Man, Metals and Magic: The Ancient History of Metallurgy

"1400 B.C. - 500 B.C."

Chapter III

Iron – ***"the most deadly fruit of human ingenuity"***

By 1400 B.C. the arts of metallurgy, pottery and agriculture were well advanced compared with scientific knowledge. It was generally believed, for example, that the earth was rectangular and the sky held up by mountain peaks; that the stars hung by ropes from the sky, and the sun floated round the earth on a never ending river cruise. And, widening the discrepancy between the lack of understanding of the natural sciences and the advanced state of metal culture, iron began to assume an ever-growing importance – iron, "the most deadly fruit of human ingenuity." But even before 1400 B.C. its use had not been entirely precluded by any lack of "human ingenuity," because some remains of iron date as far back as 4000 B.C. For, although iron may not have been smelted until much later, and although it does not occur native like gold and copper, primitive man was provided with small amounts of iron from other than terrestrial sources.

Despite several recorded falls of celestial iron – meteorites – throughout the ages, many scientists until the 19th century were rather embarrassed and ashamed to have to admit the possibility. Then in 1803, there was an obligingly spectacular downfall of meteorites in Normandy, which was sufficiently uncompromising to convince most of the doubters. So, although there is no truly native iron produced on earth, pieces of the metal have been hurled at us and may have been discovered by primitive man.

The presumption that primitive peoples used meteoric iron as a rare and valuable material is substantiated by an analysis of their metals. While archeologists, understandably, do not encourage metallurgical analysis of their finds, early irons that have been investigated show a high nickel content, which is peculiar to meteoric irons and is not a characteristic of iron made directly from ores found in the earth's crust. This high nickel content also goes a long way toward explaining the good state of preservation of most of these old articles – an effect of the presence of nickel, which was profitably rediscovered thousands of years later. Such iron could be hammered and worked just like native gold and copper, and it became harder than either of these. But it was much more highly prized, largely on account of its rarity and because it was more obviously "heaven-sent" than other metals.

In support of the idea that early iron was meteoric in origin it may be pointed out that religious and other ancient writings frequently associate iron with the heavens. Further, later developing civilizations, when explorers from more advanced civilizations first discovered them, were reported to know and use meteoric iron. The inhabitants of South America, for example, had not learned how to smelt iron when the Spanish subjugated them, but they made some implements from the iron of meteorites. And the Eskimos relied upon meteoric iron until as late as the 18th century, when European trade provided them with the smelted material.

On the other hand, it is argued that as iron ores occur very widely, and since the metal is easy to produce from them, it is likely that iron smelting began as soon as copper smelting, or perhaps before. But the smelting of iron is really not so simple. Or at any rate, although it may seem to be today, it would most certainly not have been to primitive man, for a temperature far higher than that achieved in his crude hearth is necessary to make iron that looks anything like a metal.

When the simple smelting process as it has been described is applied to iron, it yields only a spongy material without any metallic properties or obvious use. It is quite possible that, like copper, iron was produced accidentally many times in the campfire, but, as it completely lacks luster, it may have gone unnoticed repeatedly. To transform it into a useful metal it is necessary to forge it. That is, the spongy lump has to be hammered and reheated alternately until most of the slag associated with it has been squeezed out. This produces wrought iron, a material, which until the introduction of cheap steel in the 1870s A.D. was of first-rate importance, and today still has valuable, but limited, applications. But it is difficult to imagine so elaborate a process being conceived or practiced as early as 400-300 B.C., and irons which pre-date 1400 B.C. do not exhibit the structure that is characteristic of wrought iron. On the contrary, their analysis implies a meteoric origin. However, comparatively few prehistoric irons of this antiquity have been examined so the second argument has less force than it might have.

Another argument that has been put forward in support of early iron smelting is that much of the stone masonry of pre-1400 B.C. could hardly have been achieved with copper or even bronze tools. If one answers the exponents of this point of view by suggesting that primitive man was more patient than we are, and that, although the process would be tedious, it would not be impossible to carve stone with bronze chisels, they reply most defiantly: “Try it.” It is doubtful, too, whether meteoric iron occurred in such profusion as to allow its use for such a commonplace purpose as a carving stone. Another argument is that the only answer (an unsatisfactory and dangerous one) is that these early people had very much more patience, and perhaps a little more ingenuity than that with which we credit them. Of course, if we allow them enough ingenuity to carve stone in a way we cannot image now, more than 6000 years afterwards, perhaps we should credit them with sufficient inventiveness to smelt iron.

