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METALLURGICAL EXAMINATION OF KNIFE EXCAVATED FROM A MANITOBA MOUND BURIAL SITE (N.M.C. Cat. #XA-391)

by

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SUMMARY OF RESULTS

Metallurgical examination of a knife, excavated from a Manitoba mound burial site and held in the National Museum collection, was carried out to assist in dating and in tracing the origin of manufacture.

The knife was manufactured from steel containing unusual silicate slag inclusions, suggesting that the steel had been melted by the crucible steel process. The knife had been forged, carburized and hardened by local heating and quenching of the cutting edge. The handle had been carburized but had not been quenched.

The discovery site, history, and metallurgy of the knife indicate that it could be a Hudson's Bay Company trade article, manufactured in Britain and acquired by the Assinaboine Indians at a time when most of their implements were fabricated from buffalo bone. The absence of other ferrous articles in the mound site suggests that the knife was a rare possession and indicates limited trading contact. These facts suggest that the knife may trace to early trade contact with the Hudson's Bay Company, or Northwest Trading Company in the period AD 1750 to 1800.

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INTRODUCTION

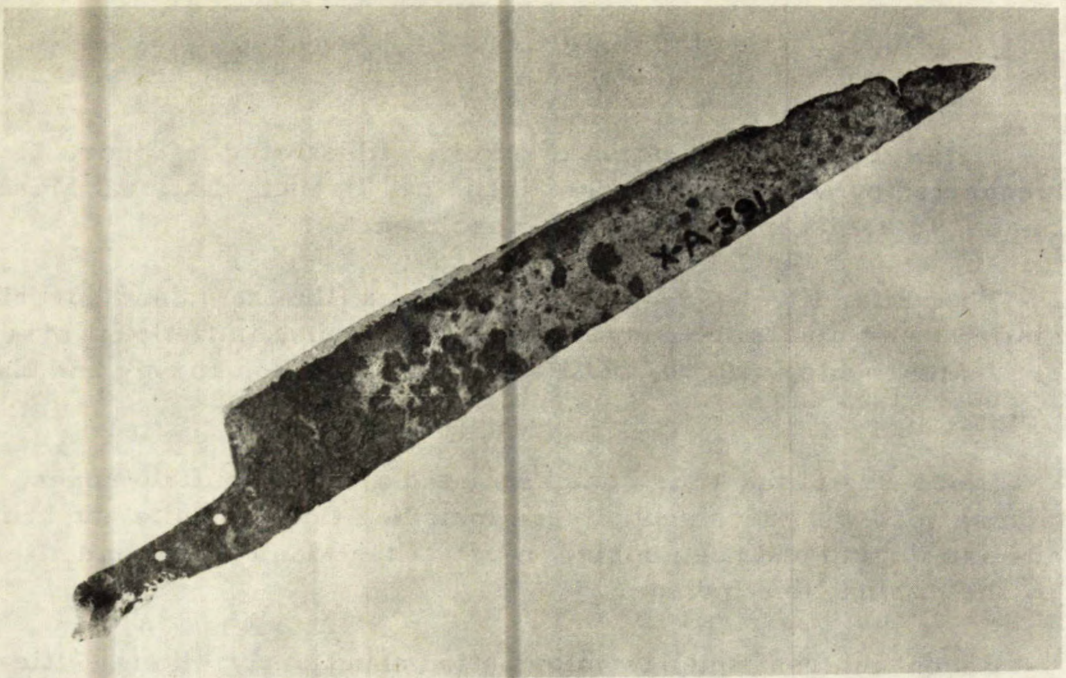
Metallurgical examination of a knife, illustrated in Figure 1, was requested by Miss Capes, Human History Branch, National Museum of Canada, to assist in dating of this specimen.

The knife, (N.M.C. Cat. #XA-391) was illustrated and described, in relation to its discovery near Ardenne, Manitoba, in National Museum Report - Anthropology No. 4, 1963 - "W.B. Nickerson Survey and Explorations."

Discovery of the knife and associated articles (buffalo bones, skeletons) were well documented, and indicated that the knife had been a trade article and had been buried in one of the Manitoba mound sites left by the Assinaboine Indians.

Recent interest and new information about early Viking settlement in North America suggested the possibility that some of their implements might have entered Eskimo and Indian trade routes. Accordingly, this knife, held in the museum collection since 1900, has been re-examined to confirm its origin and to prove that it had not been manufactured from meteoritic iron.

