

REPORT

TO THE

SECRETARY OF STATE FOR THE HOME DEPARTMENT

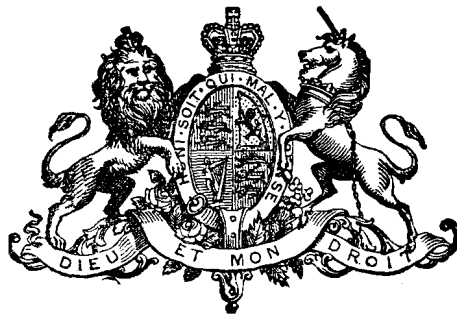
ON AN

OUTBREAK OF ANKYLOSTOMIASIS IN A CORNISH MINE.

BY

J. S. HALDANE, M.D., F.R.S.

Presented to both Houses of Parliament by Command of His Majesty.



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OUTBREAK OF ANKYLOSTOMIASIS IN A CORNISH MINE,

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J. S. HALDANE, M.D., F.R.S.,

FELLOW OF NEW COLLEGE, OXFORD.

To the Right Honourable Aretas Akers-Douglas, M.P.

SIR,

As a full report of the enquiry now being made at your request by Mr. J. S. Martin, H.M. Inspector of Mines, and myself into the ventilation of Cornish mines cannot appear for some time, I beg to submit the following interim report dealing with an outbreak of ankylostomiasis.

At the outset of the enquiry my attention was directed by Mr. Martin to the occurrence of a number of cases of illness, described as "anæmia," at Dolcoath Mine, and generally attributed to some defect in the ventilation. Our first visit was, therefore, made to this mine, which is one of the most important in Cornwall, on October 16th. We went over the mine in company with the Manager, Mr. R. Arthur Thomas. The general ventilation appeared to be on the whole extremely satisfactory, and the analyses of samples of air collected at different points fully confirmed the impression we formed at the time. There was evidently nothing in the state of the air to give any clue to the cause of the anæmia.

After obtaining from Mr. Thomas an account of the outbreak I examined one of the men affected. His symptoms and the history of his illness, seemed to correspond to ankylostomiasis and to exclude other probable causes of anæmia, such as lead poisoning or the careless handling of roburite. Taking into account the high temperature of the mine, and the fact that some of the men employed had returned from tropical countries, I came to the conclusion that the anæmia was probably due to the introduction of this tropical disease. After a consultation with Dr. Telfer Thomas, Medical Officer of Health for Camborne, it was arranged to administer to the patient whom I had seen a large dose of extract of male fern with a view to the expulsion and identification of the worms. In spite of very careful search, however, we could find no worms in the motions passed, and as I was at the time very imperfectly acquainted with the means of definitely identifying the disease, which I had never seen before, it seemed wiser to obtain full information before proceeding further. After studying the subject, and communicating with Dr. Patrick Manson, who kindly wrote giving me valuable advice, I obtained with your consent the co-operation of Mr. A. E. Boycott, M.B., Senior Demy of Magdalen College, Oxford, and we returned from Oxford to Dolcoath after making

preparations to carry out your instructions for a thorough investigation. Mr. Thomas placed at our disposal the laboratory of the mine, and has furthered our work in every way.

We were able without difficulty to identify the ankylostome ova in the fæces of each of the cases examined, and from the first case treated with thymol the worms themselves were obtained in the fæces. In the case of the patient from whom a large dose of male fern had failed to expel any worms, 260 ankylostomes were expelled in the first motion passed after treatment with thymol. Dr. Manson, who examined the ova, confirmed our diagnosis.

The disease now generally known as ankylostomiasis is due to the presence in the upper part of the small intestines of a species of nematode worm, to which the various names have been given of *Ankylostoma duodenale*, *Anchylostomum* (or *Ancylostomum*) *duodenale*, *Dochmius duodenalis*, and *Strongylus duodenalis*. Its definite relation to a disease characterised by anæmia was established in 1854 by Griesinger, who showed that it is the cause of what was then known as "Egyptian Chlorosis," a disease very common in Egypt. A few years later ankylostomiasis was identified by Wucherer as one of the commonest maladies in Brazil, and since then it has gradually been found to exist as a very common, widespread, and troublesome disease in tropical and sub-tropical countries all over the world. About 25 years ago a disease known at first as "Miners' Anæmia" attacked the workers constructing the St. Gothard tunnel, causing great trouble and much loss of life. This disease was shown by Perroncito to be ankylostomiasis, which was thus brought into prominence in Europe. It has also appeared among coal miners at St. Etienne in France, in Westphalia, and in Belgium; among brick-makers near Cologne in Germany; and elsewhere. Hitherto its occurrence in England has never been recorded, except by Manson among lascars on vessels from India. In part IV., p. 274, of his annual statistical Report on Mines and Quarries for 1898, Dr. Le Neve Foster directed the attention of British mine owners to the desirability of being on the watch for this disease, owing to the great trouble which it has caused in Belgian and other collieries on the Continent; and in his report for 1899, p. 352, he again refers to the subject.

