This is the same fallacy in another form. The cost per ton when working six days a week being 6s., and when working three days being 7s. 1d., it is obvious that it pays the owner better to work six days at a selling price of 6s. 6d. than to work three days at a selling price of 7s. In the one case he gets a profit of 6d. on 13,000 tons, or £325 in the week, in the other a loss of 1d. on 6,500 tons, or £27 in the week. In fact, in order to get the same weekly profit in the latter case he requires a profit per ton of 1s. on the lesser tonnage, and in order to realize this, must have a reduction of 1s. 1d. per ton in wages, which is equal to 26 per cent. of the present rate of wages. It must not, moreover, be forgotten that the reduced price, by stimulating consumption in iron making and other coal consuming industries, tends to improve the demand, whilst prices unduly raised have, of course, an opposite tendency. The all important principle to be recognised, and which cannot be too strongly emphasised, is that so long as a colliery is not working at or near full time, tonnage and not price is and must be the primary factor in determining the profit, and therefore the amount of wages the coal owners can afford to pay.

It is impossible to leave the subject without a few words on the present cry for "a living wage." Every one, and employers especially, must wish that working men should be able to earn wages that will enable them to live in comfort as well as make provision for old age or illness in the future. But to put up the cost of production for this purpose to a point which the state of trade will not bear, and which either kills the demand by enhanced prices or renders it impossible to work except at a loss, must be a suicidal policy. In order, however, to rightly appreciate the unreasonableness of the demands made, it is necessary to examine them in detail. The daily wage of a collier may be taken as varying from 6s. to 10s., according to his skill and the conditions of the stall in which he works. No one suggests, not even the miners themselves, so far as I am aware, that this wage is inadequate, but their contention is that, owing to slackness of trade, a miner often only gets three days' work or even as little as two and a-half days a week, and they argue that 15s. or 18s. is not a sufficient weekly wage, and therefore the standard daily wage should be increased, so as to make the wage adequate. Can anything be more unreasonable or impracticable? If the miners, and therefore the pit, is only working three days in the week —and this is the very time when trade is slack, prices low, and, as I have shown, owing to small output, the colliery owner's burdens are heaviest, and when he most probably is losing money—that, according to the reasoning of the men, is the time when wages should be raised so as to enable them to earn in three days the wages they formerly earned in five or six. In other words, the weekly earnings of the miner are to be practically guaranteed whether there is or is not sufficient trade to keep him employed, and consequently in case of extreme depression the wages may rise to a point at which it is impossible to work the pit at all. In what other trade is such a demand made? Has not the bricklayer, the carpenter, or the dock labourer, and every other artisan to take his chance of employment, and when his employer suffers through slackness of trade, to suffer with him? So long as the claim of the workmen is directed to attaining a fair wage for a fair day's work it is legitimate, but when it takes the form of requiring a fair week's wage when only a fraction of a week is worked it becomes impossible and absurd. Are there, then, no ways in which it is possible to adjust the relations of coal owners and miners in the varying condition of trade without resort either to the barbarity of strikes or the tedious and invariably unwieldy process of arbitration.

One plan, that of the sliding-scale, in which the day's wage rises and falls with the price of coal, has been tried with, at times, considerable success; but, although undoubtedly a step in the right direction, it is open to the objection that, as has been shown above, price alone does not always correctly represent the wage-paying capacity of the coal owner. There is another plan which has been more than once suggested, and which, if the miners could be persuaded to have confidence in it, would, I believe, work far more justly and satisfactorily. I allude to profit sharing. On this plan the coal owners would be entitled to a minimum interest on their capital and the miners to a minimum daily wage, *i.e.*, such a daily wage as could be paid under the most depressed condition of trade; the whole of the profits remaining after these payments being divided equally each year between owners and men, and the men's share being divided among themselves in proportion to their individual earnings during the year. The men would of course be entitled to appoint auditors or accountants of their own to examine the accounts, but it is essential to the successful management of the colliery that it should be left entirely and exclusively in the hands of the masters. Such a system, if cordially accepted by men and masters, would, I believe, soon be recognised as enormously to the advantage of both. There would be established and felt a unity of interest that would practically abolish the trade disputes and strikes that at present interfere so much with the prosperity of trade. But who shall persuade the men to lay aside their attitude of suspicion and their inveterate distrust of results obtained from the books of their employers? Could this be accomplished, and could they be induced to see that with proper safe-guards and checks they would be safe in so throwing in their lot with the owners, and in trusting to their self-interest for an intelligent management of the business in which both are interested, the results that would be realised in general prosperity, contentment, and absence of friction are not easily to be estimated.

Nickel—Its History, Uses and Distribution.*

By Mr. A. G. Charleton.