The appearance of the knife is illustrated in Figure 1. The National Museum catalogue number, XA-391, is also visible.



X3/4

Figure 1. Knife from Assinaboine Mound Site (XA-391).

Metallurgical examination was carried out as follows:-

(1) Radiography - X-ray

(2) Metallographic Examination. - Examination of metal cut from the back of the handle and from the cutting edge near the point. (Sections taken parallel to the long axis of the knife). Hardness tests.

(3) Semi-Quantitative Spectrographic Analysis - Filings taken from the handle of the knife.

Radiography

Radiographic examination of the knife blade revealed random elongated inclusions. Flow lines due to forging were also seen. The quantity and size of inclusions indicated that the knife was manufactured from forged steel rather than from carburized wrought iron.

METALLOGRAPHIC EXAMINATION

Inclusions

Numerous elongated slag inclusions were observed. The longest of these was about 1/16 in. in length. The inclusions had undergone heavy reduction, apparently by forging, to produce thin and irregular (non-linear) laminations. The inclusions were typical of steel rather than wrought iron.

Under polarized light, the inclusions appeared to contain $FeO.MnO.SiO_2$ and were generally bright and anisotropic. The only exceptions were traces of dark grey, (Mn-rich) MnS inclusions duplexed with FeO or $FeO.SiO_2$. None of the common, detached, (dove-grey) MnS inclusions or Al_2O_3 inclusions characteristic of modern deoxidation were observed. (This steel contained slag stringer inclusions to the extent that modern free-cutting steels contain sulphide inclusions).

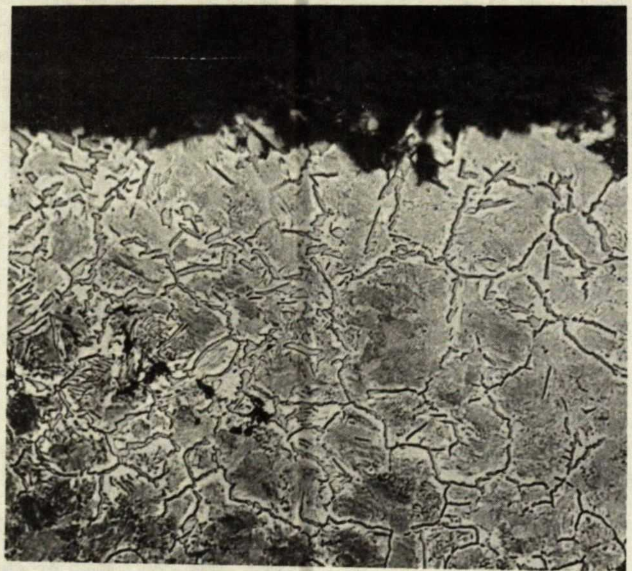
The appearance of a cleaner than average area is illustrated.

X100 as-polished

Figure 2. Longitudinal section taken at the handle of the knife. Oxide-silicate elongated inclusions are illustrated. A heavy layer of iron oxide, corrosion product and carbonate mineral deposit covers the surface of the metal. No separate MnS (dove-grey) inclusions were observed. The inclusions appear black or dark grey when viewed under the microscope.

Heat Treatment

The knife had been carburized, probably in a blacksmith-type forge, followed by slow cooling so that the microstructure of the handle consisted of lamellar pearlite and had a hardness of Rockwell 'C' 32. The metal at the extreme surface of the handle had been carburized in excess of 0.80% C, followed by slow cooling so that hypereutectoid cementite was present as illustrated in Figure 3. Slow-cooling of the carburized knife was accomplished without any evidence of decarburization.



etched 2% nital X

Figure 3. Carburized and slow-cooled microstructure present at the surface of the knife handle - (Hardness - R_C 32). No decarburization was observed at the corroded surface.

The microstructure of the cutting edge of the blade showed that this had been hardened by liquid-quenching, followed by tempering at about 593°C (1100°F) to a hardness of approximately Rockwell 'C' 34. Local hardening of the blade-edge was accomplished without decarburization. The microstructure of the hardened knife-edge is illustrated in Figure 4.

etched 2% nital X500

Figure 4. Hardened and tempered microstructure of cutting edge (Hardness - R_C 34). The microstructure illustrated, although slightly softer than modern knives, would provide adequate toughness, resilience and wear resistance for a good quality knife.

