

CHAPTER 1

MAGNETISM, FROM THE DAWN OF CIVILIZATION TO TODAY

The historical approach of this chapter introduces qualitative ideas which will be reconsidered and analysed in later chapters. The great adventure of magnetism has progressed, slowly at first, following the pioneers who lived long ago at Sumer, in China or in Greece, while the last two centuries have witnessed an explosion in knowledge, investigative techniques, and industrial applications in this model domain of Science. In 1779, the Encyclopædia of Diderot and d'Alembert [1] still said about magnetite:

*“It is in this metal married with salt and oil
rather than in stony substances
that resides true magnetism”*

We have come a long way in the years that followed... !

1. THE DISCOVERY OF LODESTONE AND THE OBSERVATION OF MAGNETIC PHENOMENA THROUGH THE AGES

The oldest manuscript that mentions the existence of lodestone is the work of a Chinese writer, Guanzhong (died 645 BC), but objects made from magnetic materials have been found in archaeological sites dating from much further back.

1.1. OBJECTS MADE FROM IRON AND LODESTONE IN ANCIENT TIMES

Small tubular beads made from iron of meteoritic origin (containing at least 7.5% nickel) were discovered in many Sumerian and pre-dynastic Egyptian tombs (fourth millennium BC). These appear to be the oldest traces of ferromagnetic objects wrought by human hands. The question remains, however, as to whether their “attractive properties” had been discovered in these distant times. The ancient Egyptians, who

called iron *bia-n-pet* (= metal from the sky), did not study the metallurgy of iron until relatively late, and certainly after the Hittites, who did so about 1500 BC; the tomb of Tutankhamon (1340 BC) already contained a dagger and various other objects made of iron and iron ores [2]. Much later, in the temple of Edfu, an inscription mentions “living metal”: this was the expression of the ancient Egyptians for lodestone [3]. In Crete, at the palace of Knossos (2000 BC - 1300 BC), the throne room of Minos is paved in the centre with a rectangular flagstone made of iron oxide, consisting mainly of magnetite. Perhaps this was not a random choice, it is possible that the ancient Cretans understood its magnetic properties, which could justify its presence in such a central part of the palace.

1.2. THE FIRST TEXTS DEALING WITH LODESTONE. ORIGIN OF THE NAME “MAGNETISM”

All our information on the origins of magnetism in China were taken from the Chinese work *The History of Electromagnetism* [4] as well as from a recent work by M. Soutif on the origins of Science and Technology in the East [5]. We know from Guanzhong that, in ancient Chinese civilization, lodestones were called “**soft stones**”. This is the general name of all strongly magnetic oxides existing in nature and having a permanent magnetic character. They are the magnetic minerals based on iron: $\gamma\text{-Fe}_2\text{O}_3$, $\text{FeO-TiO}_2\text{-Fe}_2\text{O}_3$, sometimes also FeS_{1+x} , and especially *magnetite* Fe_3O_4 . The name “soft stones” is due to their attraction for ferrous metals, in analogy with the tenderness that a mother shows her child.

At the time of the Eastern Han dynasty (25 - 220), Gaoyiu wrote: “Soft Stone is the mother of iron, it can therefore attract its child” [4]. This text leads us to think that iron had already been extracted from magnetic ores. Habits have changed today, magnets are known as “**hard**” magnetic materials as opposed to “**soft**” magnetic materials which demagnetise spontaneously!

In Greece, Aristotle reported that Thales of Miletus (625 BC - 547 BC) knew lodestone, and Onomacritus provides us with the most ancient name known, *magnetes* which evolved into *magnitis*, from which derives the modern term magnetite. Sophocles (495 BC - 406 BC) called lodestone “Lydian rock” while Plato (427 BC - 347 BC) called it “Heraclitian rock” in his work *Tinaeus*. These various names suggest that, in Greco-Roman antiquity, the first magnets were made from ores found at mount Sipylus, close to a town in Asia Minor named “Magnesia ad Sipylum”. This town name is the origin of the words “magnetism” and “magnetite”. Lucretius confirms in *De Natura Rerum* that the name for lodestone comes from the region where it was extracted. The Latins used the word *sideritis* [1], derived from the Greek word for iron, *sidèros*, which seems to have the same root as the Latin word *sider* meaning *heavenly body*: once again, we come across the belief that iron is of celestial origin, a belief also held by the ancient Egyptians.

1.3. FIRST OBSERVATIONS OF MAGNETIC PHENOMENA

1.3.1. Magnetic attraction

It seems that magnetic attraction was the first magnetic phenomenon to draw the attention of man to “lodestone”, since the Chinese name “soft stone” comes from this attraction, as does the name that Hippocrates (460 BC - 377 BC) gave it in *Lib. de sterilib. mulier: the rock that attracts iron*. At the same time, in China, Gui Guzi (400 BC) noticed that rock magnets attracted needles, while Liu An (120 BC) wrote in *Huai Nanzi*: “It is impossible for lodestone to attract tiles as it attracts iron; and the same for copper”. Thus, from the very beginning, this mutual attraction was considered as a specific property of iron and its ores.

1.3.2. Magnetic shielding

Saint Augustine (354 - 430) noted that a silver plate could not stop lodestone from attracting iron. Later the question arose whether there existed a material capable of preventing the attraction of a magnet for iron; the *Notes of Guang Yang* gave the reply: “A Ru, son of Liu XianTing (1648 - 1695), had the intuition, and he then experimentally verified, that only iron could act as a shield effective against this attraction”. This is the first mention of magnetic shielding.

1.3.3. The compass

The Chinese writings of Gui Guzi and Han Fei (280 BC - 233 BC), showed that the orientation of natural lodestone towards the earth’s geographical poles had also been known for a very long time. The oldest “directional tool” known was made in China: it was a natural lodestone sculpted and polished into the form of a spoon. This “directional spoon”, the ancestor of the compass, was described by Wang Chong (27 - 97) in *Lun Heng*: “This instrument resembles a spoon, and when it is placed on a plate on the ground, the handle points to the south”. On an etching dating from the Han period, we see a spoon placed on a small square tray (fig. 1.1-a), very similar to the trays made from iron-copper alloys, and painted wood which were recently exhumed by archaeologists. It is commonly accepted that this is a painting of a directional instrument.

The interest in these early directional instruments was limited by the rarity in supply of the materials, the need to polish them, and their directional inaccuracy. It was in response to the needs of “geomancers” (commissioned to select the orientation of palaces and towns), soldiers and navigators that artificially magnetised needles, the directional fish, and then compasses evolved.

Zeng Gongliang described the fabrication of a *directional fish* in his *Wu Jing Zong Yao* (1044): “We cut a very thin piece of iron into the shape of a fish... We make it red hot in a coal fire, and then retrieve it with tongs. The tail remaining oriented towards the north, we quench it in water for a few minutes”. This process constitutes a quench under magnetic field (the earth’s field), which reinforces the magnetism and