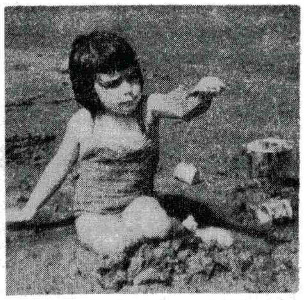
Screenings from the Soil Research Lab

IOWA ENGINEERING EXPERIMENT STATION
IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY
AMES, IOWA

Mar. - Apr., 1959
Vol. 3, No. 2

A WORD ABOUT SAND

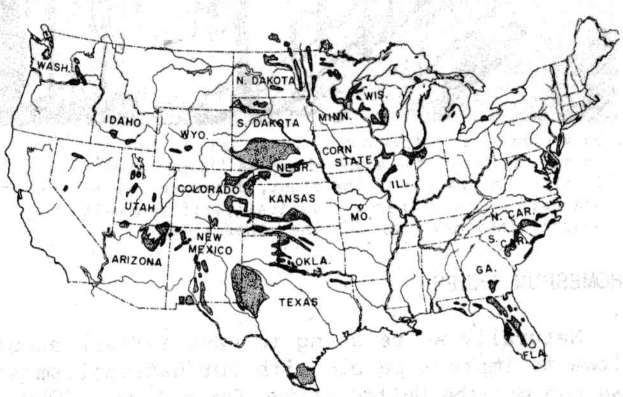


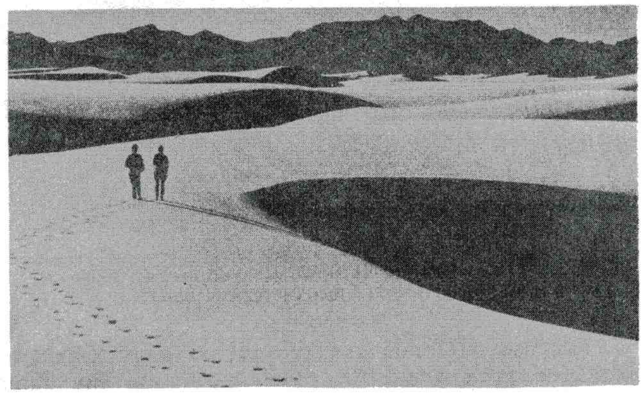
In a word, sand is sand, and we aren't going to pretend you don't know what sand is.

Still, to be truly objective we must include a definition: Size-wise, sand is a cheerful adolescent between silt and gravel--too big to carry very far and be called silt, too small, fine-featured and unsettled to be called gravel.

From another point of view, sand is a coquettish sprinkle of beauty marks on suntanned thighs, or outrageous specks of whimsy cornered in sleepy eyes. Sand is trickling lifeblood to the hourglass, intestinal dignity to the earthworm, ephemeral castles to the child.

Sand is a public mirage of the Sahara or the American West; there's sand on the palms of Texas, held out in a prayer for rain, and there is sand all over the back porch of Nebraska, stretched out likewise. There's sand in the seat of Kansas, sand in the heart of Florida, sand in the hair of Minnesota and Wisconsin, sand on the lapels of Illinois and Iowa. There's even sand in Hell, where they French-fry it in lizard fat and feed it to Congressmen for popcorn. On the Second Day God created land, and before the week was out there were wind and snakes and rivers and, undoubtedly, sand.





Grandpa

If this is nonsense to the academician, as to some others, we had better bristle some alternate views. The ultimate grandparent for most sand is coarse-grained crystalline rock such as granite. Granitic rocks are widespread, and when they weather they do a stately transformation into individual grains of sand.

Granitic rocks average about a quarter quartz, the remainder being pink or white minerals called feldspars. But the feldspars are weathered rather readily to clay, whereas quartz is as persistant as hunger pangs in an insurance man. This creates a preponderance of quartz, much like it creates a preponderance of insurance men, and in natural sands quartz is our most important product. The remainder is feldspar, micas, dark minerals, gold and uranium. (So we dream a little.)

Sand? Naturally! This stable dune area is in North Dakota. Unstable or active dunes have that fresh, bare, windblown look (above).

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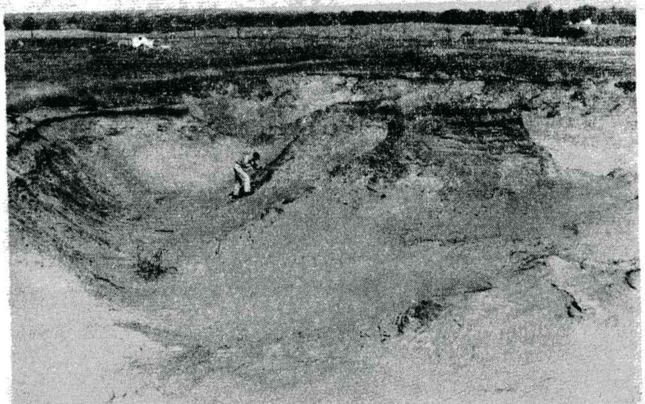


Blowout. Even a stable dune area shows signs of life if vegetation is removed by farming, overgrazing, roadcuts, etc. This blowout is in Benton County, Iowa.

Rounded outlines are typical of quartz grains derived from granitic rock, although the sand may experience much subsequent rounding due to its rugged social life. Through a process of grinding against neighbors, individuality soon gets its corners rubbed off.

