543.5: 620.192.45

(565) ELECTRON OPTICAL STUDIES OF NONMETALLIC INCLUSIONS IN ANCIENT & MODERN STEELS

Lehigh Univ., Bethlehem, PA M. R. Notis

I. Introduction

A number of years ago, C. S. Smith[1] performed a classical study of the microstructure and the techniques used for the fabrication of the Japanese sword; light optical microscopy was the primary analytical technique used in that study. The present work concerns a re-examination of the same samples used by C. S. Smith, and some earlier dated specimens, but using a variety of high resolution electron analytical techniques in order to study the microstructure and microchemistry of slag inclusions in these sword blades.

II. Experiments

Eight specimens taken from Japanese swords dating from the Yayoi period to modern times have been examined by a variety of electron optical analytical techniques including scanning electron microscopy (SEM), electron-probe microanalysis (EPMA) and scanning transmission electron microscopy using energy dispersive x-ray analysis (AES). Slag microstructure has been examined and the microchemistry has been categorized in terms of both major and minor constituents. Quantitative metallography has been performed by computer-controlled SEM in order to examine slag distribution and morphology, as well as total inclusion volume fraction.

III. Results

The earliest blades examined appear to be of wrought iron of excellent quality; no attempt at working or hardening can be seen. Consistent with earlier findings, blades of the 12-13th century show evidence of sophisticated laminating and hardening techniques. Slags present in these blades appear to be predominantly two phase Wustite-Fayalite mixtures (FeO-SiO_2-Al_2O_3) with little Ca or Mg. High levels of K and Ti are indicative respectively of the wood charcoal fuel source and ore source used during fabrication. The possibility of correlating Ti and K levels in the slag inclusions to ore source location, or to validate the blade identity is considered. Maps of local chemistry distributions in the slag inclusions are used to examine the details of the folding and hardening processes.

[1] C. S. Smith, "A Metallographic Examination of Some Japanese Sword Blades" p. 41-68, Documenti e contributi Storia della Metallurgia, No. 2 (1957).