XXXIII. *An Examination of various Ores in the Muſeum of Dr.* William Hunter. *By* George Fordyce, *M. D. F. R. S. and Mr.* Staneſby Alchorne.

Read May 20, 1779.

MINERS and aſſay-maſters being generally employed in finding out metals for profit, without inquiring into the ſtate or combination they are in, have made uſe of proceſſes adapted, in many caſes, to inveſtigate the quantity of metal, gueſſing often at its ſtate or combination; and ſpecimens being procured from them for cabinets, an erroneous account has not only been given of their contents, but theſe errors have alſo crept into books of natural hiſtory: for this reaſon Dr. FORDYCE determined to aſſay many of the doubtful ſpecimens, by proceſſes better adapted to find the ſtate or combination of the metal than thoſe commonly in uſe; and procured the aſſiſtance of his friend Mr. ALCHORNE. The reſult of ſome of their inquiries they now lay before the Society.

The firſt ore we mean to conſider is called gold pyrites. Pyrites is an ore of iron, containing ſometimes copper, ſometimes arſenic, ſometimes other metals; generally, if not always, combined with ſulphur.

This ore, from its yellow colour, has at firſt ſight been often taken for an ore of gold. It is the moſt common of all ores, and on examination is very ſeldom found to contain gold. Specimens, however, have been found from which gold has been procured; and, particularly, there have been found in Fatchobuigna near Zalatna, in Tranſylvania, maſſes which contain a large proportion of this metal. Sometimes the gold is in its metallic form, and viſible to the naked eye; ſometimes it is not: and in theſe caſes the ore has been thought to contain the gold united firſt with iron, and that compound united with ſulphur.

Dr. FORDYCE obſerves on this propoſition, that it has not as yet been proved, that a compound metal can be combined with ſulphur. If two metals are ſoluble in ſulphur, and each be ſeparately combined with it, the two compounds may be diffuſed through one another, as is the caſe with the compounds of ſulphur and iron, and ſulphur and copper; which may be diffuſed through one another: but if we have a compound of two metals, of which one is ſoluble in ſulphur, and the other is not, if

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we apply ſulphur to this compound, it will diſſolve the one, and leave the other; as, if gold and ſilver be combined, if we reduce the maſs to fine particles, and mix them with ſulphur, and throw them into a crucible, heated white hot, and afterwards melt the whole maſs, the ſilver will combine with the ſulphur, and the gold will fall to the bottom of the veſſel. This being the caſe, we doubted whether this ore contains the gold in its metallic form, only mechanically mixed with the pyrites; or combined with the ſulphur by means of the iron: and therefore ſubjected a ſpecimen to examination, in which we could not diſcover, even by the help of a microſcope, any particle of native gold.

EXP. 1. We powdered one hundred grains of this ore, and boiled it in nitrous acid diluted with water; a ſolution took place with effervescence. Having digeſted them together, till the whole ſoluble part was taken up, and poured off the ſolution, and made a precipitation by fixed vegetable alkali, the precipitate appeared to be iron. Having waſhed the remaining part with water, and expoſed it in a glaſs matraſs in ſand, to nearly a red heat, a very ſmall portion of ſulphur ſublimed; the remainder was quartzoſe ſand, with particles of gold, which were ſimilar in figure, though ſmall, to the particles of gold found native in veins mixed with various matrixes, and

not at all like particles which had been combined with a *menſtruum*, which ought either to have appeared in a powder, whoſe particles were hardly viſible from their ſmallneſs; or in cryſtals ſimilar to one another.

EXP. II. If any metal be combined with ſulphur, mercury will not precipitate the ſulphur from it; we therefore took 140 grains of the ſame ore, and triturated it for ſome hours with about five times its weight of mercury: the powdered ore was waſhed off from the mercury, the remainder put into glaſs veſſels, and evaporated by heat: a maſs of gold was left, but part of it being accidentally loſt, its weight could not be aſcertained; it did not amount to above two or three grains at moſt.

The powder, waſhed off and dried, weighed 134 grains: theſe, mixed with as much litharge, and four times their weight of fixed vegetable alkali, and one fifth of wheat flower, and the whole melted produced a regulus of lead, weighing 80 grains, which, on coppelling with a few grains of ſilver, and parting in *aqua fortis*, left one ſixteenth of a troy grain of gold.

It is to be remarked, that in great works, where gold is ſeparated from pieces of crucibles, ſand, or other matter, by amalgamation, notwithſtanding the proceſs be

frequently repeated, and with great care, ſome ſmall portion of the gold ſtill remains; ſo that the ſmall quantity left in this caſe might eaſily have either eſcaped the mercury, or, have been left unobſerved in the powder combined with ſmall particles of it.

We may therefore conclude, that in this ore the gold was in its native form, and not mineralized.

EXP. III. We examined gold pyrites mixed with quartz, with a deep magnifier, and found evidently native gold interſperſed. One hundred grains of this ore, was powdered; and boiled in nitrous acid diluted with water: a ſolution of iron took place, as in the firſt experiment. The *reſiduum* being expoſed to a red heat, there was no appearance of ſulphur; the gold was found in ſuch large particles, and ſo ſimilar to native gold, that we did not think it worth while to apply mercury.

The gold being diſſolved out by *aqua regia*, a quantity of quartz and arſenical ſalt was left.

EXP. IV. When gold and ſilver are found in their metallic form, it is not uncommon to find them mixed; but it ſeldom occurs, that they are mixed in ſo large proportion as in an ore obtained from Norway, and which was given to Dr. HUNTER, by Mr. FABRICIUS.

