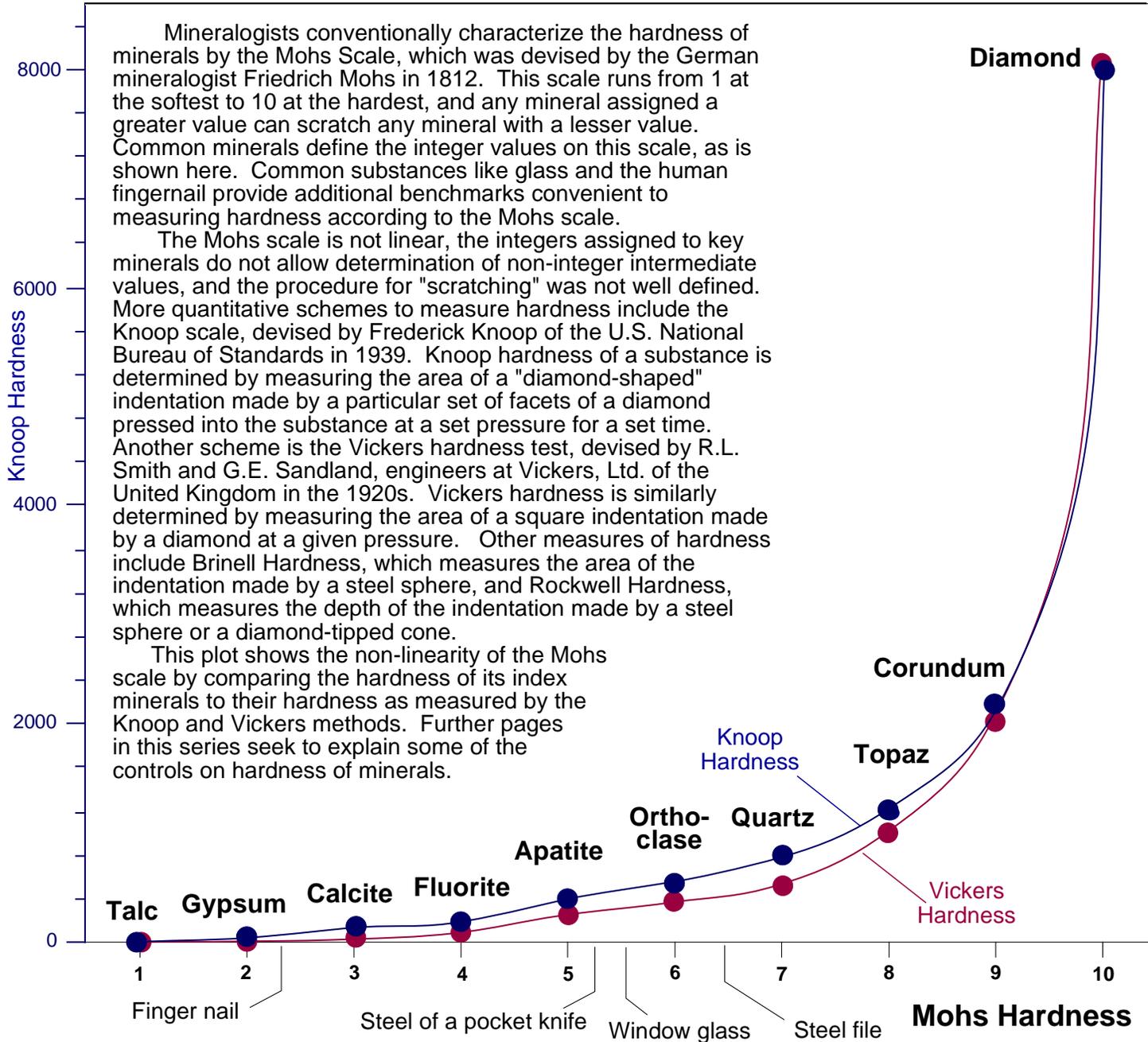


# Hardness of minerals I: the Mohs scale

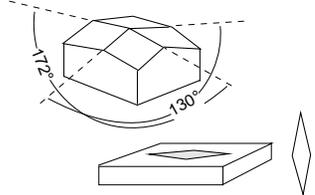
Mineralogists conventionally characterize the hardness of minerals by the Mohs Scale, which was devised by the German mineralogist Friedrich Mohs in 1812. This scale runs from 1 at the softest to 10 at the hardest, and any mineral assigned a greater value can scratch any mineral with a lesser value. Common minerals define the integer values on this scale, as is shown here. Common substances like glass and the human fingernail provide additional benchmarks convenient to measuring hardness according to the Mohs scale.

The Mohs scale is not linear, the integers assigned to key minerals do not allow determination of non-integer intermediate values, and the procedure for "scratching" was not well defined. More quantitative schemes to measure hardness include the Knoop scale, devised by Frederick Knoop of the U.S. National Bureau of Standards in 1939. Knoop hardness of a substance is determined by measuring the area of a "diamond-shaped" indentation made by a particular set of facets of a diamond pressed into the substance at a set pressure for a set time. Another scheme is the Vickers hardness test, devised by R.L. Smith and G.E. Sandland, engineers at Vickers, Ltd. of the United Kingdom in the 1920s. Vickers hardness is similarly determined by measuring the area of a square indentation made by a diamond at a given pressure. Other measures of hardness include Brinell Hardness, which measures the area of the indentation made by a steel sphere, and Rockwell Hardness, which measures the depth of the indentation made by a steel sphere or a diamond-tipped cone.

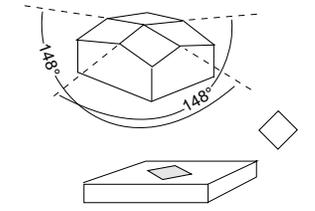
This plot shows the non-linearity of the Mohs scale by comparing the hardness of its index minerals to their hardness as measured by the Knoop and Vickers methods. Further pages in this series seek to explain some of the controls on hardness of minerals.



A Knoop indenter:



A Vickers indenter:



Original literature:  
 Mohs Hardness: Mohs, F., 1822, *Grundriß der Mineralogie* (two volumes, 1822 and 1824): Dresden, Arnoldschen Buchhandlung (translated to English by Wilhelm Ritter von Haidinger as *Treatise on Mineralogy* in 1825 and published by Constable & Co. Ltd. of Edinburgh).  
 Vickers Hardness: Smith, R.L., and Sandland, G.E., 1925, Some notes on the use of a diamond pyramid for hardness testing: *J. Iron St. Inst.*, v. 111, p. 285-294.

Knoop Hardness: Knoop, F., Peters, C.G., and Emerson, W.B., 1939, A sensitive pyramidal-diamond tool for indentation measurements: *Journal of Research of the National Bureau of Standards*, v. 23, p. 39-61 (see esp. Table 8).

Other sources:  
 University of Maryland Center for Advanced Life Cycle Engineering, ~2005, *Material Hardness*: [www.calce.umd.edu/general/Facilities/Hardness\\_ad\\_.htm#3.6.2](http://www.calce.umd.edu/general/Facilities/Hardness_ad_.htm#3.6.2).  
 Archae Solenhofen, 2003, *Rock properties and their importance to stoneworking, carving, and lapidary working of rocks and minerals by the ancient Egyptians*: [www.geocities.com/unforbidden\\_geology/rock\\_properties.htm](http://www.geocities.com/unforbidden_geology/rock_properties.htm)