VIII. THE VINLAND MAP INK

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IN 1968, YALE UNIVERSITY LIBRARY personnel discussed with McCrone Associates the analysis of the inks used for the Vinland Map, the *Speculum Historiale* and the *Tartar Relation*. Only in 1972, however, were the available microanalytical tools and techniques judged adequate for the job. Ultramicro samples were then taken from each document for analysis.

Microprobe analyses of inks from the three documents and from other known sources show clearly and consistently that:

(i) The inks in the *Tartar Relation* and the *Speculum Historiale* are iron gallo-tannate.
(ii) The ink from the Vinland Map is not iron gallo-tannate.
(iii) The Vinland Map ink is different from sepia, bearberry and Indian ink or any other early ink tested.
(iv) A variety of inorganic elements—e.g. calcium, zinc, aluminium, potassium, sodium, iron, sulphur, silicon and titanium are found in the Vinland Map ink; only one, titanium, is consistently high, ranging from 3 to 45 per cent.

Polarized light microscopy was used to study the physical nature of the Vinland Map ink. It was found that:

(i) The ink, both map line and legend, consists of a relatively thick yellow-brown line sparsely covered with thin shiny black flakes apparently making up a second ink application. Subsequent flaking away of more than 90 per cent of this black coating and consequent exposure of the yellow-brown line accounts for the faded ink appearance.
(ii) The yellow-brown ink is made up of various yellow or white pigment particles in an unknown organic binder.
(iii) Pigment particles, other than soot, are unusual in a writing ink. Most of the pigment in the Vinland Map ink is transparent, finely divided (less than one micrometer in diameter) with very high refractive indices and moderately high birefringence.

The pigments in the Vinland Map ink were identified by x-ray diffraction (XRD) principally as titanium dioxide (in the form of anatase) but with calcium carbonate (also precipitated) in lesser amount.

Samples of the ink were also examined by electron microscopy. The scanning electron microscope (SEM) shows major amounts of titanium on ink surfaces with many tiny particles protruding from the surface. The transmission electron microscope (TEM) was used to examine crushed fragments of the ink. It shows tiny particles ranging from 0·03–0·5 μm (1·5-20 millionths of an inch) in diameter (Plate III). Selected area electron diffraction with the TEM shows these to be predominantly titanium dioxide in the form of anatase. The TEM also shows these anatase particles to be a precipitated rather than a ground material. The latter would resemble the jagged, irregular flakes of ground glass; instead they are smooth, rounded rhomb shapes identical in shape and size to the modern commercial pigment anatase. Furthermore, although anatase is found as a natural mineral (albeit rare), it is nearly always associated with iron and manganese; the anatase in the Vinland Map was a refined product, chemically quite pure.

To be certain the several samples examined were not recently retouched areas,

→ Walter C. and Lucy B. McCrone are partners in Walter McCrone Associates Inc. who conducted the analysis of the Vinland Map Ink. A full report of the results is available from Yale University Library.