GEOLOGY

Seeing Through Stone

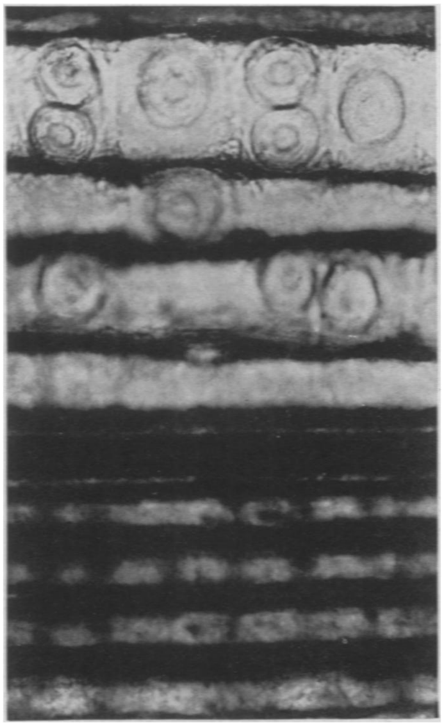
Not Clairvoyance, But Development of a Technique For Slicing Rock Thin Enables Scientists to Look In

By DR. FRANK THONE

SEEING through a stone wall is an old folk-synonym for sheer impossibility.

The piercing eye of the lynx was credited, in medieval bestiaries, with this quasi-miraculous power, but it was not for the weak sight of mortal man. The walls of ancient castles may have had ears, but eyes they had not.

Thanks to the techniques of modern science, however, man of today can see through stone. X-rays are used for some of this rock-viewing, but that is only indirect seeing-through. For X-rays themselves are without effect on the eye; we must first make a photograph, or cast their shadow-pattern on a fluorescent screen, to see through things with X-rays.



PHOTOMICROGRAPH

Here is a cross section of fossilized wood. Note the transition from dark-walled, small-celled summer wood to larger-celled spring wood of the following season. The large openings are probably resin canals.

Seeing directly through stone, using only ordinary sunlight and ordinary human eyes, can be done and is being done every day in a number of geological laboratories in this country. One of the most active of these laboratories is a part of the setup of the U. S. Geological Survey in Washington, D. C. Others are in various great museums, state universities, and a few in commercial establishments.

For seeing through stone is a highly practical business, in some of its applications. If you can get a microscopic view of the fine details of structure of a given piece of stone you can form a better judgment as to the load it will carry in a building, how well it can resist weathering or the effects of city smoke and acid fumes, and a number of other points of interest to builders.

Seeing through stone, like seeing through anything else, depends on the transparency of the particular sample you have in hand. Some kinds of stone are highly transparent in the natural state—common rock crystal, for example, and the more precious diamond. Glass might be thought of as a kind of artificial stone, with a similarly high transparency.

Colored Transparencies

Some stones, again, are transparent but colored. These are frequently valued as gems: emerald, ruby, amethyst, topaz. Color in a stone need not interfere seriously with its transparency: the world's finest monocle, according to tradition, was a large emerald mounted on a ring, which the emperor Nero used to aid his defective vision when he wanted to get a better look at a dancing-girl, or a Christian being chewed up by a lion.

But the great bulk of the world's common stones—the granites, marbles, slates, volcanic lavas, etc.—are not transparent at all, in the ordinary run-of-the-quarry specimen. Yet these are the materials of the world's mass industries in stone. Their inner secrets are the ones most important for science and engineering to know.

The secret of their opacity lies chiefly in the way they are put together. The

SEEING THROUGH STONE

Ground thinner than the thinnest paper, the prepared slice of stone can be examined in its minutest details with the microscope.

rarer stones like diamond and emerald are transparent because each specimen is made of a continuous mass (usually crystalline) of a single kind of mineral. The submicroscopic bits of which it is made are all arranged in the same way, so that a beam of light can pass through without being all broken up.

The commoner kinds of stone, the workstones of the world, are more complexly formed than the transparent aristocrats of the jeweller's shop. Rocks of the granite type are made of innumerable fine crystals of several different kinds of minerals, arranged helter-skelter. Limestones and sandstones are made of only one or two kinds of mineral as a rule, but still arranged in helter-skelter particles. So light rays are reflected, bent back, some of them absorbed completely. Anyway, they don't get through; the stuff is not transparent.

