:

5. Not less than 6 feet, and full 7 feet or more where air-pipes are required for ventilation. There are no horseways in Cornish mines.
6. Above 20 lodes, fluctuating in thickness front 8 feet big to only a few inches.
7. If the lodes be perpendicular, and of a sufficient size for the levels to be driven, we have no occasion to break or cut away any of the overlay or underlay; but very rarely a lode is perpendicular.

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reserved fund. Plans and sections of Dolcoath and Fowey Consols Mines are given in Mr. De La Beche's *Report on the Geology,* Those appended to this Report were obligingly furnished, for East Wheal Crofty and North Roskear respectively, by Mr. Phillips of Tuckingmill, whose school is spoken of in the Evidence, and by Mr. Vivian, lately a pupil in Sir C. Lemon's Experimental Mining School.

8. All depths from the adit to nearly 200 fathoms below it, and some above the adit, and even to within a few fathoms of the surface. The adit level under the principal parts of the mine is from 30 to 40 fathoms deep.

Trefoil *(i)* is another copper-mine in this district, the returns from which are particularly well drawn up. The answers are:

5. The levels are generally 5 or 6 feet high; 6 feet high the main levels. The smallest height 4½ feet, or 5. There are no horseways; horses are not worked underground in Cornwall.
6. It varies from 6 inches to 3 feet or 4.
7. The dip or underlie of the lode is about 2 feet in a fathom. Levels are driven in the lode, after which the ore is taken away from these levels, generally upwards, and ore is also taken away by the winzes sideways.
8. About 60 fathoms from the surface, and 40 from the adit.

The answers from Wheal Friendship (*k*), the largest copper-mine in Devonshire, will serve to show the identity of the method there employed with that practised in Cornwall. They are:

5. None less than 6, and generally 7 feet high, and 4 feet wide.
6. Veins and lodes of ore, varying in size from 2 inches to 7 feet wide.
7. This and some of the other queries have reference to coal-mines. From the answers to the two last queries, it must be evident that some of the "country" must be taken away with the lodes, etc. (It had been stated before that their inclination was 3 or 4 feet in the fathom.)
8. The bottom of the mine is about 180 fathoms perpendicular depth below the surface, and the workings of the mine are from about 30 fathoms below the surface to the bottom of the mine, but principally towards the bottom.

As specimens of lead-mines, the Cornubian (*l*) in the N.E. part of the Central district, and Wheal Betsey, in Devonshire, may be given. The answers for the former are:

5. Varying from 4 to 7 feet.
6. From 1 inch to 18.
7. We take away the top and bottom, but secure the vacancies by stemples, or props.
8. From surface to 55 fathoms below.

For Wheal Betsey *(m)* the answers are:

5. None less than 6, and generally 7 feet high, and 4 feet wide.
6. The veins vary greatly in size, from 2 inches to 6 and 7 feet wide.
7. The inclination of the lode is from 1 to 2 feet in the fathom; some part of the "country", or sides, is therefore taken away.
8. The bottom of the mine is about 120 fathoms below the surface, and the principal workings are from the bottom to within 60 or 70 fathoms of the surface.

The statement made in the answers from the United Mines of the relatively larger dimensions of the levels in the more recent than in the older workings is true of the mines generally, and especially of those which have been carried to a great depth.

28. The natural conditions of these shafts and levels, supposing no one to have been in them for some time, are darkness, and an air more condensed than that on the surface, and a temperature higher in proportion to the depth. There is no reason to believe that any gas, except carbonic acid, is generated from the strata or veins in these mines. Where they have been carried beneath beds of alluvium which are periodically submerged, some of the inflammable compounds of hydrogen are at times emitted. Instances of this kind are mentioned in the Evidence (p. 851, l. 28; p. 852, l. 7).

29. With regard to the natural *temperature* of these mines at different depths, and in different strata, I am enabled, by the kindness of Mr. Henwood, to give the following summary, which shall be stated in his own words:

I have personally inspected, (he says) every part of about 200 mines in Cornwall and Devon, and have made many hundreds of observations on the temperature of the streams of water which flow into them immediately as they issue from the unbroken rock. The following is a general summary of my results:

Temperature.