The pearlitic microstructure of the handle, adjacent to the surface (shown in Figure 3) is illustrated in Figure 5.

etched 2% nital X500

Figure 5. Microstructure of handle adjacent to surface illustrated in Figure 3. The steel has been carburized to approximately 0.80% C in this area. Lamellar pearlite has been formed by slow cooling from the hardening or carburizing temperature. Typical siliceous inclusions are illustrated.

The McQuaid-Ehn grain size of the steel is approximately 6, as illustrated in Figures 3 and 5, respectively.

Semi-Quantitative Spectrographic Analysis

Results of Semi-Quantitative Spectrographic Analysis on Handle

Element	Quantity (Weight Per Cent)
Iron	Primary Constituent
Manganese	0.54
Silicon	0.59
Nickel	N.D.
Cobalt	N.D
Vanadium	N.D.
Zirconium	N.D.
Copper	0.03
Molybdenum	0.09
*Magnesium	0.02
*Aluminum	0.04

N.D. - Not Detected
* - These elements are probably due to interference from the surface scale.

The only alloying elements detected were manganese and silicon at 0.54% and 0.59%, respectively. Insufficient metal was available, without damage to the specimen, for determination of carbon, sulphur and phosphorus. However, the carbon content appears to be approximately 0.80% after carburization (slightly higher at the extreme surface) - the scarcity of manganese sulphide inclusions indicates that the sulphur content is low, probably less than 0.02%. No evidence of phosphorus banding was observed, suggesting that this element is present in smaller quantity than commonly observed in acid Bessemer steels (last half of 19th and first half of 20th century).

The presence of 0.59% silicon and the appearance of the siliceous slag inclusions indicate that the steel was of crucible grade. This process was discovered in 1740 at Sheffield, England.

(The intentional addition of manganese to the level shown did not commence until approximately 1860, hence its presence is believed to be due to judicious choice of iron ore).

DISCUSSION

The knife had been manufactured from steel, probably crucible steel, and had been forged, carburized, and hardened using a relatively sophisticated technique. The sulphur content of the steel appears to be low; however, numerous elongated silicate inclusions illustrate the difficulty of avoiding trapped slag with crucible melting.

The knife could have been manufactured, carburized and hardened by a blacksmith, but more probably has been machine-forged, for example, in Sheffield, and supplied as a trade item. The hardness and microstructure showed that it possessed toughness, resilience and was capable of retaining a cutting edge. In modern practice the cutting edge would be harder and would be less tough but would retain its cutting ability for longer periods without resharpening. A description of the probable hardening technique is as follows:

"A peculiar but frequent way of hardening tools consists in heating the tool to the proper temperature and then cooling quickly to a black heat only that portion of it which should be hard, while keeping the other portion out of the quenchant and, therefore, at a high temperature. Upon withdrawing the tool from the bath, the heat stored in the hot portion diffuses to the cooled portion, which is in this way reheated, that is, tempered - the amount of tempering being regulated at will by again quenching the metal as soon as the desired tempering colour has been obtained."

The presence of manganese must have been accidental at this date since discovery of the function of manganese in improving hot workability did not occur until the Bessemer period at the middle of the 19th century. This element may have been present in Swedish ore and together with traces of molybdenum and copper indirectly assisted in the forging of a high quality knife.

CONCLUSIONS

1. The knife was manufactured from carbon steel (possibly crucible steel) carburized and having the cutting edge hardened by quenching.

2. The appearance of the steel and the relatively sophisticated (blacksmith or cutlery manufacturer) heat treatment, together with the location and history of the article, suggest a date in the period 1750-1800 coincident with early trade between the Hudson's Bay Company and the Assinaboine Indians.

   The presence of numerous and unusual silicate stringers show contact with acid slag. Bessemer origin for the steel appears to be ruled out by the presence of silicon and the scarcity of manganese sulphide inclusions. The presence of 0.54% Mn is believed to be a fortuitous addition resulting from the presence of manganese in pig iron charged into the melting crucible.

ACKNOWLEDGEMENT

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REFERENCE

1. Albert Sauveur - "The Metallography and Heat Treatment of Iron and Steel" - The University Press, Cambridge, USA, p. 297 (1916).

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