49-23-G

Translation No. 12

USE OF SULPHITIC LIQUID TO REDUCE THE RESISTANCE OF QUARTZOSE ROCKS TO DRILLING
(A translation)

Lemaire, E., Ingénieur des Arts et Manufactures, Paris. L'emploi des lessives sulfitiques pour diminuer la résistance des roches quartzeuses à la perforation; Génie Civil, vol. 121, pp. 33-34, 1 fig., Feb. 15, 1944, Paris.

Translated by Mrs. Severine H. Britt, U. S. Geological Survey, 1947.

Hardness is a property common to all solid bodies, but it varies enough from one to another to permit identification of a rather large number of materials by its measurement. Hardness is measured with the aid of various processes or apparatus: ball-testing or scleroscope for metals; Vicat needle for the setting-time of cements; Mohs' scale for minerals._/

_/ The Mohs' scale includes 10 terms, represented by mineral types, arranged in order of increasing hardness. They are: 1) talc, 2) rock salt or gypsum, 3) calcite, 4) fluorite, 5) apatite, 6) feldspar, 7) quartz, 8) topaz, 9) corundum, 10) diamond. Gypsum and rock salt can be scratched by the finger nail; soft steel will scratch feldspar which, in turn, will be scratched by quartz. Most of these mineral types have cleavage planes, and their hardness varies on the different planes and in different directions.

Hardness is not a constant, real characteristic of minerals, however. Some observations seem to prove that, like refractive power, hardness varies according to the medium in which the test is carried on, although these variations seemed so slight that little heed was taken of them until recently. Tests made recently at the Sediment-Petrographisches Institut of Göttingen show that, in the case of minerals, the variations may be large enough to justify the adoption of new methods of drilling since these methods would result in appreciable savings in work, time, and material.

The first research done by Messrs. Bentz and Correns dealt with quartz, which is practically the hardest mineral encountered in mining operations and is also associated with a very large number of metalliferous deposits. Mr. W. Engelhardt gave an account of these experiments in a lecture which was published in "Oel und Kohle" of August 15, 1943.

In order to give comparable results, the first tests were made with a crystal of quartz exerting an even pressure (1 kg/cm^2) on a horizontal cast-iron plate which moved simultaneously by both rotation and radial translation so that the crystal rubbed in a spiral against the whole surface of the plate.

If the hardness of quartz in water is arbitrarily taken as 100, the following values will be found for the liquids tested: hexane, 109; benzene, 103; carbon tetrachloride, 100; nitrobenzene, acetone, and methyl formates, 95; methyl and ethyl alcohol, 87; acetic acid, 83; normal butyl and amyl acetates, 77; primary butyl alcohol, 67; primary pentyl alcohol, 63; secondary octyl alcohol, 59.

Thus, in hexane, quartz is nearly twice as hard as in octyl alcohol. Of course, it is not practical to use any of the latter compounds, but the study of their chemical and molecular composition made it possible to develop the theory that the types of compounds which reduce hardness are the heteropolar compounds such as water, alcohols, fatty acids, and the quartz itself. In addition, the larger their molecules, the more active are the compounds. This was checked by testing._/

_/ It will be noted here that the repairers of china perforate hard china after placing a drop of oil, petroleum, or turpentine on the spot to be perforated.

By using crude petroleum containing longer-chain homologous hydrocarbons, a hardness of 73 was obtained. With kerosene which was extracted from this crude petroleum but which does not contain these hydrocarbons, the hardness was 77. When 0.5 percent octylic alcohol is added to kerosene, the hardness of quartz is reduced to 67. The same applies to additions of butyric acid: mixed with benzene, it reduces the hardness of the quartz from 103 for 0 percent of acid to 73 for 100 percent acid.

When butyric acid is added to water, however, a slight increase in hardness is first noted. With 5 percent butyric acid content, hardness reaches a maximum of 114 and, with a higher percent, decreases to 78. Such a maximum is observed for all compounds which, like butyric acids, can be mixed in any proportion with water and for all electrolytes in aqueous solution.

