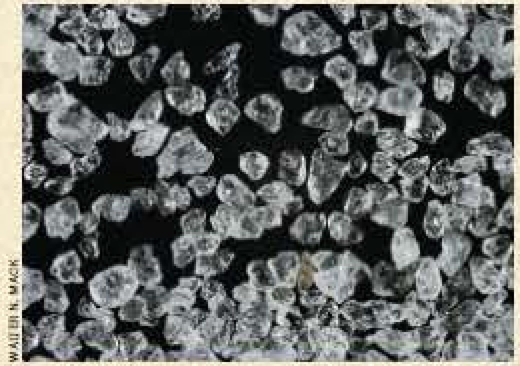
Sands of the World

One of the most common elements on the earth's surface, sand is also one of the most various

by Walter N. Mack and Elizabeth A. Leistikow



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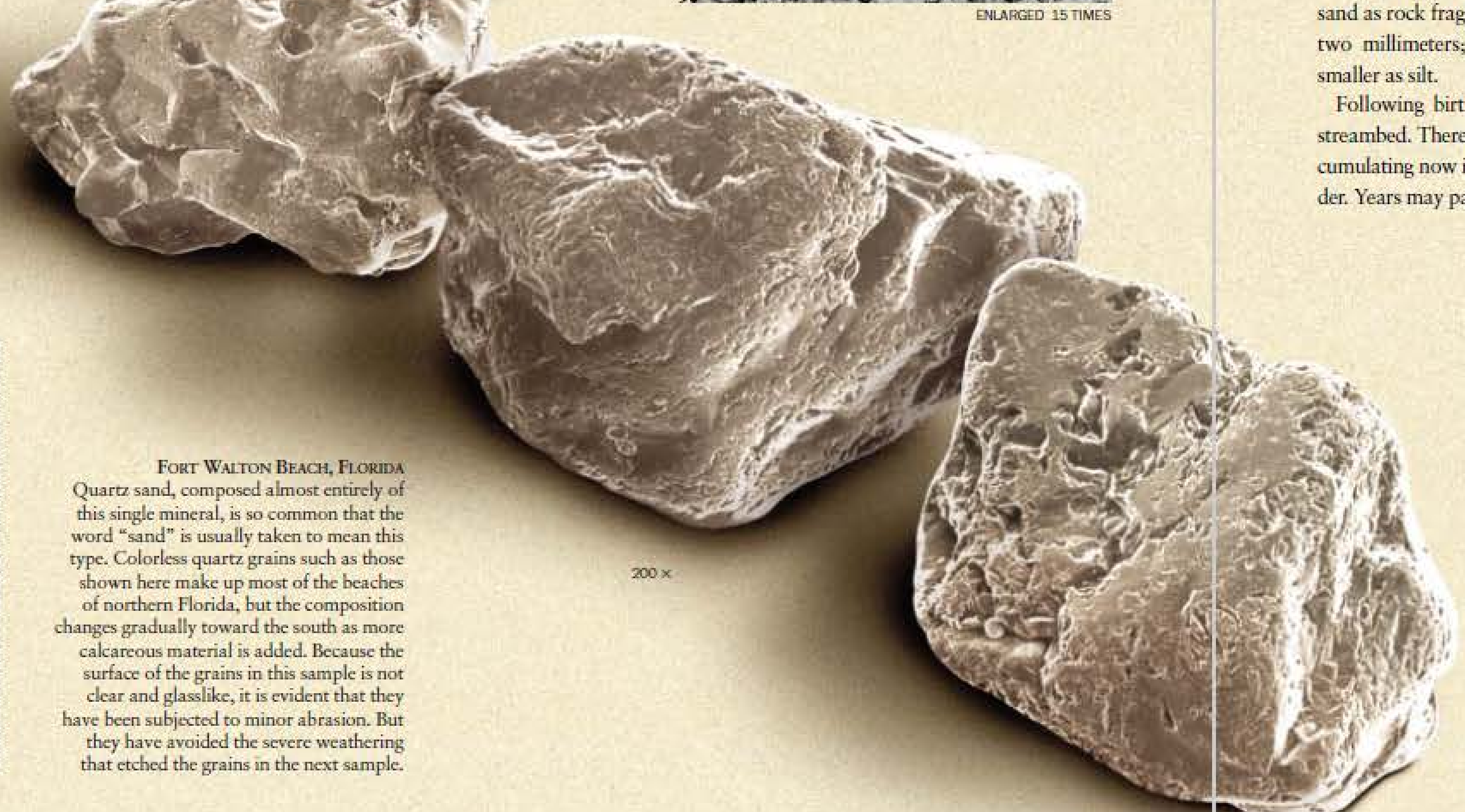

200 ×

ANDREW PAUL LEONARD APL Microscopic; DIGITAL MANIPULATION BY LAURIE GRACE

FORT WALTON BEACH, FLORIDA
Quartz sand, composed almost entirely of this single mineral, is so common that the word "sand" is usually taken to mean this type. Colorless quartz grains such as those shown here make up most of the beaches of northern Florida, but the composition changes gradually toward the south as more calcareous material is added. Because the surface of the grains in this sample is not clear and glasslike, it is evident that they have been subjected to minor abrasion. But they have avoided the severe weathering that etched the grains in the next sample.