Depth, in Fathoms, of Place of Observation.	In Slate Degs (Fahr.)	In Granite. Degs. (Fahr.)
Surface to 50	57.0	51·6
50 " 100	61·3	55·8
100 "150	68.0	65·5
150 " 200	78.0	
200 and upwards	85.6	81·3*

These conditions would exist even if the ventilation amid drainage were perfect; but this being very seldom the case, there will commonly be an accumulation of carbonic acid gas, and a lodgment of water.†

*The whole letter, from which the above extract is taken, is given in the Appendix (A).

†The two following returns to queries will serve to illustrate the variations of temperature in different mines, and under different circumstances. In the *first,* from Wheal Coates, a tin-mine, on the north coast, coming within the Central district, Mr. Carne, the manager, writes-

30. When work is carried on, there is, of course, a rapid exchange of oxygen for carbonic acid, by means of the respiration of the miners and the burning of the candles; and, when blasting takes place, the gases generated by the explosion of gunpowder are diffused, and a thick smoke fills the shaft or level. The following analyses* show the extent of impurity of the air in the places in which the men are often employed.

Sample 1. Wheal Vor, tin-mine in slate. One gallon sample from the 250 fathom level below the surface; 15 fathoms west of any shaft or winze, and taken a few minutes after firing a hole, with two men in a core. Specific gravity of air 0·997; nitrogen 81·519; oxygen 18·416; carb. acid 0·065; no trace of any other gas.

Sample 2. Wheal Vor, as before, 250 fathoms; 16 fathoms east of any shaft or winze; two men in a core; ten minutes after firing a hole. Specific gravity 0·993; nitrogen 83·00; oxygen 16·69; carbonic acid 0·075.

Sample 3. Wheal Vor, 240 fathoms; 24 fathoms east of any shaft or winze; two men in a core; taken half an hour after firing a hole. Specific gravity of air 0·997; nitrogen 80·98; oxygen 18·95; carbonic acid 0·066; sulphuretted hydrogen and sulphurous acid, strong trace.

Sample 4. Wheal Vor, as before; 230 fathom level; two men in a core; 22 fathoms from winze or shaft; half an hour alter firing a hole. Specific gravity 0·994; nitrogen 82·556; oxygen 17·282; carbonic acid 0·082; sulphuretted hydrogen 0·080; sulphurous acid, strong trace.

Sample 6. Wheal Vor, *Penhale,* slate; 36 fathom level; four men at work in a dead end; candle burned with difficulty. Specific gravity 0·994; nitrogen 85·01; oxygen 14·76; carbonic acid 0·23.

Sample 8. Great Work, granite; tin and copper; 160 fathoms from surface; two men in a core; 30 fathoms from winze or shaft; 15 minutes after firing a hole. Specific gravity 0·992; nitrogen 84·705; oxygen 15·15; carb. acid 0·145.

Sample 13. Cairn Brea, copper-mine, granite; 95 fathom level; machine blowing. air; two men in a core; spot wrought only 16 hours out of the 24; sample taken three-quarters of an hour after firing a hole. Specific gravity 0·992; nitrogen 85·36; oxygen 14·51; carbonic acid 0·13.

Sample 14. Tresavean, copper-mine, in granite; 156 fathom level, 208 from surface; two men in a core; directly after firing a hole; 65 fathoms from winze or shaft. Specific gravity 0·993; nitrogen 83·52; oxygen 16·35; carbonic acid 0·13; a slight trace of sulphuretted hydrogen.

The summary of the analysis of 18 samples from different localities is this; oxygen 17·067; carbonic acid 0·085; nitrogen 82·848.

The temperature of the mine, by observation, does not vary materially in summer or winter. The western part of the mine is a pale sand, with hard bars of a darker description intersecting. The 30, 53, 65, and 75 fathom levels are in this ground. The eastern part is a soft granite, intermixed with china-clay. The 40 and 50 fathom levels are in this part of the mine; and the temperature has been at all times found to be many degrees colder, varying very little from the water.