Whenever water, soluble electrolytes and organic compounds are used, it is necessary, therefore, for the concentration to be rather high in order to obtain a notable reduction in hardness. It should be noted, however, that a low concentration is effective if the electrolyte exerts a dissolving action on quartz, thus, even decinormal solutions of sodium silicate Na_2SiO_3 and caustic soda NaOH reduce hardness to 97 and 88.

It is not economically feasible to use the organic compounds or electrolytes which have just been mentioned, but a superfluous by-product which has the same properties to a very high degree is available. This by-product is derived from lignin, an incrusting but not glucidic substance of the cell-wall of woody tissue. When wood is treated with sulfurous acid or bisulphites in order to separate the cellulose from the lignin ("bisulphite process") the by-product is lignin-sulphonic acid. Since this acid is soluble in water the cellulose factories supply it in liquid form. Uses for these sulphitic liquids have been sought for a long time. Several were found, but none of them except a little-used method of tanning calf and sheep skins required large quantities.

These liquids are very acid and become still more so when they are in contact with air. When they are too acid to be poured (as is frequently the case) they must be neutralized by lime and then concentrated in order to be transported. They are then shipped in the form of a syrupy liquid or calcium salt to the dumping areas or to the places where they are used. A dry extract, which is powdery and non-hygroscopic is also prepared. This extract contains 50 percent by weight of the organic substance from the treated wood and is combustible.

Accurate information on the chemical constitution of lignin-sulphonic acid and its salts is not yet available, but they are known to have very long-chain heteropolar molecules. It may be expected, therefore, that its aqueous solution reduces the hardness of quartzose rocks. When solutions containing 80 percent lignin-sulphonic extract were used in abrasion tests, quartz showed 1.43 times greater wear than when water was used for the same length of time.

The practical conditions for use of these solutions were determined for different quartzose rocks (sandstone, quartzite) by means of an apparatus which operated approximately like the crown of a rotary drilling or boring machine; in both cases, this crown turns in a liquid mud prepared with a fuller's earth or an absorbing earth of the bentonite type.

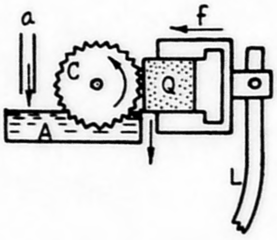
As shown in fig. 1, the tested rock "Q" exerts (by means of a lever "L" and a counterweight) a constant force "f" of about 6 kg.,_/

_/ Actually in drilling and boring machines, the pressure usually is as much as a thousand times higher.

against a Widia alloy cutter, "C", which turns at a constant speed of 80 revolutions per minute. The axis of the cutter forms a 7° angle with the face of the rock, so that the teeth attack it sideways. The lower part of the cutter dips in the sulphite liquor, "A", which is continually renewed and maintained at a constant level. The liquid comes in at "a" and escapes through an overflow. This liquid contains 6 parts by weight of dry sulphitic extract to 10 parts of water.

The abrasion of the rock is measured by its loss in weight during 15 or 30 minutes of running alternately in sulphitic liquid. If the tests were made using two specimens of the same rock and two cutters as identical as possible were to be used, the results would no longer be comparable. Consequently, tests using the same rock and the same cutter with alternating liquid and water are repeated, until the weight of the rock remains constant indicating that the edge of the cutter's teeth have become so blunt that the cutter no longer attacks the rock and must be replaced. The total test period for certain rocks may last several days.

In general, at the end of 4 or 5 total running hours, the sum of losses in weight during 15 or 30 minutes is 1.43 to 1.62 times greater for the liquid than the loss for water. The difference decreases as the duration of the test is increased. It was observed that, with water, the abraded surface of the rock is polished, whereas it is rough when sulphitic liquid is used. This corresponds to the general experience, that hard materials take a higher polish than soft materials.



Sketch of the device used to measure the hardness of quartzose rocks in contact with a sulphitic liquor.

The fact that this liquid does not corrode steel has been attributed to its high organic content. For the rock drilling the liquid mud around the boring-crown or the bit should be thixotropic and also sufficiently viscous. The most desirable properties of the mud are still under study although a viscosity 0.07 poise, seems to be sufficient.