TO SEE A WORLD IN A GRAIN OF SAND
AND A HEAVEN IN A WILD FLOWER,
HOLD INFINITY IN THE PALM OF YOUR HAND
AND ETERNITY IN AN HOUR.
—*Auguries of Innocence,* William Blake

When we pick up a handful of sand from the beach and watch it sift through our fingers, we are seeing the product of millions of years of geologic history. Much of this history can be uncovered by examining the particles under magnification, where they give up the secrets of their origin and subsequent travels.

Most sand starts life in mountainous areas as continental rock—primarily as quartz and feldspar. Mechanical breakdown (by the movement of glaciers; by cycles of freezing and thawing) produces boulders and pebbles. Then chemical assault (by vegetation and rain) combines with mechanical disintegration to eat away at these boulders and pebbles, eventually giving birth to individual grains. Geologists define sand as rock fragments having a diameter between 0.05 and two millimeters; larger particles are classified as gravel, smaller as silt.

Following birth, the grains are washed downhill into a streambed. There they roll and bounce along the bottom, accumulating now in an eddying pool, now in the lee of a boulder. Years may pass before the next step of their journey, but at last they leave the mountains by way of a river. Some of the river's sand reaches the shore; some is deposited along the way. A medium-size river will take something like a million years to move its sandy deposits 100 miles downstream. In the process, chemicals in the water polish many grains to a high gloss.

Wind as well as water plays a part in distributing sand. Wherever vegetation is meager, wind sets the particles in motion. They bump and wiggle along, sometimes blown a foot or so above the ground. Grains that are transported by the wind do not become polished but take on an opaque and frosted appearance.

Not all sandy beaches originate as rock fragments washed and blown down from the mountains. Some beaches are composed of particles of limestone that have formed in or near the sea. And where the water is warm and the biological activity is great, beaches may consist in part or entirely of fragments of marine invertebrate animals. These are the calcareous beaches, and their "sand" grains are, by far, the most interesting to examine microscopically, because they represent some of nature's most colorful and delicate works of art.

SAHARA DESERT, BETWEEN CAIRO AND ALEXANDRIA
This sand displays telltale signs of wind erosion. The dull, opaque surfaces reflect the buffeting grains receive when they are transported by wind rather than by water. The wind-borne particles are roughed up more because they lack the buoyancy and buffering provided by a watery medium; their contact with other particles thus subjects them to more abrasion. The speed of the wind also exposes the grains to more punishment. Another difference is evident as well: desert sands tend to have a wider assortment of grain sizes. Water sifts its sediments more selectively than air does, depositing particles of similar size close together.

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7×

23×

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North Beach, Hampton, New Hampshire
As the North American ice sheet receded, it dumped vast amounts of debris along the rugged shoreline of the northeastern U.S. This specimen provides a sampling of those deposits—a mixture of quartz (*colorless grains*), feldspar (*pink and amber*), and opaque igneous minerals (*black*).

6.5×

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Punaluu, Hawaii
The sand of Hawaii's famous black beaches is obsidian—volcanic glass created by magma that flowed into the sea, where it cooled so rapidly that it vitrified. Water and waves worked on broken bits of the glass, eventually reducing it to fine black sand.

30×

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South Shore of Lake Superior, Michigan
Many beaches show intriguing black streaks at the waterline. The streaks appear to be composed of organic debris or oil-soaked sand, but they are actually made of particles of magnetite. Heavier than the surrounding grains, these hard, magnetic particles are left at the water's edge as the waves toss the lighter quartz fragments higher up on the beach. (In this sample, the quartz grains are pink; the deep red may be garnet.) Twelfth-century navigators placed magnetite, or lodestone, as they called it, in a hollow reed; by carefully floating the reed in a bowl of water, they obtained a north-south bearing with this crude form of compass.

Northern Light Lake, Ontario, Canada
Not all black beaches are obsidian or magnetic sand. The beach on Northern Light Lake, for example, is a deposit of fine crystals of hornblende (a complex silicate mineral). Both the lake and its hornblende beach were left behind by the North American ice sheet.

23×

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Hawksbill Cay, Exuma, Bahamas
Some of the most photogenic, glistening white beaches lie along the Gulf of Mexico and on the islands of the Bahamas. Their sand is made of smooth, porcelain-hard particles of limestone called oolite. The name comes from the Greek, meaning "egg stone." The exact method by which these tiny "eggs" are formed is unknown. One essential element is shallow water that contains precipitating amounts of calcium and magnesium carbonate. Another is ripple marks on the sea bottom, which enable wave action to rotate a particle of clay or fine sand, on which concentric layers of carbonates then form.

Inset: Seen under a scanning electron microscope, a fractured grain of oolite discloses the lamination around the core of the particle (which is itself not visible)—layer after layer of calcium and magnesium carbonate.