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The ore has the appearance of native ſilver, in ſcaly particles, intermixed with a hard quartz, tinged brown in ſome parts by iron. Twenty-five grains of the maſs, where the metal was in the largeſt proportion, melted with litharge, alkali, and phlogiſtic matter, and afterwards coppelled, yielded a globule apparently ſilver weighing two grains which, being boiled in nitrous acid diluted with water, left full nine ſixteenths of a grain of fine gold. Hence one hundred pounds of metal obtained from this ore, conſiſts of ſeventy-two pounds of ſilver, and twenty-eight pounds of gold.

There is an ore of ſilver which is commonly called vitreous (*minera argenti vitrea*, or *argentum vitreum*).

This ore has always been ſuppoſed to conſiſt of ſulphur and ſilver; becauſe, if we melt ſulphur and ſilver together, they form a maſs which reſembles it, eſpecially in colour and malleability; but, as we could find no experiment in any author which authorized this conjecture, we determined to endeavour to aſcertain it by analyſis, Dr. HUNTER not refuſing to ſubject the ore to an aſſay, although ſcarce and expenſive.

EXP. V. Fifty grains of this ore broken in pieces, for it is too malleable to be powdered, were boiled in nitrous acid diluted with water; the acid diſſolved the ſilver with much difficulty, and left a *reſiduum*. The ſolution being poured

poured off, and the *reſiduum* waſhed and expoſed in a glaſs matraſs to a red heat, there was no ſublimate of ſulphur, or any thing elſe obtained. The *reſiduum*, before it was expoſed to heat, did not appear to contain any ſulphur; being of a blackiſh colour after expoſure to heat, it had a number of yellow particles mixed, which eaſily diſſolved in *aqua regia*. Tin being applied to the ſolution made no precipitation, which it would have done if thoſe particles had been gold; hence we ſuppoſed they were iron.

The ſilver was precipitated from the acid by copper: waſhed and dried it weighed four grains, which, on coppelling with lead, loſt one twenty-fourth.

There were particles of powdered quartz apparently mixed with the yellow particles left after the ſolution.

EXP. VI. Being much diſappointed in not finding any ſulphur in the former experiment, we took three hundred grains of the ſame ore. We freed it as well as poſſible from heterogeneous matter: we mixed it with four times its weight of mild fixed vegetable alkali, put them into an earthen body, to which was affixed a glaſs head, and expoſed them to nearly a white heat in a naked fire for a full hour and an half; but no ſublimation took place, there diſtilling only a few drops of water. We then put the body into a melting furnace, and rendered

the whole fluid; as ſoon as it was melted, it was removed from the fire.

The maſs, on concreting, was found divided into two; a black maſs a-top, and a metallic maſs at bottom. The metal being aſſayed by ſolution in nitrous acid and precipitation with volatile alkali, ſhewed no ſign either of gold or copper; loſt nothing by coppellation with lead; it weighed 213 grains, which were pure ſilver.

The black maſs a-top, or *ſcoriæ*, was boiled repeatedly in water, but did not all diſſolve. The inſoluble part was unfortunately thrown away; but to the ſolution we added muriatic acid: on the addition of the acid, there was a ſtrong ſmell of *hepar ſulphuris*, and a copious precipitate, which, on being examined by a microſcope, appeared to conſiſt of pellucid cryſtals, without the ſmalleſt appearance of ſulphur. This precipitation, being expoſed to heat, did not ſmell in the leaſt like ſulphur; it was not in the leaſt inflammable. Excepting then the ſmell of *hepar ſulphuris*, there does not appear any mark of ſulphur in this ore, and a very ſmall particle of inflammable matter dropping in by accident would give this ſmell.

The foregoing experiments occaſioning ſome doubt of ſulphur's being contained in vitrous ſilver ore, we endeavoured to inveſtigate it by other means; and after ſeveral

experiments,

experiments, we made the following one, which ſeems concluſive.

Half an ounce of ſilver was precipitated from nitrous acid by copper, in ſmall flaky cryſtals as uſual; being waſhed and dried, it was mixed with the ſame weight of ſulphur, and put into a crucible, over which another was placed ſo as to cover it, and the two crucibles were luted together, leaving a ſmall aperture for the eſcape of vapour, but not ſo as to admit air for the inflammation of the ſulphur. Theſe being put into the fire, as ſoon as they were heated red-hot, the ſulphur in part eſcaped through the ſmall hole, and as it paſſed through burnt with a blue flame. The fire was increaſed to a ſufficient degree to melt the maſs within; in the mean time the blue flame diſappeared, which ſhewed that no more ſulphur eſcaped.

After we had applied heat enough, as was ſuppoſed, to melt the maſs, the crucibles were removed from the fire, and being ſeparated when cold, a regular button-like maſs was found in the crucible, of a dark lead colour both without and within, brittle, and ſtreaked on the inſide, bearing to be cut with a knife, exactly like the vitreous ore, which it in every way reſembled. The whole maſs gained twenty grains or one twelfth in weight, which may be conſidered as the true weight of the ſul-

phur in this compound, as ſilver combines with ſulphur in its metallic form, without loſing its inflammable air. Fifty Troy grains of this compound was powdered with difficulty, from its toughneſs, and boiled in nitrous acid diluted with water; it diſſolved with difficulty, leaving a very ſmall quantity of a light blackiſh powder, certainly not nearly a grain in weight.

It appears, therefore, that the ſmall portion of ſulphur contained in the vitreous ore may have been decompoſed by the nitrous acid, and the alkali, or the heat, in the former proceſſes; and we may conclude, that vitreous ſilver ore is a compound of ſilver and ſulphur, and when pure, that it contains between ninety-two and ninety-three grains of ſilver in one hundred.