

In September 1955, Fred A. Hildebrand (U. S. Geological Survey, written communication) reported, on the basis of an x -ray pattern (film no. 8675), that the sample was “. . . hematite with small to moderate amounts of goethite and siderite and trace of quartz. The hematite appears to be poorly crystalline and has a unit cell somewhat larger than normal hematite.” The trace of quartz is 1.10 per cent of SiO_2 by Wells' analysis.

Plotting the percentages of FeO shown above against time (years) and extending a straight line through the last five points, suggests that in early 1960, about 45 years after Wells' analysis, all the ferrous iron will have spontaneously oxidized to ferric iron.

These results lead to speculations on the history of natural deposits of ferric iron oxides. How many of these were at one time ferrous carbonates? These speculations we leave to the geologists. Burchard (1916, p. 76) noted the partial oxidation of nodular masses of siderite to iron oxide on Bowie Hill, Cass County, Texas, stating, “The iron carbonate is in general partly altered to limonite or to reddish hydrated oxides of iron, which form a scale or crust of varying thickness around the carbonate nucleus and along cracks which intersect the masses.” A massive sample of siderite perhaps could be protected from further oxidation by a surface layer of ferric oxide whereas no such crust of oxidized iron would form in a powdered sample.

What was it that caused the spontaneous, almost complete oxidation of this sample in approximately 43 years? Specimens of siderite in collections remain unoxidized for much longer time. Was there a latent after reaction due to the mechanical and thermal effects produced by, induced by, or accompanying the grinding of the sample?

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A QUANTITATIVE CORRECTION FOR THE HOLMES EFFECT

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The Holmes effect (1) arises in modal analysis because it is impossible to confine the observation to a single plane in a transparent specimen.

Thus when looking at a thin slice there is a tendency to measure the particle's projected area instead of its area of intersection with the surface of the slice. This leads to an over-estimate of the area fraction and also of the volume fraction which is derived from it. The correction is especially serious for small grain diameters or cross sectional areas.

In a recent paper on quantitative transmission metallography, Cahn and Nutting (2) developed a set of expressions which relate quantities measured on the projected plane to parameters in the metal specimen. One of these relations can be used for an accurate quantitative correction for the Holmes effect.

The expected projected area fraction f_A of a phase, for a slice of thickness t , is given by (2)

$$f_A = f_V + \frac{1}{4}St \quad (1)$$

where f_V is the volume fraction of this phase and S is the total surface area per unit volume. This equation holds true for convex particles of any shape although it ignores overlap of two or more particles on the plane of projection. This overlap is only a problem when the slice thickness is many times the grain diameter and need not concern us here. A first order correction was developed by Cahn and Nutting.

The derivation of the equation is quite straightforward. Consider the elements of grain surface in the interior of the slice. If the slice is obtained by a random section, these surfaces on the average will be so inclined that their projected area is half of the actual area (3). However the surfaces created by the intersection of the grains with the plane of section are always normal to the light beam, and thus their projected area is equal to their actual area. If the particles are convex then every element of projected area results from two surfaces in the specimen.

From the Delesse relation (1) the area fraction on the plane of section is expected to be equal to f_V . The surface area in the interior of the slice is expected to be St . Thus the equation is proven.

In order to obtain a useful correction for the Holmes effect S must be evaluated. This can be done in a quite straightforward manner based on relations derived by Smith and Guttman (4). They give for S either

$$S = \frac{4l}{\pi A}$$

or

$$S = \frac{2N}{L}$$

where l is the total particle perimeter observed on plane of section and A

is the section area, or N is the number of intercepts of grid lines with the particles or grain surfaces and L is the total length of grid lines. Thus

$$f_V = f_A - \frac{Nl}{2L}$$

or

$$f_V = f_A - \frac{lt}{\pi A}. \quad (2)$$

It should be pointed out that in the measurement of S there will again exist an effect analogous to the Holmes effect in that the perimeter, or the number of intersections will appear to be larger than they actually are. This is a second order correction, however, which may also be easily estimated.

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GRAPHICAL REPRESENTATION OF AMPHIBOLE COMPOSITIONS*

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Compositional variations of amphiboles are complex and difficult to memorize. As data are generally more easy to assimilate in a visual than in a mathematical form, a graphical representation is desirable.

Amphiboles fall readily into two groups,

anthophyllite and cummingtonite formula $A_2B_5C_8O_{22}D_2$

where

A is largely Mg, Fe²
B is Mg, Fe², Al, Fe³ etc.
C is Si, Al
D is OH, F, Cl.

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