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EXAMINATION OF SAMPLES FROM METALLIC MATERIAL FROM LES ECUREUILS, QUEBEC

by

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SUMMARY

Samples have been examined from a large piece of ferrous material, found at Les Ecureuils, Quebec, in 1960, and thought by some investigators to be extra-terrestrial.

The piece was found to have two major components, one magnetic and one non-magnetic. The former was a 0.2% carbon, low-chromium steel containing boron; the latter was a low-chromium austenitic manganese steel. Microstructures and hardness measurements were consistent with the analyses.

From the shape of the piece, the composition, and structures of its constituents, it is concluded that the piece was most probably produced in a foundry by dumping excess metal from ladles into a hollow in sand, a process known as "pigging".

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INTRODUCTION

Samples have been examined from a large piece of ferrous material, found at Les Ecureuils, Quebec, in June 1960. The material is thought by some investigators to be of extra-terrestrial origin, either meteoric or from a space vehicle, since it was found shortly after the reported sighting of a large meteorite-like object in the sky. Several examinations, most of them limited in scope, have been made on samples from the main piece and conflicting results have been obtained. An investigation by CARDE at Val Cartier, Quebec, concluded that the metal was of terrestrial origin and was a manganese steel. But doubt has persisted and the material has been widely quoted as being of extra-terrestrial origin. This report has been prepared at the request of Dr. P. M. Millman, of the Upper Atmosphere Research Group of NRC, to try to clear some of the confusion surrounding the material.

THE MAIN PIECE

The main piece was found on the tidal flats of the St. Lawrence River at Les Ecureuils, Quebec, in June of 1960. It is now in the possession of members of the Ottawa New Sciences Club. It is metallic, roughly saucer-shaped, about 4 feet across, with a flat top and very rough edges and bottom. The whole is very rusty and has many small particles adhering to it. It is reported to weigh about 3,000 pounds. No precise measurements of size or weight were made. The following points were noted:

1) There is what appears to be a piece of pipe about 10 inches in diameter embedded in the centre of the piece and projecting from the top surface. There is a smaller object like another piece of pipe next to it.

2) The structure of the piece is layered. There are two principal interpenetrant layers, one magnetic, the other non-magnetic. There are numerous thinner layers, mainly of non-magnetic metal.

3) The non-magnetic material hardened considerably when sawn with a hacksaw, but it was possible to saw it by avoiding dragging the saw blade across the metal on the return stroke. This behaviour corresponds to that of an austenitic manganese steel and is in keeping with some of the previous analyses. The magnetic metal could be sawn without difficulty in the normal way.

4) Pieces of both layers were knocked off the main piece with a sledge hammer. The fracture surfaces of the two layers were different, the magnetic metal showing much larger facets than the non-magnetic layer.

5) The main piece is very similar in appearance to the residues produced in foundries when, after a mould has been filled, the excess metal remaining in the ladle is dumped into a hollow in a bed of sand, so that it will not solidify inside the ladle. This treatment is commonly known as "pigging". The rough bottom and edges of the piece are similar to surfaces produced by molten metal penetrating sand. In addition, it is common to put a piece of pipe or rod in the hole before the metal is poured in, so that the solidified mass can be lifted more easily by a crane. The disposal of residues from several ladles would produce a layered structure.

Other foundry residues from furnaces or ladles, known as "skulls" could have similar shapes but are commonly more nearly basin-shaped.

EXAMINATION OF SAMPLES

Chemical Compositions

Metallic Samples

Compositions of samples from both magnetic and non-magnetic layers were determined using spectroscopic, chemical and electron microprobe analysis, and metallography. Three samples from each layer were examined though not all were analysed completely, the main purpose being to examine the homogeneity of the layers.

Compositions of the two layers are listed below.

Elements	Magnetic (%)	Non-Magnetic (%)
Fe	84.70	96.30
C	1.06	0.22 (see below)
Mn	12.37	0.72
Si	0.40	0.24
S	0.01	0.035
P	0.03	0.025
Ni	0.07	0.09
Cr	0.75	0.34
Cu	0.10	0.10
Sn	0.01	0.03
Trace Elements less than 0.01%	Co, Al, Nb V, Mo, Pb	Co, Mo, V, Al Ti, Nb, B

No magnesium was found in the steels. The analyses were made for all elements likely to be alloyed with iron. The iron content quoted is a measurement and is not determined by difference. The fact that the total percentages do not add up to 100% is due mainly to errors in measurement of the iron content rather than the presence of another element. The greatest error would be expected in the magnetic material where the presence of pearlite causes low readings for iron.