The fact that the few remaining iron implements that antedated 1400 B.C. are of a composition that implies meteoric origin does not allow any conclusions to be drawn on this subject, for ordinary man-made wrought iron -- except under the most artificial conditions even more preservative than the static dry atmospheres of Egyptian tombs – would rust away in a comparatively short time.

However, even if one insists that iron was made as long ago as 4000 B.C. it is not until about 1400 B.C. that its use begins to assume importance, and for that reason alone, it seems quite justifiable to suggest that this date marks the beginning of the Iron Age.

Probably the earliest known man-made iron article is a dagger blade found in the tomb of Tutankhamen, which was placed in such a position as implies that it was a most treasured possession. The dagger dates from 1350 B.C., while only 50 years afterwards there is the first known recorded reference to man-made iron. The reference is in a letter written a little after 1300 B.C. by the King of the Hittites, and is of a “sorry-for-the-delay” type, of which he may have been the originator. He wrote to the Egyptian Pharaoh, Rameses II . . . “*there is no good iron in the house of my seal at Kissuwadna, for it is a bad time to make iron. I have written ordering them to make good iron, but so far they have not finished it. When they do, I will send it to thee. Behold! Now I am sending thee an iron dagger blade!*”

The letter from the King of the Hittites is said to indicate that while iron was probably in very short supply, and that the art was confined to limited areas, differences in material quality were already appreciated. It seems more probable, however, in view of the unsettled relations between the Hittites and the Egyptians, that the reference to “a bad time to make iron” was simply a political excuse. Only later civilizations have been sufficiently sporting to provide their enemies with arms.

To those of us who have no more than a general acquaintance with the affairs of the Ancient World, the origins of iron making seem to be wrapped in an almost impenetrable obscurity. The Hittites, between 1500 B.C. and 1400 B.C. were becoming increasingly powerful, due largely to their early knowledge of iron. Whether they discovered or only learned the art of iron making at second hand is questionable. It has been supposed for a long time that the art originated somewhere in the mountainous country to the south of the Black Sea, and this is substantiated by the fact that suitable iron ores are found there. A study of the nature of the remains of early iron objects has indicated that appropriate ores were available in the foothills of the mountains to the southeast of the Black Sea, which was dominated by the Hittites. Further, this belief is supported by legend, and together they indicate that iron was first made in the valley of the River Halys, which flows from the mountains to the Black Sea.

The Hittites traded their metal to the Palestinians, for implements have been discovered in Gerar, which are believed to date from about 1350 B.C. Within a hundred years or so, the art of iron making had been either learned or discovered in Palestine. Furnaces dating to 1200 B.C. have been unearthed at Gerar, together with iron objects that were made there.

We can summarize by asserting that iron was first made in the north of the Ancient World – a belief that is not without its romance, for copper smelting was introduced into Mesopotamia by settlers from the north. No one knows where these settlers came from, and no one is positively certain where iron was first smelted, nor can the position be contradicted that both originated somewhere in that mountainous country between the Mediterranean and Caspian Seas.

The way in which these old metallurgists made their iron can only be surmised from the type of metal they produced, and from the methods used by later primitive peoples whose techniques are more adequately recorded in history. In all probability they had discovered the value of building a deeper hearth, either by digging a larger hole or by making a cylindrical clay wall around an existing hearth, and so produced a higher temperature and more metal. Charcoal and ironstone were charged on a lighted fire, and a draft was induced by bellows, which blew air through clay tubes inserted near the bottom of the charge. After many hours had elapsed, during which more charcoal may have been added, the furnace was cooled sufficiently for the spongy metal to be removed -- dirty, unmetallic in appearance and contaminated with clinker and gangue. Therefore, only the cleaner portions were selected, and forged by alternately heating and hammering them. One can only presume that, in the very earliest days of iron making, the hot metal would be handled with green wood tongs or stones, and hammered with a heavy stone. In doing this, adherent impurities would detach themselves and the pockets of earthy slag would be strung out. This improved the mechanical properties enormously, for while a lump of slag produces a region of weakness and consequently results in easy fracture, strings of slag do not cause such a local rift in the metallic structure. Further, the forging operation reduced the sponginess of the metal, and after sufficient working, the iron could be hammered while still hot into suitable shapes.

