# *Correlation of the Mohs's scale of hardness with the Vickers's hardness numbers.*

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MINERALOGISTS have long been accustomed to describe hardness with the aid of a scale devised by Friedrich Mohs, who lived from 1773 to 1839. The test is qualitative, each mineral in the scale being capable of scratching those that precede it, but the ten minerals have held their ground as a useful representative series with which it is now interesting to compare another method of estimating hardness.

In the metallurgical world hardness is now usually expressed by means of the Vickers's hardness numbers or their equivalent, and the figures are derived from the size of the impression made by a diamond indenter in the form of a four-sided pyramid with the opposite faces worked to an included angle of 136°.

More recently micro-hardness testers have been devised to enable minute impressions to be formed under light loads on small individual crystals of a metallic alloy,[1] and it occurred to the author to obtain hardness figures for the various types of optical glass by means of a scratch test with such an instrument. The intention was to draw a lightly loaded diamond across a polished glass surface and to measure the width of the resulting furrow. This method proved to be promising, but as an experiment a static indenter was also used, and it was discovered that glass was sufficiently plastic to take good impressions, so long as the load did not exceed 50 grams or thereabouts.[2]

The next step was to determine if minerals behaved in the same way, and, although the impressions were not always perfect, it has been possible to construct a comparative table and to assign to each of the minerals in Mohs's scale a Vickers's hardness number.

It was realized that the minerals belong to various crystal classes and that the hardness figures obtained might, like the scratch hardness,

[1] E. W. Taylor, Micro-hardness testing of metals. Journ. Inst. Metals, 1948, vol. 74, p. 493.
[2] E. W. Taylor, Nature, 1949, vol. 163, p. 323.

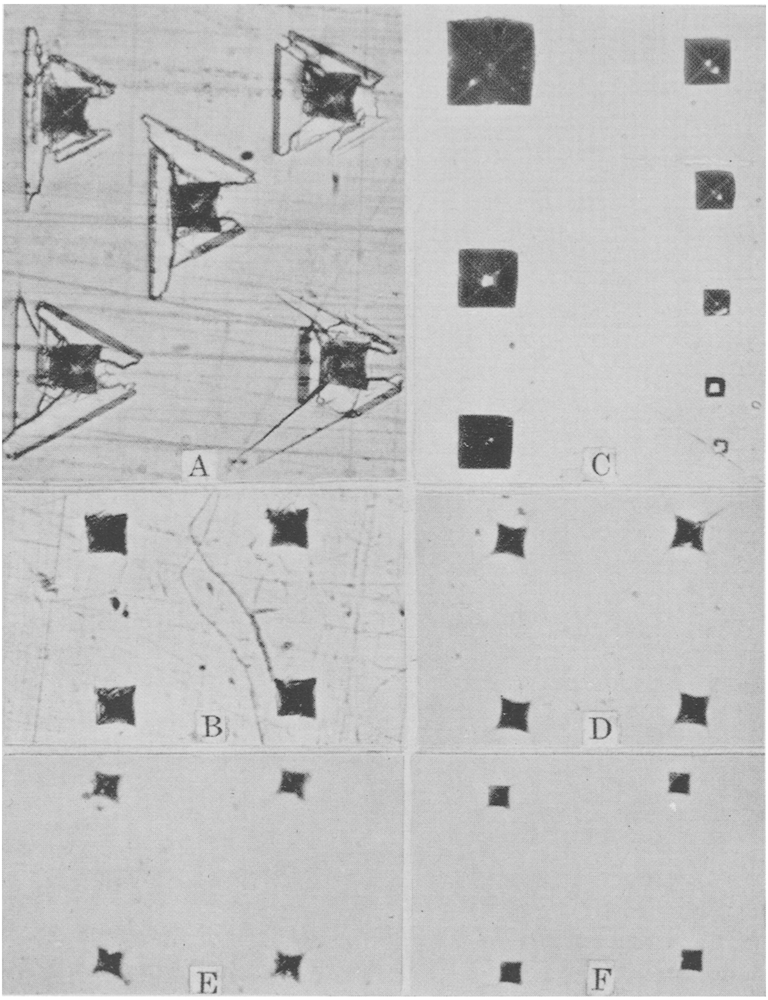


FIG. 1. Hardness of minerals shown by indentations with a diamond point.
A. Calcite, surface normal to optic axis. Load 20g. ×500.
B. Calcite, surface parallel to optic axis. Load 20g. ×500.
C. Fluorite. Loads 100, 70, 50, 40, 30, 20, 10, and 5g. ×500.
D. Quartz, surface normal to optic axis. Load 100g. ×500.
E. Quartz, surface parallel to optic axis. Load 100g. ×500.
F. Corundum, section unknown. Load 100g. ×500.