The adult worm lives in the duodenum and upper part of the small intestine, with its head fixed in the mucous membrane. The female is about half an inch in length, the male being a little shorter. The head is provided with a suckorial apparatus and four curved teeth. The posterior end of the male is provided with a very characteristic bursa. Both the head and the posterior end of the male are shown in the accompanying micro-photographs, for all of which I am indebted to Mr. C. A. Coventon, M.R.C.S. They were taken at the Pathological Laboratory, Oxford, from specimens brought from Dolcoath. The female worm produces an enormous number of ova, which may be easily found in the fæces of all persons suffering from the disease. These ova measure about .05 to .06 by .03 to .04 millimetre, are very characteristic, and are easily distinguished by their delicate and perfectly transparent oval shells. Segmentation has usually advanced considerably, so that each egg contains from two to eight or more cells. If the fæces are left at a moderate temperature for several days, or in a warm place for a few hours, an embryo worm develops and hatches, as shown in the photographs and in the accompanying illustration taken from a paper by Lutz. According to Giles, the embryo develops in polluted soil at a sufficiently high temperature into a sexually complete rhabdite form existing outside the body; and if this be so it is presumably only the progeny of the rhabdite form which is capable of infecting men. Probably the infection is conveyed by the swallowing of these worms when they are present in dirt, but it has recently been shown by Looss that the worms are also capable of passing into the skin and producing a temporary skin eruption. Whether they pass onwards from the skin into the intestines is still doubtful.

The symptoms of the disease are briefly as follows. The face, and particularly the lips, tongue, and inner surface of the eyelids, become pale, just as in the case of the "anæmia" or "chlorosis" commonly met with in young women. At the same time the affected person begins to complain of palpitations, and a tendency to dizziness and shortness of breath on exertion.

He and his friends often suspect that he has heart disease. There is also frequently discomfort or tenderness in the region of the stomach, with capricious or abnormal appetite, and other symptoms of gastro-intestinal disturbance. These various symptoms become more and more pronounced, until at last it becomes impossible to work, and a miner would not dare to ascend a ladder on account of the risk of fainting. The pallor and the other main symptoms depend on a deficient percentage of hæmoglobin, the oxygen-carrying constituent of the blood. The fainting, palpitations, &c., are due to the consequent defective aeration of the tissues, and in particular of the heart, just as occurs in poisoning by carbonic oxide. We have measured the total volume of the blood in several cases, and the results indicate that the "anæmia" is due, not to loss or destruction of blood, as has hitherto always been supposed, but to a great increase in its volume, with a corresponding dilution of the hæmoglobin. The gastro-intestinal symptoms are probably due mainly to irritation caused by the presence of the worms.

In the Dolcoath epidemic skin symptoms have been very prominent, nearly all of the men affected having suffered from itching of various parts of the skin, with urticaria-like, or pustular eruptions, called by the miners "bunches."

In more advanced stages of the disease the symptoms of simple anæmia become gravely complicated. There is frequently dropsy together with signs of heart failure. Death may occur in untreated cases, the immediate cause being often some intercurrent disease, such as pneumonia or phthisis.

I have shortly described the symptoms as it is very important that they should be known to officials in mines, and not merely to doctors.

The definite diagnosis of the disease depends chiefly on the recognition of the ova in the fæces. The adult worm is not found in the fæces unless a vermifuge remedy has been administered. Another important aid to diagnosis is afforded by examination of the blood, in which the eosinophile leucocytes are largely increased, the changes in the proportion of hæmoglobin and of red corpuscles being otherwise similar to those in chlorosis, and entirely different from those in "pernicious anæmia."