Some variations in composition were found within the samples, mainly in measurements of the carbon content of the magnetic metal. Values varying from 0.15% to 0.4% were found. The reason for these variations is that the cast structure contains large ferritic and pearlitic areas, either of which would have a major influence on a carbon analysis made over a small area, the ferrite giving a low and the pearlite a high reading. These errors show up especially if the microstructure is used to measure the carbon content since the area observed is small relative to the microstructural variations. Analysis of large areas and microstructural analysis of a specimen heat treated to give a finer homogeneous structure showed that the true carbon content was about 0.2%.

Variations in other elements was less than 10% of the amounts present for both magnetic and non-magnetic samples.

Neither of these analyses gives cause for surprise. The composition of the magnetic sample is similar to AISI steel specification 50B.20, a low-carbon, low-chromium, boron steel. Manganese steels are not given specification numbers but the composition of the non-magnetic material is within the specifications for Hadfield's manganese steel, namely 1.0-1.4% carbon, 11-14% manganese, 0.2-1.0% silicon. The amount of chromium most commonly found in manganese steels to which chromium is added is 1.5-2%, higher than the 0.75% in this steel. However, austenitic manganese steels containing less than 1% chromium are commonly cast by at least one foundry in the Province of Quebec. It is therefore reasonable to suppose that the non-magnetic material is a low-chromium Hadfield's manganese steel.

The trace elements found in both metals are typical of those generally found in steels. Boron is sometimes added to steels in small quantities to improve hardenability, and so is not truly a trace impurity.

X-ray Analysis

A sample of the non-magnetic metal was examined by X-ray diffraction and found to be austenite, i.e., face-centred cubic iron, as in austenitic manganese steels.

Scrapings from Surface

Some of the particles adhering to the outside surfaces of the samples were removed by scrubbing and scraping and the resultant powder examined by X-ray diffraction. The main constituent was a hydrated iron oxide as commonly found on the surface of rusty steel. There was also some silica present which could be accounted for if some of the particles adhering to the surface were sand grains.

Hardness of Samples

Hardness measurements made on the samples gave values of from 134 to 142, average 138 VPN (74 Rockwell B) for the magnetic material and 306 to 387, average 355 VPN (Rockwell C 36) for the non-magnetic metal. These values are consistent with the microstructures of the specimens.

Metallographic Examination

Samples of the metals from the two layers were polished mechanically and etched to show up their microstructures.

Non-Magnetic Metal

Figure 1 is an optical micrograph of the non-magnetic material. The microstructure is similar to that of cast Hadfield's manganese steel, consisting of equiaxed grains of austenite. At the grain boundaries are large irregularly shaped particles known as the "massive" form of iron-manganese carbide, $(Fe,Mn)_3C$. There are also needle-like particles of this carbide within the grains and at grain boundaries. In manganese steels the carbides are formed by precipitation on cooling of the cast steel. Their presence gives rise to intergranular fracture on impact, which is the way in which the steel fractured on being hit with a sledge hammer. In manganese steel used for high impact resistance, formation of the carbides is suppressed by quenching the steel from a temperature of about 1000°C (1832°F).

In some of the grains at the outside surfaces of the specimen there are fine parallel lines (Figure 2) typical of the twins formed when austenitic manganese steel is subjected to impact. These could be accounted for by the sledge hammer blows or general handling of the piece because no twins were found in the interior of the sample more than a few grain diameters from the outside surfaces. This, and the fact that the grains themselves were not deformed, indicate that the overall specimen had not been subjected to heavy deformation such as mechanical working and was still in the cast condition.

In the sample were very many inclusions of manganese sulphide and many gas holes, showing the metal to be of poor quality that might be expected of residues cast without care.

Magnetic Metal

The microstructure of the magnetic metal (Figure 3) has two major features: white acicular ferrite and dark pearlite, itself a lamellar eutectoid of cementite and ferrite. There are wide bands of ferrite at the original austenite grain boundaries that are responsible for the large bright facets seen on the fracture surfaces of the sample broken from the main piece with a sledge hammer.

This structure is typical of a cast, low-carbon steel. The grains showed no evidence of deformation.