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87×

23×

18×

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Silver Sands Beach, Grand Bahama
The "sand" shown here is almost exclusively coral rubble from the nearby reefs. There are, in addition, two cigar-shaped spicules, a cross section of a marine worm tube, a gastropod shell and two large, round red foraminifers.

Indian Key, Florida
All the coral and shells in this sample have lost their gloss, leaving the exteriors dull, chalky and pitted. This condition is sometimes seen on the white beaches of the tropical Florida Keys, attesting to the decay of calcareous beach material. Warm seawater, direct sunlight and abundant freshwater from rain can conspire to take back into the sea the carbonates of the dead plant and animal skeletons. We see here four fusiform and one globular gastropod shell and the remains of at least two bivalve shells, all in the process of being reclaimed by the ocean.

5×

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Sand Samples without Magnification

Fort Walton Beach
Florida

Sahara Desert
between Cairo and Alexandria

North Beach
Hampton, New Hampshire

Punaluu
Hawaii

South Shore of Lake Superior
Michigan

Northern Light Lake
Ontario, Canada

Hawksbill Cay
Exuma, Bahamas

Silver Sands Beach
Grand Bahama

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6.5×

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21.5×

Lifuka Island, Haapai Group, Tonga, Southwest Pacific
The remains of crinoids make up part of the sand on some islands of the South Pacific. Originally thought to be plants (their common name is sea lily), these animals have a long stem that consists of a series of calcified, wheellike plates. After the animal dies and the soft tissue decays, the stem becomes separated, and the stony disks fall in large numbers to the ocean bottom. Some find their way into the calcareous deposits of a beach. The disks vary in shape, depending on the species from which they come. The periphery of several pictured here has been eroded, disclosing the complex compartmentation of the interior structure.

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15×

Indian Key
Florida

Lifuka Island, Haapai Group
Tonga, Southwest Pacific

Seven Mile Beach
Dongara, Australia

Taketomi Shima
Ryukyu Islands, Japan

DAN WAGNER

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17×

Saint-Tropez, French Riviera
Just off Saint-Tropez the reefs support many interesting animals whose shells are tossed onto the beach by the waves. In this sample, the conical gastropod shells display their complex beauty. One has had holes drilled through it by a hungry predator; others reveal debris firmly wedged into the aperture. The long, curved tubular shell belonged to a mollusk in the genus *Caecum*. This creature begins life as a miniature, normal coiled snail but then grows in a single direction only. Below it lies the white, slightly abraded horn of a marine ram (*Skeneopsis planorbis*). Near the center is a large black and gold mica crystal; the reddish brown rod above it is a sponge or sea-urchin spine.

Seven Mile Beach, Dongara, Australia
Just off Seven Mile Beach, in the Geelvink Channel, lies a shallow continental shelf teeming with life from the Indian Ocean. Many small corals and shells are evident in this photograph; however, the most prominent objects are the three-axial, iciclelike sponge spicules and the very immature globular and discoid gastropod and bivalve shells.

6×

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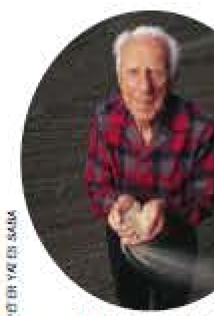
Taketomi Shima, Ryukyu Islands, Japan
Some of the southern Japanese islands are known for their beautiful star sand. Star sand grains are the shells, called tests, of foraminifers, microscopic, single-celled animals that abound in the world's oceans. The shells are the only means of classifying the animals. This sample contains primarily *Baculogypsina sphaerulata*. There is also a single round foraminifer test, from *Amphistegina madagascariensis* (*upper right*), and a single glass spiral gastropod shell (*left of center*).

Seaford, England
The city of Seaford is in southern England, on the English Channel, where tidal currents are strong and the water quite cold. Nevertheless, a sample of the beach sand discloses a surprising amount of animal life and several other noteworthy features. The flat blue and brown objects are bivalve fragments; a single white gastropod shell (*bottom left*) exhibits the growth of two body whorls. The three aggregations of sand grains are all neatly cemented together (*far left, just above center* and *far right*). The usual quartz grains are frosted, yet one grain (*far right*) is angular and the surface unscratched, as if it were recently added to the more weathered bits.

The Authors



PETER YATES SABA

REDUCED 32 TIMES

WALTER N. MACK and ELIZABETH A. LEISTIKOW have long shared an interest in sand. Trained as a microbiologist, Mack (*left*) received a Ph.D. from the University of California, San Francisco, in 1947. He taught at Michigan State University for more than 30 years before retiring in 1977. His avocational fascination with sand began early in his career, while he was on vacation at a Lake Michigan beach. Since then, he has collected—with the aid of friends and acquaintances—sand from all corners of the earth, put it under his microscope, photographed it and studied it. Leistikow, a former student of Mack's, holds an M.D. and a Ph.D. from Wayne State University. She is with FSH/Mayo Health Systems in La Crosse, Wis.