

**Note on the occurrence of remains of recent plants in brown iron-ore / by J. Arthur Phillips.**

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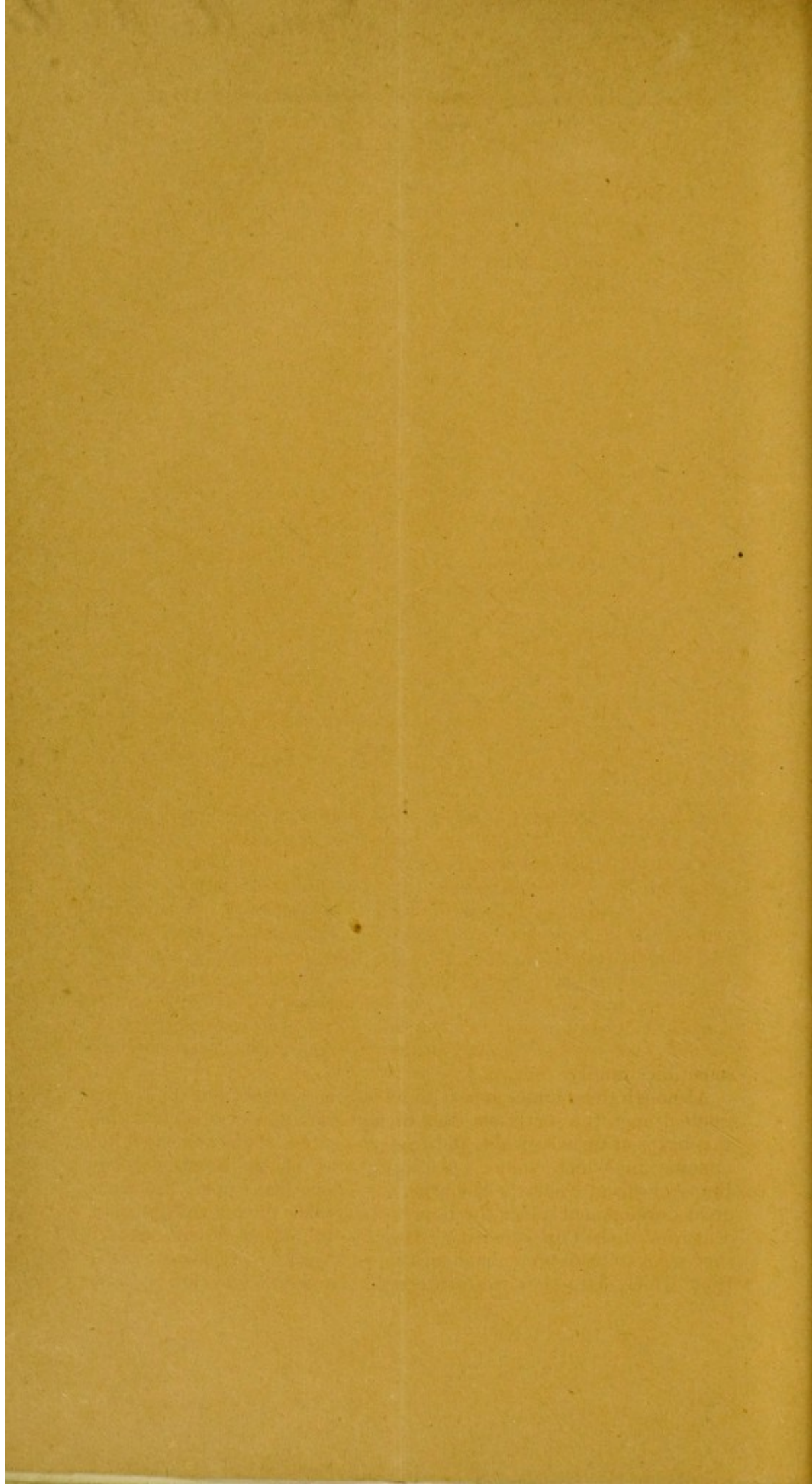
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From the Author

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NOTE on the OCCURRENCE of REMAINS of RECENT PLANTS in BROWN  
IRON-ORE. By J. ARTHUR PHILLIPS, Esq., F.G.S.

THIS bed of fossiliferous iron-ore is situated at Rio Tinto, in the province of Huelva, Spain, and is in close proximity to the celebrated copper-mines of that name.

In this portion of Southern Spain deposits of cupreous iron pyrites, consisting of a series of lenticular masses of ore, having a general direction a little north of east and south of west, extend from Aznalcollar, near Seville, in the east, for a distance of more than seventy miles westward to within the Portuguese frontier.

At Rio Tinto the deposits of this mineral are very extensive, and consist of a compact and intimate admixture of iron pyrites with a little copper pyrites, through which strings of the latter mineral sometimes ramify.