A piece of this specimen was heated to about 900°C (1650°F) and allowed to cool in air. Its microstructure then consisted of the normal mixture of equiaxed ferrite grains and pearlite colonies typical of a normalised steel of carbon content about 0.2%.

The steel also contained many sulphide and oxide inclusions, more than one would expect in a good-quality steel.

Heating of Sample with Oxy-acetylene Torch

It has been previously reported that the metal burned in a peculiar way when heated with an oxy-acetylene torch.

A piece of the non-magnetic metal was therefore heated with a small torch and it was found that the metal melted quietly in the usual way. If the oxygen supply to the flame was turned down there was sporadic sparking caused by carburisation and entrapment of gas. With too much oxygen in the flame a large shower of sparks is produced as the metal is burnt by the excess oxygen and the oxides blown away by the force of the gases.

If there are cracks or cavities in the metal, which contain moisture, carbonates or hydroxides, or all three, the transformation of water to steam and decomposition of carbonates and hydroxides on rapid heating might cause small explosions. It is not known whether this could explain the effects reported previously since it was not possible to reproduce them. No evidence of magnesium has been found in the samples, so any effects due to its burning would not be expected.

SUMMARY AND CONCLUSIONS

Samples have been examined from a large piece of ferrous material found at Les Ecureuils, Quebec, in June 1960, and thought to be extra-terrestrial.

1. Layers of magnetic and non-magnetic metal were found in the piece. Both layers proved to be steels.

2. The magnetic metal had a composition similar to specification AISI 50B20, a 0.2% carbon steel with a small amount of chromium and containing boron.

3. The non-magnetic metal was an austenitic manganese steel containing less than one per cent of chromium. Similar steels are produced in the Province of Quebec.

4. The microstructures of both steels were typical of those found in cast metals. There was no evidence that the metal had undergone severe deformation.

5. Both steels contained numerous inclusions and holes.

From the above results it can be concluded that the metal is not meteoritic.

The two steel types found in the piece are in common use, the low-carbon steel as a structural or automotive steel, and the manganese steel in the form of castings for machine parts subject to heavy abrasion such as linings for rock crushers, ball mills or excavator buckets. The steels are not high-strength aircraft materials nor are they suitable for service at high temperatures. Because of their properties their use in aircraft or space vehicles is most unlikely because other materials are available that will better meet the conditions that can be envisaged in such structures.

From the shape of the piece, the layered structure and the composition of the steels, the most probable conclusion is that it is a foundry residue, produced by pouring excess ladle metal into a sand mould or, less likely, a furnace "skull". Its most likely source was a foundry in the Province of Quebec.

Though it is not possible to locate, for certain, the source of the material, there is nothing unusual about its composition or structure that would suggest that it is in any way extra-terrestrial and, unless some new startling independent evidence is uncovered, I feel there is little point in carrying out further investigations on the material in this laboratory.

Comments

The following comments are not a result of the examination of the material itself but result from discussions that have taken place on the subject. I feel they are pertinent in that they may help to explain some of the observations made on the piece.

1. Several people with foundry experience have virtually predicted the appearance of the piece on being told only a few details. One even stated that there would probably be a piece of pipe or rod in the middle.

2. There are several steel foundries on the banks of the St. Lawrence River and its tributaries, some of which advertise manganese steels among their products.

3. Furnace and ladle residues and "skulls" are usually sold by foundries since the cost of analysing and remelting them is greater than the value of the metal. The skulls usually go to a steel works where the impurities and many of the alloying elements, such as chromium or manganese, can be removed if required. At one location, on the Richelieu River, skulls have been dumped along the shoreline to reduce erosion. It has been found that, during the winter, the ice picks some of them up and a few have been carried downstream as far as the Ile d'Orleans below Quebec City. Further, isolated deposits of ice and snow, usually covered with mud and debris, can be found along the St. Lawrence as late in the year as June which is the month in which the piece was found. In view of this, it does seem possible that the piece could have been carried to Les Ecureuils by ice that melted or was washed away during the three rainy days prior to its discovery.