If you could get a piece of one of these opaque stones so thin that the tiny crystals or other particles at any given spot were too few to quarrel with each other very effectually as to which way a beam of light should pass, the light would come through with relatively little distortion; the chip would be transparent.

That is the job that the specialists in the laboratories (petrologists, these men call themselves) set about accomplishing. They would grind down pieces of stone so thin that they could see through them.

The first step in getting a piece of stone you can see through is to slice a chip, about a twentieth of an inch in thickness, of the specimen of granite, or marble, or diorite, or what have you. This is done with a wire saw. The wire is smooth, its "teeth" consisting of a small amount of emery dust, fed on loose. Faster than you might imagine, the saw bites off the chip.

The Long Grind

Then the stone chip gets its first rough grinding. It is held against a metal disk covered with emery and corundum powder, until it is about a seventieth of an inch thick. That is about as thick as a penny postcard. The stone is quite smooth by now, but it is not yet by any means transparent.

Now the real expert takes the chip, fastens it on a simple holder, and presses it again and again upon whirling disks of metal and leather, supplied with thin pastes of ever finer and finer abrasive powders. This final grinding is usually done by a man who could qualify as a jewel shaper and polisher. Frequently he is a graduate of the jewelry craft.

Thinner and thinner grows the little flake of stone. And the thinner it becomes the greater is the danger that it will be ruined just at the threshold of success. Some of the pieces have to be reduced to a thickness of a thousandth of an inch or less, and naturally they are rather brittle.

Paradoxically, the tougher and more resistant a stone specimen is, the better are your chances for getting a perfectly ground chip out of it. At the last thin stages of grinding the tough stones, like granite and fine-grained diorite, have most resistance to breaking, while a crumbly sandstone or a soft limestone becomes more and more difficult to hold in one piece.

At last the exacting job is finished. The grinder washes the muddy paste off his precious transparent wafer of stone, dries it, with his forceps carefully lays it on a glass microscope slide with a drop of Canada balsam to hold it fast. It is ready for the microscopist's eye and camera.

Patterns of snowflake delicacy and beauty can be seen in some of these stone transparencies, radiating crystals like stars, or streaks of persistently dark stuff like reversed lightning. And he who sits in patience may read in microscopic tracery the promises of strength or the confession of hidden weakness.

The petrographer's skill is not all spent in the service of engineering and other applications of science. Some of the most fascinating research problems in paleontology, the study of ancient life on our earth, bring fossils to the grinder's wheel, so that the microscope may reveal fine details of internal structure, telling stories of plant and animal kinships millions of years ago and adding yet another inch to known territory on the map of evolution.

The availability of a fossil for this particular type of study depends in large part on how it was formed.

Not All Alike

Fossils are not all alike by any means. Some of them have little or no stony material in them. They are still the original plant parts or animal bones, preserved for ages in the acid water of a bog, or the oily tar of an asphalt pit, or frozen in the never-thawing soil of the polar regions. Some of these could be prepared by the stone-grinding process, but they will also respond to easier methods, so the laborious grinding is not used.

Other fossils are simply casts. The original bone or log rotted away in the mud where it was buried, leaving a cavity. Fine silt slowly trickled in, filled the cavity, and in time hardened into stone. Dinosaur remains are usually fossils of this kind. Fossil casts thus formed of infiltering silt of course have no more internal structure than a plaster statue, so there is little use grinding pieces of them down, in an effort to find what isn't there.

A third type of fossils are true petrifactions. Wood seems to be the best material for this kind of fossil-making. Real petrified wood apparently is usually, perhaps always, prepared by the burial of a living forest under a thick blanket of volcanic ash, such as fell

THREE STEPS

Part of the process in preparing the stone for the microscope are shown here. First it is ground down on a rather rough grindstone. Then it is mounted (center) on a table heated to keep the cement soft. Last it is smoothed on whirling abrasive disks.

when Mount Katmai in Alaska blew its top off a quarter of a century ago. The famous cliff of petrified trees in Yellowstone National Park shows on its face a dozen such eruption-whelmed forests, each growing above its predecessor's graveyard.