(Concluded from page 110.)

To explain the genesis of this class of ore deposits one must glance for a moment at the sources from whence nickel is derived. Native nickel is found alloyed with iron in meteorites, and also in some ultra basic lavas, while the spectroscope reveals its presence in the solar atmosphere. It is showered on the surface of our planet in the form of meteorites, those fiery messengers telling of the wreck of other worlds, and testifying to the common origin of the material universe, in the form of (1) holosiderites composed entirely of nickel iron; (2) syssiderites the nickel iron of which contains silicates of magnesia and iron protoxide, identical with olivine, and at other times a mineral resembling augite; (3) sporadosiderites, the most common kind, usually crystalline in structure, and containing nickel iron, troilite, chrome iron, olivine, titanic and phosphoric acids; (4) asiderites, distinguished by the presence of hydrocarbons in which nickel is present as an oxide. Some of them have been shown to contain pyroxine and felspar (chiefly anorthite) and the absence of quartz and highly silicated felspars is to be noted. These four classes of meteorites show a gradation from almost pure metal containing over 98 per cent. of nickel iron to a stony mass closely resembling some basic lavas. Now, according to the latest determinations of M. Alphonse Berget,† the density of the earth is 5·41, whilst, so far as our limited observation extends, that of the crust is about 2·5. Various theories have been advanced to account for this, and some very first-rate authorities have suggested that the heavier metallic elements might possibly be found to predominate in the nucleus, basing their views on widely extended observation of past and present volcanic phenomena.

It has been found that once the acid stage is past lavas become more basic, and while each succeeding flow from any one vent might not be more basic than the preceding one, yet the tendency is in that direction, till, finally, ultra-basic lavas are excluded from the centres of intense and long-continued activity. This average order invariably, I believe, holds good everywhere over the earth's surface, provided the volcanic force is long enough active. The ultra-basic rocks have in composition many points of resemblance to some of the above-mentioned meteorites. Thus dunite is a crystalline granular aggregate of olivine and chrome iron, which passes by alteration into serpentine; we have also picrite, half of which is olivine, associated with hornblende, diallage, and magnetite. Lherzolite is another of these peridote rocks, consisting of olivine and enstatite, with other accessory minerals. Olivine is the dominant constituent of such rocks, and as a class they possess the highest specific gravity and least oxygen of any known.

Some of the basalts, notably those of Antrim in Ireland, contain metallic iron in microscopical particles, and Professor Nordenskiold discovered, in 1870, on the shores of Disco, on the coast of Greenland at Ovifak, fifteen blocks of nickel iron within an area of half an acre, the two largest being 20 and 8 tons weight respectively; while further observations in the same locality showed that a basalt dyke, at no great distance from the supposed meteorites, contained lenticular disc-shaped blocks of precisely similar iron, and crystals of labradorite and arigite associated with viridite, round which minute particles of iron were moulded. These facts led Professors Judd, Daubrée, and others to decide that the blocks of iron Nordenskiold discovered and took to be meteorites were of terrestrial origin, as the basalt was certainly not derived from the clouds. The Ovifak iron contains 0·5 to 6·5 of nickel, and a nickel-iron awaruite, lately discovered in New Zealand, presumed also to be of terrestrial origin, is said to contain 68 per cent. Ni, 31 per cent. Fe, and 0·7 per cent. cobalt.

In the Urals platinum is found alloyed with nickel iron in association with olivine. Taking the mean density of awaruite as approximately 7·1, and that of rhyolite as 2·6, the terrestrial basic and ultra-basic rocks, which include basalt, gabbro, Lherzolite, trachite, and dolerite, are found to closely correspond in density with the extra-terrestrial meteorites. Those of solid nickel iron have a specific gravity of 7·1, and graduate down to stony asiderites, which possess a density of 2·7.

Meteorites.

	Sp. Gr.
Nickel iron solid	7·1
" considerable	6·8
" medium proportion	3·5
" small quantity	3·1
Stony	2·7

Terrestrial Metals and Rocks.

	Sp. Gr.
Awaruite, (approx)	7·1
Nickel iron in Ovifak basalt, (approx)	6·8
Basalt, gabbro, Lherzolite	3·0 to 3·5
Trachyte and dolerite	2·7 to 2·9
Rhyolite petro-silex	2·6

The conclusion to be drawn appears to be that the genesis of nickel deposits may, in most instances, be traced to the ultra-basic rocks and their derivatives, serpentines and magnesian silicates. The great nickel deposits of the world are found in rocks in which olivine is the predominant mineral, while we have seen that olivine and the magnesian silicates are found not only in the ultra-basic rocks of the earth, but also in meteorites. While these facts alone do not prove that the nickel was derived from the olivine, it is well to note the conditions under which the olivine was formed, and to see how far it is nickeliferous. Assuming a semi-metallic nucleus for the earth, and that in this nucleus iron and nickel are the predominant metals, as they are in meteorites, and allowing that the ultra-basic rocks came from the greatest depths in the earth's interior, under such circumstances, it would not be remarkable for silicates, crystallising out of the magma, to contain such metals.