Early diagnosis and treatment of ankylostomiasis is very desirable, but often a man suffering from the disease does not think it necessary to consult a doctor, and may meanwhile spread the disease to others, and become seriously ill himself. The main diagnostic symptom is the pallor of the face and lips, with palpitations on exertion. The pallor is easily recognised, and when it occurs in a miner should excite suspicion, as in England anæmia is as uncommon among men as it is common among women. Underground work, it is true, causes a certain amount of pal'or of the face, and this seems to be consistent with perfect health, but pallor of the lips is a sign of definite anæmia, especially when accompanied with unusual palpitations, &c., on exertion.

Ankylostomiasis is a disease which, at least under European conditions, is eminently susceptible of successful treatment. The worms can be expelled by the administration of powerful vermifuge remedies, the most successful of which are thymol and extract of male fern. The former is now usually preferred, largely on account of the difficulty of always obtaining a reliable preparation of male fern. The administration of these remedies in sufficient doses requires careful medical supervision. When the worms have been expelled restoration to health is rapid as a rule, provided that re-infection is prevented. The complete expulsion of the worms can be ascertained by the disappearance of ova from the fæces.

In the more advanced cases the treatment is less simple, as various secondary consequences of the disease may need special attention, especially at first, but unless some very serious complication has supervened complete success may be anticipated.

Cases left to themselves, and with renewed infection constantly occurring, tend to become more and more grave. Miners are, however, compelled to stop

work underground as soon as their anæmia becomes considerable, and, as in England at least renewed infection must then cease, the usual tendency is towards recovery, since the worms already present cannot multiply in the intestine, and must gradually die off. For this reason the graver forms of the disease can seldom occur in England. At Dolcoath the affected men have, as a rule, been transferred to surface employment or to another shaft when they became affected, and this has usually been successful in checking the disease. Others have been given leave of absence for a time, have gone into hospital, or obtained employment elsewhere; and in one way or other the majority of affected men have recovered or greatly improved. So far as we can ascertain, there is only one very grave case among the miners at present affected.*

The spread of ankylostomiasis, as appears from the life history of the parasite already described, depends entirely on contact with material which has been polluted by human fæces and remained for a sufficient time under such conditions of temperature, moisture, &c., that the ova contained in the fæces have developed. In mines there are practically no arrangements for the prevention of pollution of the ground by excrement. Any dark corner is made use of by the miners, and polluted soil is certain to be carried on the boots of the men to all parts. The ladders, tools, clothes, &c., thus become infected, and it inevitably happens that some of the infective material is swallowed, particularly during the taking of food, as there are no means underground of properly cleaning the hands. As already mentioned, it is also possible that infection occurs through the skin.

It is evident that the spread of the disease may be entirely checked by preventing the pollution of mines by human excrement. Unless this is effected, as it certainly can be, the disease will probably spread gradually throughout the mines of England, wherever the temperature and moisture are favourable to the growth of the larvae.

The epidemic of anæmia at Dolcoath first became very noticeable about five or six years ago. The following table, showing the number of men admitted for anæmia into the West Cornwall Miners' Hospital at Redruth since 1893, affords some idea of the course of the epidemic, though only a portion of the men affected sought admission. Among the men admitted for anæmia only one death occurred, and no death certified as from anæmia has occurred in the Camborne District during the last few years among miners.

Year.	Cases admitted.
1893	1
1894	3
1895	9
1896	13
1897	29
1898	23
1899	12
1900	11
1901	7
1902 (till November)	7

The cases of anæmia appear to have occurred almost entirely among men working in the neighbourhood of the Engine, or New Sump, Shaft at Dolcoath, and practically everyone employed in this part of the mine seems to have been more or less affected, as well as the Manager and nearly all the officials employed underground. The position of the Engine Shaft is shown on the accompanying Section of the mine. This shaft acts as an upcast, and consequently the air in and around it is saturated with moisture. The temperatures recently observed in this shaft and the Eastern Shaft are shown on the plan, together with arrows indicating the direction of the air currents, and letters corresponding to the positions at which samples of air were taken for the analyses quoted on page 8. The air-current down the Eastern Shaft at A was found to be about 14,000 cubic feet per minute on 16th October, when the samples were taken. On the day of our visit two of the four fans discharging air from this shaft along the levels were stopped for repairs, so that the current downwards was no doubt less than usual.