Wood thus buried decays very slowly indeed—molecule by molecule. And as each bit drops away the woody stuff is replaced, molecule by molecule, with mineral from the waters that trickle through the ash.

Thus even the minutest detail of inner structure is replaced in exact duplicate by stone of flinty hardness and often great beauty of color. It is ideal material for the petrographer's grinding apparatus.

Reduced to transparent flakes, these petrified woods can be identified by the microscopic details, just as wood from living trees can be identified by timber experts, without the aid of leaf or flower or fruit.

It is easy, for example, to tell whether these trees that lived when dinosaurs still trod the earth were related to pines and spruces and other evergreens, or whether their next of kin were broad-leaved trees like oaks and elms and maples. The distinguishing mark of the evergreen or conifer series are the curiously constructed openings from one long wood-cell into another, called border-pits. These are never found in the wood of broad-leaved trees.

Botanists hesitate to call exceedingly ancient petrified wood pine even though it looks like pine. So they compromise by calling the genus *Pinoxylon,* which is Greek for "pine-wood" or "pine-like-wood." There are quite a number of these extinct species which have been given names ending in the Greek *xylon,* meaning wood. But the scientist who named *Callixylon* must have seen something especially fine through his microscope, for that name means "beautiful wood."

Science News Letter, June 19, 1937

BIOPHYSICS

Molecules of Visual Purple Measured at Columbia

VISUAL purple, the chemical compound that enables us to see, has had its molecules measured for the first time, in the biophysical laboratory of Prof. Selig Hecht of Columbia University. (*Science,* June 11). Working with Prof. Hecht in the research were Drs. Aurin M. Chase and Simon Shlaer.

Indirect physical methods and mathematical inferences had to be used in the measurements, because the molecules of visual purple are far too small to see with any possible microscope. They have a most probable diameter of a little less than a hundred-thousandth of a millimeter. (A millimeter is approximately a twenty-fifth of an inch, or about the thickness of the lead in a pencil.)

At that, the molecules of visual purple are very large—for molecules. Their molecular weight is calculated at something like 800,000, as contrasted with weights of a few hundreds or even under 100, for most common substances. In both size and weight, the molecules of visual purple resemble protein molecules.

Visual purple is a reddish-purple liquid found in very small quantities in the finer structure of the retina, or light-sensitive film that lines the eye and is the essential organ of vision. Visual purple fades to colorlessness when exposed to light and recovers its color in the dark. Recently Prof. Hecht published a method for extracting visual purple from the eyes of frogs, and accomplished the color reversals outside the living eye, in a glass tube.

Science News Letter, June 19, 1937

SEISMOLOGY

Watch Great Dam for Quakes; Lake's Weight May Bend Rock

WILL the 41,518,125,000 tons of water backed up into Lake Mead by Boulder Dam cause earthquakes?

This question was raised before a meeting of the Seismological Society of America in St. Louis by R. R. Bodle of the U. S. Coast and Geodetic Survey.

The Colorado River in its lower course flows through a region where many violent earthquakes have occurred in the past, some of them comparatively recently. Scientists have wondered whether the vast weight of water that will be concentrated along the 115 miles of Lake Mead will put sufficient additional strain on the crustal rock layers to set off disturbances.

Mr. Bodle has devoted considerable study to the question, but stated that the data available are not sufficient to justify a positive answer one way or the other. He suggested that several seismograph stations be set up in the region, so that a better informed watch may be maintained over the earth's slow movements at this important place.

Machine-made indoor earthquakes were used at the Massachusetts Institute of Technology to test instruments intended for use in earthquake regions, called accelerometers. They are so designed that they remain "asleep" until a strong earthquake wakes them up. Then they go into action and write a curve that records what happens.

The accelerometers were tested on a "shaking table," which is a platform so mounted that it can be moved back and forth in any horizontal direction, giving a very fair imitation of an earthquake. The tests were made by H. E. McComb of the U. S. Coast and Geodetic Survey and A. C. Ruge of the Institute staff. The records thus obtained will be useful for comparison with records made by the same instruments when they go through a real earthquake.

A Restless Deity

Indians in one earthquake-tortured part of the Republic of Colombia used to believe that the disturbances were caused by a great god who slept under the Andes. When he turned over in his bed, the earth shook.

This early theory of the cause of earth-