4. It seems that in previous analyses it was not realized that there were two steels with quite different compositions and this may have led to varying results. One result, quoted by Mrs. C. Halford-Watkins of Aylmer, Quebec, gives a manganese content of 11.3% while the carbon content, 0.16%, is very low for a manganese steel. The hardness quoted for the steel, Rockwell B94, is lower than the values found in this investigation, which may indicate that the steel had been partly decarburized. This is often found at the surface of manganese steel castings. The carbon content of 0.16% is actually closer to that of the magnetic metal. Further, it is difficult to see why a manganese steel with a carbon content as low as 0.16% should harden when sawn as is typical of manganese steels of high carbon content.

ACKNOWLEDGEMENTS

The author would like to acknowledge the assistance of Mr. B.G. Renaud and Mrs. V. E. Moore who prepared and analysed most of the samples.

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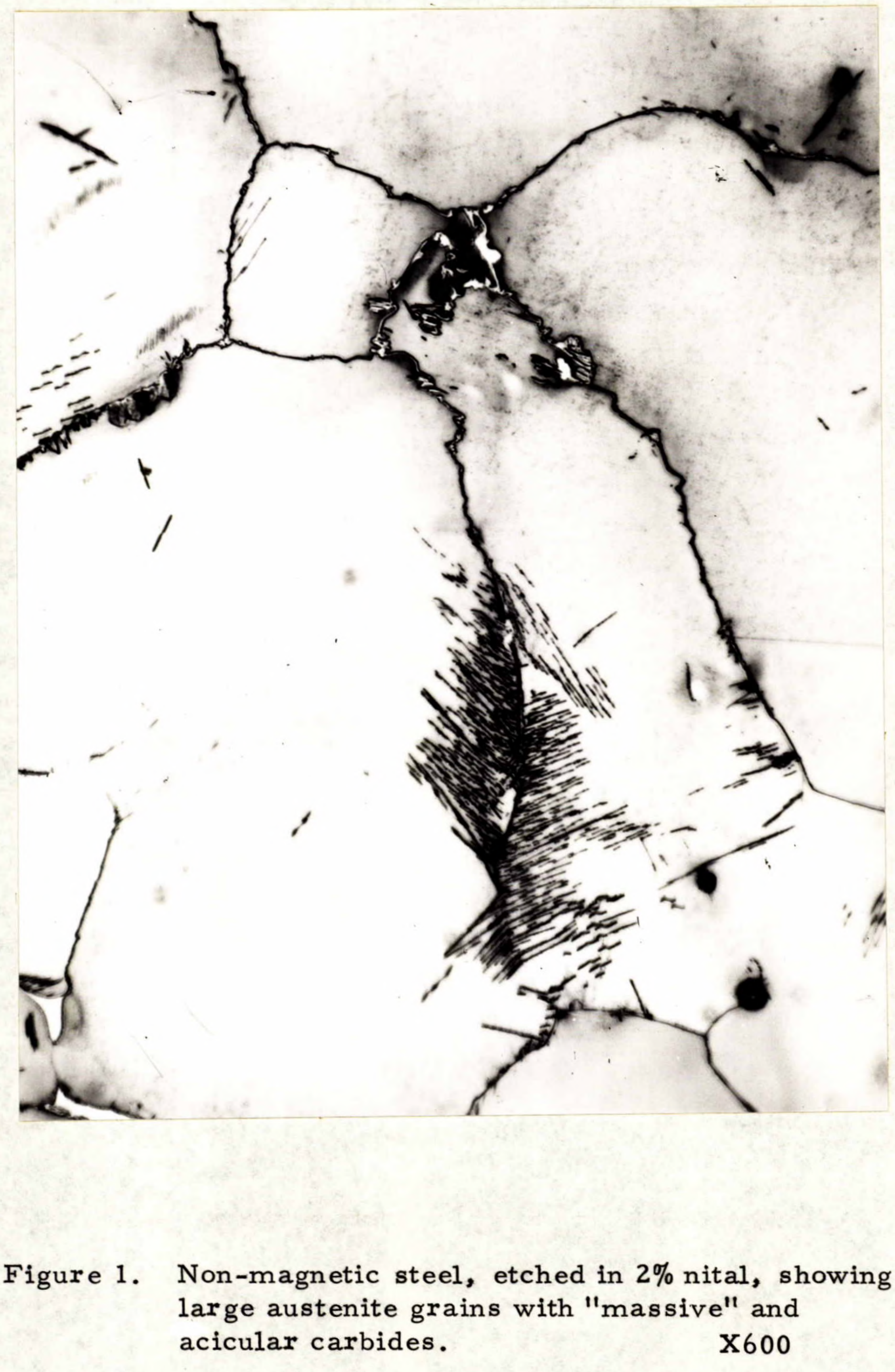