				Degs.		Degs.
In the Western part, at the	30	fathom level,	the temperature is	61	the surface being	68
“	55	“	“	62		
“	65	“	“	59		
“	75	“	“	63	whilst, in the other strata,	
At the Eastern part	40	“	“	58		
“	50	“	“	55	the water being also	55

The *second* answer is from the principal copper-mine in the Eastern district, Fowey Consols. The manager, Captain Davis, R.M., states that the temperature of the air in or near the bottom of the mine, where, in a regular course of working, it cannot be so well ventilated as the upper levels, is as follows:

			Degs
180	fathom level below the adit, and about	40 fathoms from a winze	88
170	“ “	50	87
160	“ “	20 fathoms from a cross-cut	80
55	“ “	200 fathoms front shaft and 25 from draft of air	76
100	“ “	60 fathoms from a winze	75

But where there are more communications by sufficient shafts, winzes, or cross-cuts front lode to lode, at convenient distances from each other, the circulation is quite sufficient to produce good air. On the 12th of April, 1841, the thermometer was tried at different places, and stood as follows:

Degs.	
58	at the surface.
57	at the adit, in a strong current of air between two shafts.
71	at the 80-fathom level below the adit and 10 fathoms from a cross-cut
67	in the cross-cut.

The water in this mine is found to be in general from 3 to 4 degrees colder than the air in the *same level* and *locally.* The 'country' is chiefly composed of friable and laminated killas, mixed with quartz and other courses of hard stone.

* These analyses were conducted by Mr. M. P. Moyle of Helstone. A premium was awarded for them by the Polytechnic Society of Cornwall, and they are published in its 8th Report (1840).

It has been seen that in one instance the quantity of oxygen was reduced to 14·51, and that in another the quantity of carbonic acid was raised to 0·23. These results exhibit a lessening in the proportion of the vital ingredient of the air from its usual per centage 21, and an increase in a directly noxious ingredient, carbonic acid gas, from 0·05, its ordinary amount, calculated to produce effects sufficiently injurious to those who, for hours together, inhale such a fluid. But the proportion of deleterious gases occasionally present where the miner must labour (whether of sulphuretted hydrogen and sulphurous acid, which are very rapidly absorbed by the water lying in the levels, or of carbonic acid, which accumulates, like water, where there is no drainage) is much greater than that detected in the analyses here reported. It is then that the distinctly poisonous effects of these agents are produced, and loss of life, either at once or more remotely, has often been the consequence. Carbonaceous particles from the candles and from blasting, and mineral-dust from the working of the strata or veins, are also suspended in the air which the miner inspires, and give a peculiar character to his expectoration: copper has even been detected by analysis in notable quantity in such air.

31. In proportion as a mine increases in depth, the importance of ventilation increases, and it becomes at the same time more difficult to effect it thoroughly. As far down as the adit level there is usually a free perflation, and it is only in an "end", a cul-de-sac remote from the shaft, that the air can be materially impure. Farther down, as no horizontal communication with the surface can exist, the interchange of ascending and descending currents of air affords the only natural supply; and by making the levels of large size, and establishing free communication between them by the short levels, called winzes, aeration (considered sufficient) is effected even in the deepest mine in Cornwall, without the use of air-machines. In fact, those which have been hitherto commonly adopted are much more advantageously applied in the shallower mines or parts of mines. Some account of these more special contrivances is given in the following returns, as respects their employment in particular localities.

From St. Ives Consols, an important tin-mine in the Western district, the following statement is given:

Invariably we communicate from shaft to shaft, of which we have several from 50 to 80, and some 100 fathoms apart, by levels at every 10 or 20 fathoms, as the mine is worked downwards, which furnish an abundance of air, excepting for short periods before the communication takes place. In case of ventilation being required, we attach an air cylinder machine to the engine, and the air thus obtained is conveyed through pipes to the places required. Air is also frequently obtained by a fall of water, from one level to another, through pipes. There are various other means of obtaining air, but the two noticed in all cases are efficacious.

The agent at East Wheal Crofty, a copper-mine in the Central district, gives the following answer:

By shafts, trapdoors, and winzes, 15 fathoms apart; also air-pipes, waterfalls, &c., for ends not relieved by winzes. Waterfall, where applicable, is best.

From Dolcoath, a neighbouring copper and tin mine, this return has been made:

By shafts, windses, and air-pipes. Levels are seldom driven more than 20 fathoms beyond a shaft or winds. All our pipes are made of whole boards.

Captain Davis gives the following account of the methods used at Fowey Consols:

To create circulation of air for the purpose of ventilation, we use machines commonly called duck-machines. Larger ones are worked by the engines, and the small ones with the common leverage power by boys. In some places the air is forced by a fall of water: all these answer the purpose very well.