The operation of forging, then, necessitated heating and reheating the iron in a charcoal fire – a process that inevitably resulted in the outside of the metal absorbing carbon. When one is first confronted with the fact that a hot, but solid, element may take into its structure a second element, the concept can be difficult to accept. But solid diffusion of this kind does indeed occur. In fact, it plays a crucial part in all aspects of metallurgy, including heat treatment of modern steels, when carbon atoms diffuse to produce one of many characteristic structures, when oxide ore is reduced in the blast furnace to metal before the charge becomes molten. Then, in the production of the duralumin types of alloys, it is a diffusion of atoms of a number of elements within the metal that produces the effect of “age-hardening” and, consequently, the vital properties of the alloy.

The classic experiment, which illustrated solid diffusion, involved clamping together a flat surface of gold and copper. After many years had elapsed, analysis showed that the copper had become contaminated with gold and *vice versa.* Heating a metal weakens the bonds that hold its atoms together, and so diffusion is quicker at higher temperatures. Yet, although the effects of diffusion are well known, its mechanism is not always clear, and a complete understanding would probably solve many problems that confront the metallurgist today.

But, to return to 1200 B.C., or thereabouts, it was inevitable that carbon should be taken into the outside of the forged iron. Now steel is essentially an alloy of iron with up to about 1.5% of carbon. As this is the kind of material that was produced at the surface of forged iron, it is often suggested that as early as 1200 B.C. steel was being made. This is a misleading and almost improper suggestion, for steelmaking involves the production of a uniform, homogeneous material, which this certainly was not.

The old iron maker was in effect inadvertently case hardening his iron in a way that is very similar to modern case hardening processes for steel. But to suggest that he was *making steel* would be as incorrect as to assert that the baby thrashing the piano next door is making music. What is more, he did not at first realize that it was heat rather than the hammer causing the hardening. It was not until 3000 years later that the part carbon played in the operation was appreciated. But whether the process was understood is of minor importance. The fact of over-riding importance is that at last man had at his disposal a powerful material whose potential uses were almost without limit, as future years were to show.

Within a few centuries it was discovered that quenching carburized iron made it considerably harder still. This knowledge was later used to advantage by the Greeks and the Romans. The inferiority of wrought iron weapons was shown as late as 220 B.C. when, in a battle between the Romans and the Gauls of Insubres during the early part of the Roman conquest, the

Gallic swords of iron bent so easily that they had to be straightened after the first thrust. The Romans took advantage of this, and after taking the first thrust on their spears and armor, they attacked and beat the Gauls who were bent on straightening their weapons.

The discoveries made in Gerar (Palestine) show by their variety that iron was beginning to have its first real uses. Just as bronze replaced stone, so did iron begin to replace bronze, and further, many additional uses were gradually found for the metal. At Gerar site knives, hoes, sickles and other agricultural tools were discovered, and no doubt the Palestinians were well pleased with their new metal. But it could not be cast, and production of molten iron, except perhaps accidentally, did not begin until more than 2000 years had passed.

While the Hittites were exploiting their knowledge of iron making, both in trading and in waging war, the use of bronze spread through Europe as far as the Baltic. Progress in European bronze culture is shown by developments in the designs of axes and swords. The Baltic countries, in the 12^{th} century B.C. produced gold and bronze of exceptional quality and became wealthy lands. They traded with other parts of Europe, but presumably had no need of overseas markets. After the never-very-extensive bronze importations from Span ended, Britain made more use of her own tin deposits in Cornwall. Ireland, which had no tin, traded in its' gold and regular trade between Britain and Ireland opened up.

In an account of this kind, leaps must be made either in space or in time, depending upon the review being geographical or chronological. So, jumping across to the Middle East again, we find the Hittites suppressed. History shows repeatedly that it is a country's own power, which so often results in its destruction, for power breeds enemies. The Hittite empire in Asia Minor was no exception, for in 1200 B.C. it was destroyed. Egypt, which was weakened after its spectacular building enterprises under Rameses II, was in the power of a priesthood that, whatever effect it had upon the country's morals, had a detrimental one on its metallurgical progress. The whole of the Middle East, which up to this time had led the world, was in a state of turmoil.