Figure 1. Non-magnetic steel, etched in 2% nital, showing large austenite grains with "massive" and acicular carbides. X600

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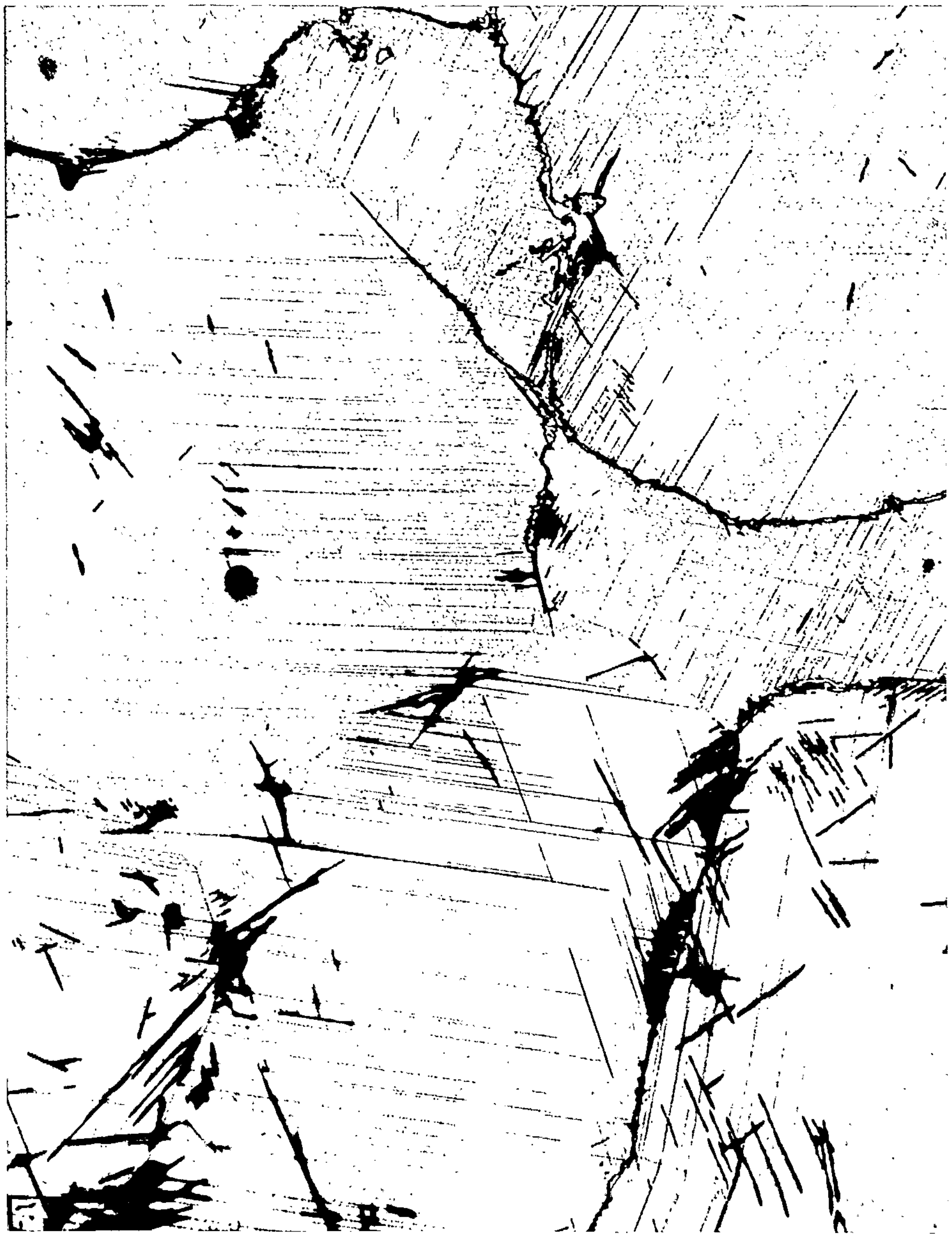

Figure 2. Non-magnetic steel, etched in 2% nital, Twin lines near edge of specimen. X600

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Figure 3. Magnetic sample showing white ferrite and dark pearlite. X600