About the end of 1898, when the cases of anæmia were so frequent, Mr. Thomas was led to suspect that the occurrence of "bunches" was connected with contamination of the mine by excrement. He accordingly assembled the men and pointed out to them that pollution of the mine must be avoided as far as possible, and that privy accommodation was provided at the surface. He also ordered a large quantity of chloride of lime and permanganate of potash to be used at polluted spots and in the shafts: At the same time the ventilation was improved by various means, and finally, at the beginning of 1900, four centrifugal fans were placed on levels close to the Eastern Shaft at the places shown on the plan, so that fresh air was blown through doors towards the Engine Shaft. By this means the temperature of the Engine Shaft was considerably lowered, the improvement being very evident to Mr. Martin when he visited the mine. The abatement in the epidemic has probably been due to these measures, and particularly, perhaps, to the reduction in temperature, as a low temperature is unfavourable to the complete development of the larvæ out-side the body.

After consultation with Mr. Martin and myself Mr. Thomas has now introduced a system of pails with accompanying disinfectants for use in case of necessity by the men underground, and issued strict orders for the prevention of pollution of the mine by excrement. The parts of the mine known to be polluted are also being treated with disinfectants in order to destroy existing foci of infection. I trust that with the co-operation of the men these measures, together with the active treatment by the medical men in the district of all cases of ankylostomiasis, will soon stamp out the disease at Dolcoath. It must be clearly understood, however, that the prevention of the disease is largely in the hands of the men themselves, and that it is their clear duty to observe, and if necessary to enforce, the precautions necessary for preventing the pollution of a mine. Unless proper arrangements are made in other mines, and carried out by the men, ankylostomiasis is very likely to spread in England and may easily affect coal mines as well as metalliferous mines. The Cornish mines are specially exposed owing to the fact that Cornish miners are continually returning from tropical countries, and that men known to have been infected are already scattered over the district. It must also be clearly understood that many of the men who are only slightly infected show no symptoms at all, as the presence of a few ankylostomes in the intestine may produce no symptoms. Such men may continue for years to be a source of possible infection owing to the presence of ova in the fæces.

So far as we can ascertain there has been no spread of the disease above ground, nor is any such spread probable considering the low temperature of England, and the fact that there are almost everywhere fairly satisfactory means for the disposal of excreta.

Dr. Boycott and I are now engaged in an investigation of the pathology of the disease, the conditions under which it spreads, and the extent to which the

infection is present in Cornwall. We have also issued a circular to medical men in the neighbourhood asking for information about suspicious cases of anæmia which have come under their observation.

In concluding the present preliminary report, I desire to acknowledge the very great help which has been afforded to us by Mr. R. Arthur Thomas, Manager of Dolcoath mine. He has not only placed a laboratory at our disposal but has devoted much time and trouble to the furtherance of our investigations. We are also greatly indebted to Dr. Telfer Thomas, Medical Officer for Health for Camborne, who has constantly co-operated with us throughout the enquiry. A number of cases of ankylostomiasis have already been treated by him. Our experiments on the blood-volume were made in the Chemical Laboratory of the Camborne School of Mines, through the courtesy of Principal Berenger.

I am, Sir,

Your obedient Servant,

J. S. HALDANE.

Camborne,

November 24th, 1902.

AIR ANALYSES AT DOLCOATH MINE.

	Oxygen per cent.	CO ₂ per cent.	Oxygen diminished per cent.	CO ₂ increased per cent.
Outside air (was perfectly pure) ...	20.94	.03	0.00	0.00
A. 302 fathoms level in Eastern (down-cast) Shaft.	20.94	.03	0.00	0.00
B. 302 fathoms level at end, crosscut in granite, air blown in.	20.82	.08	0.12	0.05
C. 375 level, North Lode, at stoping in open place.	20.79	{ .110 } { .115 }	0.15	0.08
D. 412 level, large open gunnis (dry 77°, wet 76°).	20.85	.095	0.09	0.065
E. 440 level, at New Bridge (dry 77°, wet 76°).	20.83	.09	0.11	0.06
F. 470 level, rise in crosscut north of lode, drill idle.	{ 20.67 } { 20.66 }	{ .22 } { .23 }	0.275	0.225
G. 455 level, bottom of Engine (upcast) Shaft (dry 79°, wet 78°).	20.85	.095	0.09	0.065
H. 375 level, taken from gig in Engine Shaft.	20.79	{ .110 } { .115 }	0.14	0.082

Samples B and H were examined with an incandescent platinum spiral for CH₄, CO, &c., but no traces were found.