32. These statements will sufficiently exemplify the usual arrangements for effecting ventilation. It is chiefly by the sinking of numerous shafts at short intervals beneath the lowest levels, and establishing free communications between them as speedily as possible, that the deeper mines have been rendered at all fit for the men to occupy. But no method hitherto introduced is adequate to maintaining the air in the places in which the miners work in anything like a state of purity; and even in those parts in which ventilation keeps up a fair supply of fresh air, there is in almost all mines a constant smoke after the first blasting in the morning; so that the shafts and galleries are not unlike chimneys, often sending out a visible column at the surface. The smoke is sometimes so thick (Evidence, p. 822, l. 3) that the miner can with difficulty see his hand.

33. From the nature of the ease the most advanced point of the excavation must be a cul-de-sac, and it will often be impossible to establish any communication with parts above or below. Hence it is that almost every miner in the deeper mines is at times exposed to what he himself designates "poor air", by which he means air so impure as to affect him in a noxious way distinctly perceived by him at the time. Of the less marked degrees of impurity he makes no account. Of the deficiency of oxygen, the excess of carbonic acid, the presence of sulphurous acid or sulphuretted hydrogen, he is not aware, and of smoke, however dense, he seldom takes any notice.

34. Every mine is more or less *wet.* It constitutes a receptacle for the waters permeating the strata through which it passes. The *adit* is the drain through which a great part of the water lying above its level, and a great part of that raised by machinery, is discharged. One or more of the deepest shafts are appropriated as wells, and from these the water is raised by steam-power; a preliminary process involving the greatest difficulty and outlay connected with the working of many mines.* The quantity of water in one mine differs exceedingly from that in another, partly in relation to the nature of the strata: thus mines in slate are generally wetter than those in granite. But a greater difference is artificially produced he the multiplication of mines in a district; the whole of its waters being thus distributed among many wells instead of a few, and the pumping being thus rendered less onerous to each.

35. Where a mine is situated near the coast, its drain or *adit* generally opens on the surface at a point very little above the level of the sea. When more inland the deepest valley in the neighbourhood is the place of its discharge. In other cases a large common adit has been driven from some valley, but little raised; above high water, into the centre of an upland mining district, and the separate adits of the several mines open into this general drain. In many mines a large quantity of water is constantly poured through the interstices and fissures of the strata, and it is often of a temperature so much lower than that of the air in which the miners are at work, that they are subject to very serious chills from this cause. Under particular circumstances they are obliged to work more than half submerged. Illustrations of such circumstances may be found in the evidence (p.848,1.3; p. 854, 1. 65; p.835, 1. 54).

36. It has been already stated that *ladders* are the universal means of ascent and descent in these mines. There are a few instances of veins emerging at the surface, and being inclined at such an angle that they have been followed and excavated without much other footway than steps cut in the rock; †but these are merely exceptions. The ladders vary in different mines, and sometimes in different parts of the same mine, from two and a half to ten fathoms in length, and from a direction nearly vertical to an inclination of two feet six inches, or even more, in the fathom. The distance between the levels being generally ten fathoms, or sixty feet, a single ladder very often reached in former times from one to the other. Some of these ladders are still found (Evidence, p. 848, 1. 35), but they are rare (Evidence, p. 821, 1. 20). The most usual length at present is from four to five fathoms.

37. In the perpendicular shafts the inclination is commonly such that the ladder may nearly traverse the breadth of the shaft. From eighteen to twenty-one inches in the fathom is the inclination which experience has determined to be the most calculated to facilitate the progress of the miner; being that which enables him to stand upright in the ladder, with the leg clear from the stave above, so that the effort is divided between the upper and lower extremities (Evidence, p.824, 1. 49; and Mr. Henwood's letter, Appendix A). The inclination of the ladders is however, in many cases determined by that of the veins, and when the underlie is great, the footway will be at times much further removed from the perpendicular (Evidence. p. 821, 1. 7).

38. The distance of the staves in these ladders is very generally one foot from the upper surface of one to the same point in the next. In some old ladders they were as much as fourteen inches apart (Evidence, p. 824, 1. 50). But the results of

* Such a well or pit at the bottom of the engine-shaft, the deepest part of the mine, is called the *sump.* When the water has been so far removed as to admit of the workings being carried on in the lowest levels, it is said to be *in fork*.