Although these mines appear to have been worked, and the copper smelted upon the spot, from time immemorial, it is evident from the vast heaps of furnace-slugs, and from the extent of the various other remains in which coins and inscriptions of the reigns of the Emperors from Nerva to Honorius have been discovered, that their great development under the Romans took place during the first four centuries of the Christian era. After the fall of the Roman empire they seem to have been abandoned down to as late as the year 1727, from which date they were intermittently worked by the Spanish



Government and by various private speculators until 1873, when they were purchased by an English company. The extent of the mining and metallurgical operations anciently carried on in this district will be understood when it is stated that at Rio Tinto alone, in addition to hundreds of Roman shafts and miles of Roman galleries, the heaps of copper slags resulting from the smelting at that period cannot amount to much less than one and a half million of tons, and that there are large accumulations of similar ancient refuse at Tharsis, Buitron, and other mines.

As illustrating the care and skill of the metallurgists of that period it may be stated that each ton of their slags seldom contains above three pounds of copper.

The prevailing rock throughout this region is clay-slate, which, from the evidence of various fossils found by Mr. A. Hill, Mr. G. W. Clement, and other officers on the staff at Rio Tinto, is apparently of Silurian age. These specimens were kindly examined by Mr. R. Etheridge, who did not hesitate to identify them as belonging to that period.

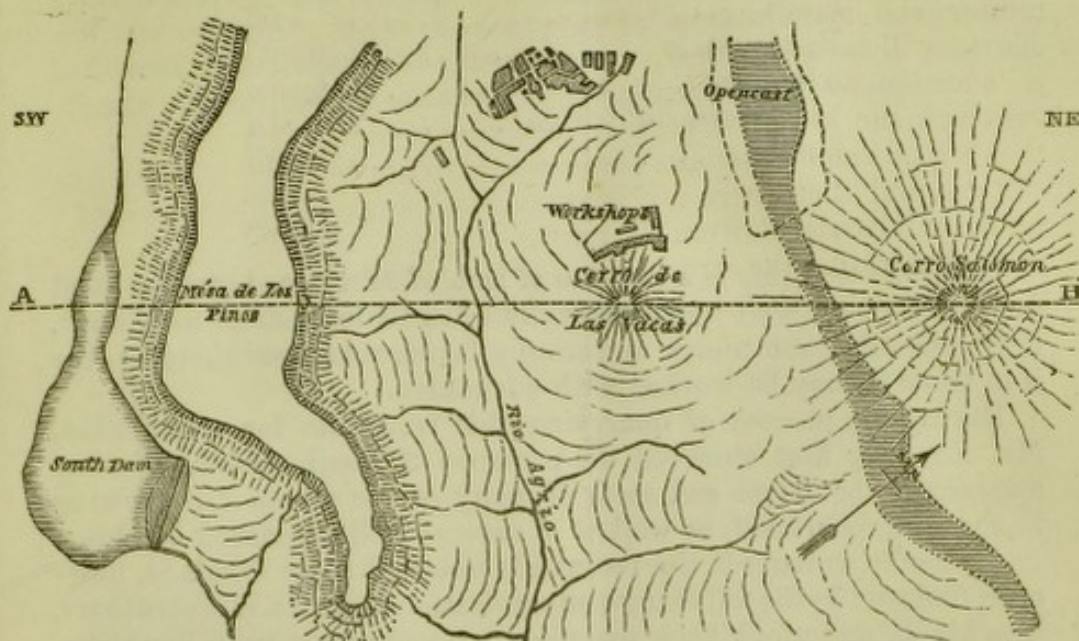
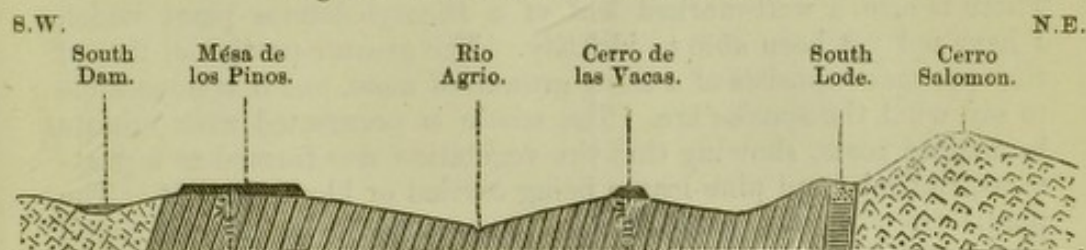
These slates are, in places, broken through by large dykes of quartz-porphyry, which frequently form one of the walls of the various deposits of cupreous pyrites.

The fossiliferous iron-ore which is the immediate subject of this note forms a cap one kilometre long, with an average width of one hundred and thirty metres, on the top of the Mésa de los Pinos, nine hundred metres south of the open cutting at Rio Tinto. Its surface is approximately level, but it varies in depth from one to seventeen metres in accordance with the conformation of the surface of the slate upon which it lies; the rock beneath it is bleached and to some extent decomposed.