WEST.

SECTION OF DOLCOATH MAIN LODE .

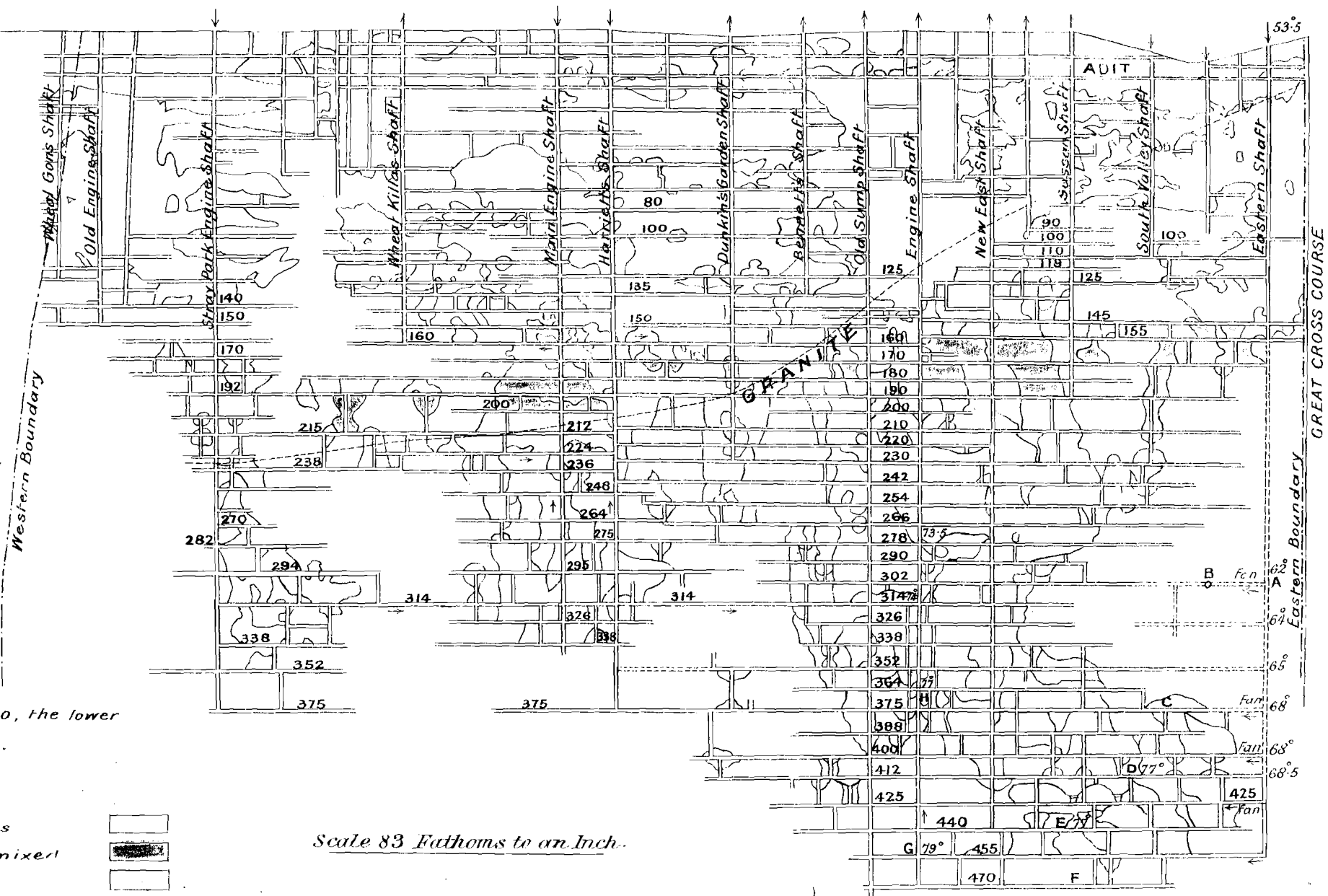
WEST DOLCOATH

West Dolcoath is partially worked to a depth of 280 fms. under adit and is drained by Dolcoath to the 140 fms. level.

Harriett downcast to 160, the lower workings being upcast.

Copper workings
 Copper and Tin mixed
 Tin workings

Scale 83 Fathoms to an Inch.



GREAT CROSS COURSE

Eastern Boundary

DOLCOATH MAIN LODE.

LONGITUDINAL SECTION.