† There is one instance, at Carclaze, near St. Austle, of a tin-mine being worked, like a quarry, quite open to the surface. It is situated on some of the highest ground in the neighbourhood, and, if not very valuable as a mine, is very picturesque.

the trials made of shorter intervals will tend to produce a gradual change in that direction. It will be seen in the evidence, that at Tresavean (p. 824, 1. 46), at Trethellan (p. 821, 1. 11), and (Mr. Henwood's letter, Appendix A) at Wheal Mary, the distance of ten inches has been adopted with very important effect in facilitating the climbing: so that one-fourth of the labour is estimated to be saved; and even men who had been obliged to relinquish work in the lower levels have been able to resume it.

39. The staves are most usually of wood; iron is in many instances preferred; in others it is said to become both slippery and jagged from the corrosive action of water impregnated with salts of other metals, chiefly copper.

40. Each ladder usually terminates on a platform (sollar), an opening (man-hole) in which leads to the ladder below. This is generally so situated that the ladders are parallel to each other. In a few instances there is, in addition to this platform, a penthouse placed between the back of the ladder and the walls of the shaft, so that it covers the passage to the ladder below, and prevents the risk of the descending miner falling more than a few feet, supposing the ladder to be from four to five fathoms in length,— and the much greater risk of the falling of anything from above upon those who are below (Evidence, p. 851,1. 63). A contrivance of similar intention is adopted in some mines—that of placing trap-doors over the manholes, and making it a rule for the last man of a party to close them (Return for Boscean Mine). It is clear that more is here trusted to the carefulness of the miner than in the former method; the closing of these trap-doors must also, it is conceived, cause a serious obstruction to ventilation.

41. The principal tools used by the miners are *picks* for working the rock, and *borers* and *mallets* for making the holes for blasting. These are often sent up and down in the bucket (kibble) in which the ore or rubbish is drawn to the surface; but the miner very commonly carries with him from 10 to 20 pounds weight of tools. There is a constant necessity for hardening and sharpening them, which is done at the smith's shop. In one mine only (Wheal Vor) a forge has been established under ground, in imitation of the practice in some parts in Ireland,* for the performance of work of this description. It is said to be very advantageous in an economical view, the weight of coal sent down being only one-fortieth of that of the tools formerly sent up, and time being likewise saved; but its most beneficial effect is the saving of the miner's labour, and the avoidance of the risk of accidents. (Evidence, p. 842, 1. 28).

42. A brief consideration may now be given to the adults by whom the under-ground operations in these mines are carried on. The miner of the West of England is a man of moderate stature, spare and muscular, with a chest and upper limbs rather more developed than the lower, and having the shoulders slightly inclined forwards. The complexion is sallow, and rather soddened. A miner of very large frame is seldom seen; a very fat miner could be hardly met with. The following table will exhibit the weights of miners in different districts:

Table 1. Weights of Miners working under ground in the several Mining Districts of the West of England.

District.	Mine.	Principal Produce.	Depth in Fathoms.	Number of Men employed.	Number weighed.	Age of those weighed.	Average weight.	Greatest weight.	Least weight.	Remarks.
Western Cornwall	Levant .	Copper	260	300	30	20 to 30, average 25	lbs. 144½	lbs. 165	lbs. 124	These men were taken as they followed each other up from under ground.
Ditto .	Balleswidden	Tin .	85	535	30	20 to 30	158½	..	..	The circumstances under which these men were weighed are not stated, neither are the greatest and least weights.
Central Cornwall	Wheal Vor	Tin .	250	..	8	..	169¾	..	..	These men were weighed when they were about to go under ground, at 6 P.M. They were taken indiscriminately.
Ditto .	N. Roskear	Copper	194	320	45	20 to 30, average 24½	156	166¾	146	These men were taken indiscriminately from the whole body assembled on the pay-day. Three picked men, whose average age was 28⅓, averaged 188 lbs.; and three, whose average age was 49, averaged 163 lbs. They were weighed by threes; the greatest and least weights therefore represent the averages of three each.

*In the Allihies Mines, County Cork, two underground forges have been worked for several years advantageously.