depend to some extent on the orientation of the crystal under test. Of the minerals tested, the direction of the optical axis was known only in the case of nos. 3 and 7.

The following notes relate to the specimens tested by this means and include samples of silica-glass and synthetic sapphire in addition to Mohs's list of minerals.

1. *Talc.* The impressions were rarely clear to the edges and their size was therefore difficult to determine with accuracy.

2. *Gypsum.* As with no. 1 above, though the impressions were definitely smaller.

3. *Calcite.* When the indentation was made on a face perpendicular to the optic axis, good but somewhat irregular impressions were obtained, surrounded always by cleavage fractures which formed an equilateral triangle (fig. 1 A). When the indentation was on a face parallel with the optic axis good but smaller impressions with slightly concave sides were obtained without any sign of fractures (fig. 1 B). On a cleavage surface the impressions were difficult to measure owing to further fractures.

4. *Fluorite.* The impressions formed on a worked face were perfectly square and regular in outline without any sign of fracture or crumbling, though a tendency for the extreme point of the indenter not to make an impression was noted (fig. 1 C). The impressions made on a cleavage surface were somewhat larger.

5. *Apatite.* The impressions were regular, but apt to flake away shortly afterwards. To avoid this the load was reduced to 20 grams.

6. *Orthoclase.* The impressions were bounded by concave sides or even took the form of a simple cross.

7. *Quartz.* When the indentation was made on a face perpendicular to the optic axis good impressions with concave sides were obtained (fig. 1 D). When the indentation was on a face parallel to the optic axis good but smaller impressions were obtained with markedly concave sides (fig. 1 E). A piece of fused quartz (glass) was also tested and yielded good but larger impressions than the natural crystal.

8. *Topaz.* No trouble due to fractures was experienced on a face ground and polished in our glass shop, but on a second unrelated face, lapped by diamond workers, it was difficult to avoid flaking.

9. *Corundum.* The impressions showed a tendency to be kite-shaped rather than square. This surface was diamond polished (fig. 1 F). A diamond-polished surface of synthetic sapphire gave good, clear impressions.

TABLE I. Comparison of Mohs's scale with Vickers's hardness numbers.

| Mohs. | Mineral. | Load grams. | Vickers. |
|---|---|---|---|
| 1 | Talc ... ... ... ... ... | 50 | 47 |
| 2 | Gypsum, cleavage surface ... ... | 50 | 60 |
| 3 | Calcite, surface ⊥ optic axis ... | 50 | 105 |
| | ,, ,, ‖ ,, ,, ... ... | 50 | 145 |
| | ,, cleavage surface ... ... | 50 | 136 |
| 4 | Fluorite ... ... ... ... | 50 | 200 |
| | ,, cleavage surface ... ... | 50 | 175 |
| 5 | Apatite ... ... ... ... ... | 20 | 659 |
| 6 | Orthoclase ... ... ... ... | 50 | 714 |
| 7 | Quartz, fused silica-glass ... ... | 50 | 480 |
| | ,, surface ⊥ optic axis ... | 50 | 1103 |
| | ,, ,, ‖ ,, ,, ... | 50 | 1260 |
| 8 | Topaz ... ... ... ... ... | 50 | 1648 |
| 9 | Corundum ... ... ... ... | 50 | 2085 |
| | Sapphire (synthetic) ... ... ... | 50 | 2720 |

It will be seen that the quantitative Vickers's numbers are in the same sequence as Mohs's scale of hardness and that it may now be possible to correlate them, though it must be admitted that the numbers given for the first three minerals in the table are only approximate.

One question still remains unanswered: What is the Vickers's number for diamond? No doubt impressions could be made on at least some faces of diamond, but we have not cared to risk the loss of an expensive diamond point in pursuit of this inquiry.