From the microscopic study of the igneous rocks, much light has been thrown on the order of crystallisation of their component minerals, which has pretty definitely been proved to be fairly uniform. Thus the first minerals to form appear to be magnetite and illmenite, sometimes chromite and picotite. Next come silicates, which occur in minute quantities, such as zircon and titanite; pyrite and pyrrhotine usually follow; and next the metallic oxides and sulphides, and the heavy dark-coloured basic silicates, olivine, augite and hornblende. Olivine is the first of the rock-forming silicates to crystalize out of the basic magna. According to Rutley, olivine sometimes contains traces of titanic, phosphoric and chromic acids, and the protoxides of nickel and cobalt. Sandberger's experiments with rock silicates almost invariably show traces of Ni, Co, and Cu, from olivine and augite. Whether the nickel occurs, as he supposes, in chemical combination, or, as Mr. A. W. Stelzner thinks, mechanically admixed, is practically immaterial to the question under discussion; it is sufficient to know that olivine contains the metal in quantity enough to form, when dissolved and re-precipitated, rich and extensive deposits. We have seen, indeed, that the olivine in the Oregon rock gave 0.25 per cent. Ni, while the serpentine from Dillenberg showed 0·66 per cent.; and much of the serpentine in New Caledonia runs over 1 per cent. A review of the foregoing facts certainly points to the conclusion that the nickel, at least of the serpentinous deposits, has been derived from the basic magnesian silicates of the original rock masses. As regards the nickeliferous pyrrhotite deposits, they may possibly have a different origin as suggested by Vogt.

It has been proved that workable deposits of titaniferous iron have been probably formed in certain basic eruptives in Norway and Sweden by a process of differentiation or segregation of the iron ore to the centre of the eruptive mass; and Vogt has suggested, and endeavored to apply, the same theory to account for the formation of the nickel sulphide deposits in the norites of Norway and Sweden and the Huronian deposits of Canada. As against this theory, it is remarked that the pyrrhotite deposits referred to occur along the contact planes of the gneiss and schists; and therefore, if they were formed by segregation from a molten magma, this process has taken place from the centre towards the outside, or in reverse order to that which characterizes the iron ore and the supposed structure of the interior of our globe.

Though there may be grounds for further investigation in this direction, these ore bodies would seem more probably to have been deposited from circulating mineral waters. Some geologists explain the presence of deposits of mineral by supposing them to have been formed by the agency of circulating solutions bringing them to the surface from unknown depths, disregarding the fact that fissures have never yet been proved to have indefinite extension, nor can water circulate below certain limits. Before, therefore, adopting an ascension theory for the formation of nickel deposits in basic eruptives, it is well to recollect that these rocks came from greater depths within the earth than circulating water is likely to have penetrated; much deeper in all probability than any vein fissure could have extended to. It is more rational, it seems to me, to suppose that the metals were brought within reach of surface agencies, and it is probably owing to the subsequent leaching of these basic eruptives that our principal deposits of nickel were placed at the disposal of the miner's pick. The practical lesson to be gathered from this is, I think, that the prospector looking for new deposits of this class will best turn his attention to a field where rocks of this character are met with.

The progress of science day by day makes the art of mining less speculative and more business-like, and it should be I think, the function of the engineer to apply science to this legitimate commercial end; to raise it, in fact, into the position of an industry, which has materially assisted in building up the prosperity of all new countries; which has done so for America already, and which will do so for our British colonies in the future, with marked advantage to us. Mining supports tens of thousands of our population, opens outlets for remunerative enterprise and emigration, and exercises a civilising influence which is world-wide, and, I think, the surest means to foster it is to point out its risks as well as its advantages; to encourage the employment of necessary capital in profitable fields; and, equally, to discourage wasting valuable money on enterprises which do not possess the elementary conditions for achieving success. There are, in fact, three classes of people, I believe, who engage in mining: those who get most metal out of the pockets of the public, those who are content to mine in pockets of ore, and those whose endeavour is to successfully develop valuable mineral deposits on what I would term a profitable commercial basis, with the aid of scientific knowledge applied practically.

The contracts for the metal in America closed early in 1892 were made at prices ranging from 55 to 60 cents

*Abstract of a paper read before the Society of Arts, May 2, 1894.

†*Comptes Rendus*, July 1893.