As a result, China, the Baltic States and Europe began to catch up culturally, while the rest of the civilized world marked time. Iron made a cautious entry into parts of Europe and the Baltic and its use slowly began to supersede that of bronze. In China, the renowned Chow Dynasty had begun, and while iron was not introduced, as far as one knows, for another 400 years, the Chinese civilization temporarily prospered and the most beautiful bronzes were made for domestic use.

For purposes of this account, only historical events that bear upon metallurgical development will be included. Thus, the next few hundred years can be skimmed over lightly, for we have seen already that the use of bronze spread over most of the then known world, and that by 1000 B.C. iron was beginning to be known. As future years showed no comparable achievements, they will be dealt with only briefly.

The early Iron Age in Central Europe is usually divided into two convenient phases. The first, the Hallstatt Period, is named after the center of the salt industry that existed at Hallstatt, Austria. Because the salt industry was important in an essentially agricultural community, the spread of culture quite naturally developed around it. Evidence of this was found in 1846 A.D. when a prehistoric cemetery was unearthed, with its earlier bronze weapons and later iron axes and swords. Hallstatt culture penetrated into many parts of Central Europe sooner or later and spread northwestward. The period ended in Central Europe about 400 B.C. when Hallstatt was no longer the focus of development and industry, and the second phase began. The La Tene phase was not marked by any striking metallurgical advance, but rather by a characteristic difference in style. In France the use of iron followed later, and in Britain later still. Even so, iron making was fairly widespread at the time of the Roman landings in Britain in 55 B.C.

Turning eastward again, there were some significant changes. Brass (an alloy of copper and zinc) was discovered, presumably accidentally, at some time during the period under review. The exact date of the first brass to be made, like its location, seems to escape accurate definition. Dates from 1600 B.C. to 600 B.C. are cited. Persia, China and Palestine are most commonly accorded the honor of being its birthplace. The discovery of brass must have been as fortuitous as that of bronze, for zinc ores when smelted alone produce zinc vapor, which becomes oxidized. The product is not a metal, but a scattered white powder. When, however, zinc ores and copper are smelted together the copper, producing the alloy brass, absorbs the zinc vapor. It was probably under these circumstances that the early articles were made. Perhaps its' value was not appreciated, or the method by which it was made could not be repeated, for there is no indication that the alloy was used much or even known, apart from a few instances, until the time of the Roman Empire, when brass currency was introduced.

Roman currency was not, however, the earliest system. The first reliable one evolved in Lydia, in the Aegean, where a standard alloy of gold and silver (electrum) was used and stamped, in about 700 B.C. This encouraged the trading that had already become well established in the Aegean region, where the valuable line of harbors in Phoenicia assumed great importance in the centuries subsequent to the downfall of the Hittites.

Phoenicia was a powerful country, and from the 12th century B.C. the Phoenicians and later their successors, the Carthaginians, controlled the mines in Spain until the time of Roman domination. They traded with Britain, and it is very possible that they bartered for Cornish tin ores, which like their mineral deposits in Spain were to be governed by the Romans. That the Phoenicians traded with Britain for tin ores is controversial. They, as had others before them, obtained tin from what Herodotus in the 5th century B.C. was the first to call the Cassiterides, or tin islands. The whereabouts of these islands is not at all certain. The matter is confused by the fact that the Phoenicians endeavored to mislead the Romans as to their source of metal. Hence, Roman records on the subject are not reliable and there is little other evidence of the routes that were followed or the subsequent destination. It seems possible that the Cassiterides were, in fact, Cornwall. While Cornwall is not an island, geographers of that period had a carefree recklessness not found among cartographers today. It is also possible that adjacent islands (now the Scilly Isles) were included among the Cassiterides, although they would probably yield little ore.

It should also be recorded in this period that China began to make her own iron about 700 B.C. Her increased resourcefulness had little effect until 500 years later when the Chinese Empire dominated the East as the Roman Empire dominated the West. Meanwhile, however, in Greece, after the defeat of the Persons in 500 B.C. there came the welcome beginnings of scientific thought.

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