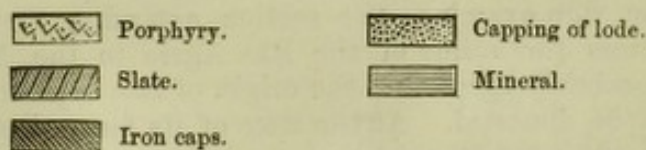
The order and relative positions of the several formations will be best understood on referring to the accompanying plan and section (figs. 1, 2), for which I am indebted to Mr. Neil Kennedy, a gentleman in charge of a portion of the work at the mines, through whose kindness I am also enabled to lay specimens of the fossiliferous iron-ore upon the table.

On the extreme right of the section is a broad porphyritic dyke forming the north wall of the south lode, next to which is the lode itself, which at this point has only one third of its greatest width. Next in succession, to the south, comes a band of slate, which is again penetrated on the left by a broad dyke of quartz-porphyry. It will be observed that the upper part of the vein has, to a considerable depth, been converted into a ferruginous capping (gossan), of which a large portion has been removed by denudation. The stratum of iron-ore forming the surface at the Mésa de los Pinos is shown with precipitous sides; and a small patch of a similar formation occurs, at within a metre of the same elevation, at the Cerro de las Vacas. Numerous fissures occur in the surface of the larger deposit of iron-ore, and out of these pine-trees formerly grew in considerable numbers, their presence giving the name to the locality; these were eventually destroyed by sulphurous fumes



Fig. 1.—*Plan of part of Rio Tinto.*Scale of Plan and Section  $\frac{1}{15,000}$ .Fig. 2.—*Section in line A B on Plan.*

Level of Rio-Tinto Station.



resulting from the metallurgical operations which were carried on upon the declivity of the opposite hill.

In some instances the decomposed clay-slate has been partially removed from beneath the iron-ore, from which blocks have been detached, and have slid a considerable distance down the surface of the slaty declivity.

A specimen of this iron-ore, analyzed in my laboratory, afforded the following results:—



Water	{ hygrometric .....	1.40
	{ combined .....	11.85
Silica .....		1.53
Ferric oxide .....		84.65
Alumina .....		trace.
Phosphoric anhydride.....		.14
Sulphur .....		.23
		<hr/>
		99.80

It follows that this is a rich ore of iron of fairly good quality ; and as there is now a well-appointed railway in its immediate proximity, it is probable that under moderately favourable conditions of the iron trade it may be worked with advantage.

During the process of quarrying this ironstone for exportation, Mr. Kennedy first observed the presence of fossil remains of what appeared to be leaves and seeds of many of the plants still growing in the neighbourhood, as well as of several well-preserved beetles.

All doubt as regards the recent character of these fossils is, however, removed by the following communication from Mr. W. Carruthers, who kindly undertook their examination, and who says, "The specimens you have sent me for examination from Rio Tinto contain the following fragments of plants which I have been able to identify:—leaves and acorns of *Quercus Ilex*, Linn. ; leaves and seed of a two-leaved species of *Pinus*, most probably *Pinus Pinea*, Linn. ; the cone of *Equisetum arvense*, Linn. ; and a small branch of a species of *Erica*. There is also a well-marked leaf of a Dicotyledonous plant which I have not yet been able to identify. The greater portion of two of the specimens consists of a thick growth of moss, but it is impossible to say what the species are. The whole is permeated with minute branching roots, showing that the vegetation was formed as a peat-moss, the oak- and pine-leaves being carried or blown into it. The plants are evidently, all of them, the same species as are still found growing in Spain."

In addition to these fossils this deposit sometimes contains minute concretionary patches of imperfectly crystallized quartz.

Every one who examines the section extending from the Cerro Salomon across the valley of the Rio Agrio to the Mésa de los Pinos will probably agree that the origin of this deposit of iron-ore can scarcely be doubtful. At the time of its formation a marsh or shallow lake extended from beyond the last-named point to the foot of Salomon, and into this flowed solutions of iron-salts resulting from the decomposition of the upper portions of the immense masses of pyrites constituting the south lode.

From these salts oxide of iron was deposited, as in the case of bog iron-ores generally ; and, finally, the valley of the Rio Agrio was eroded, as well as that south of the deposit, leaving the Mésa capped with iron-ore, while a small patch of the same mineral was left at the Cerro de las Vacas.

That the deposit took place at a comparatively recent date is evident from the fossils it contains ; and it is equally certain that the

erosion of the valley is older than the occupation of the district by the Romans. Not only are numerous remains of buildings and other works belonging to the Roman period found in the valleys, but the Roman grave-stones, of which scores are still scattered over some parts of the district, are invariably made of this iron-ore.