Stop and Go

The reason that sand is such a geological gypsy is its grain size: it is easily eroded by wind or water, readily transported, but given the least opportunity it will settle down and stay a while.

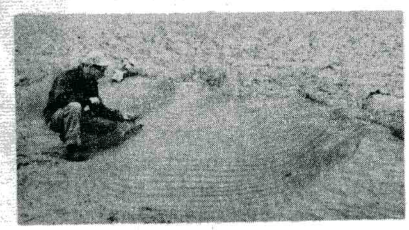
During such relocations sand is separated or sorted from associated clay, silt, and gravel. Like many a minority group it forms small Bohemian settlements where most of the population is alike in origin and habits. If the sand stays long enough and becomes stable, it adopts some native dress and develops a soil profile, which ordinarily means loss of racial purity from infiltrations of silt and clay.

Since sand can be sorted by either water or wind, we have two kinds of deposits. Wind-deposited sands are called eolian after the Greek god Æolus, who occasionally whistled up a storm. Water-deposited sands include beach sands, marginal to lakes and oceans; also stream deposits or alluvium, from the great Sioux Chief Allu, who stood on the banks of the Mississippi, drank the river dry and created the Missouri, singlehandedly making green Iowa. (Actually alluvium is from Latin, to wash.)

As a general rule eolian sands are finer than alluvial sands, for birds are small and shiftier than whales. Water can move coarser particles than wind, although the difference is reduced because wind usually moves faster.

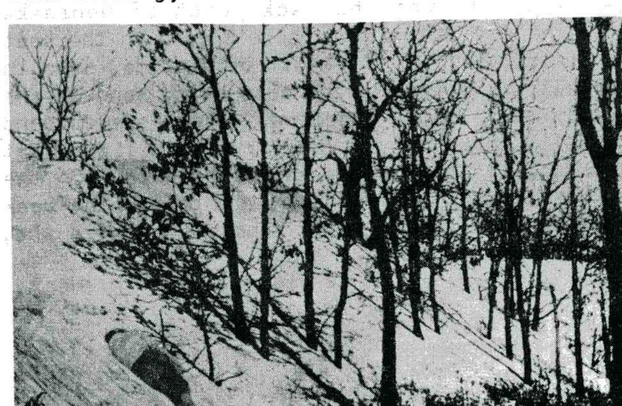
Peppy peppering

When sand moves it doesn't glide, it bounces. This primeval jitterbug is called saltation and accounts for quite a peppering near the ground. Thus in sandstorms the moving sand is concentrated low, chewing off fenceposts and the like. Most likely that's what makes rattlesnakes so mean; shotgun effect.



Saltation or bouncing accounts for the ripples commonly seen in sand deposits, and on a much larger scale contributes to the formation of billowy, sometimes beautifully symetrical deposits called dunes. Sand grains confidently bounce up the front face of a dune and suddenly find there is no more dune to bounce on. After a short glide a la Wright Brothers they fall and skitter down the back side of the dune, called the slip face because the sand is loose and slips.

Sand dunes are sometimes troublesome neighbors because they migrate, encroach, and literally take over. The best way to avoid the inevitable is not to be there when they do. Other ways are to cut off the supply of sand or stop the wind from blowing; whichever is easier.



Back side of an active dune. Loose sand in the slip face is said to lie at the angle of repose (illustrated). Dune is slowly migrating to the right, drowning innocent bystanders and wayfarers. Eventually, if you wait long enough, they may come out the other side.

HOMESPUN TALES

Naturally we're going to have to talk about Iowa to impress people with our nationalism so we can hit the United States for a loan. (Obviously this is not the idle provincialism of a New Yorker.)

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HOMESPUN TALES (cont.)

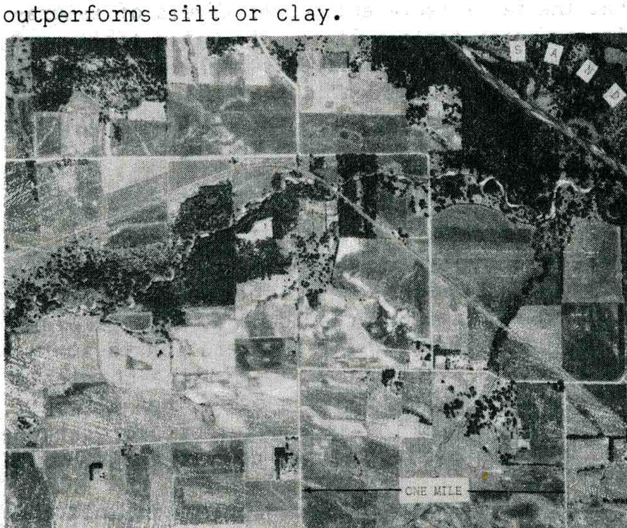
Iowa has the spice of variety in her sands, what with her moody wind and weather.

River sands, or fluvial sands, occur on the flat floodplains adjacent to rivers, and in raised floodplain remnants appropriately called terraces. Very common. If you walk around a sand pit the chances are you'll be on a terrace.

But sometimes there is water-laid sand in a most unlikely spot for a terrace, because there is no river. Then the chances are it's a glacio-fluvial deposit left from melting glaciers, which were notoriously untidy. Many glacio-fluvial deposits are also terraces. Then they actually represent former river levels when valleys were filled high with debris from glacial melting.

The average Iowan would not believe there are dunes here except for runty corn, which is so unusual. Our sand dunes are all stable and no longer busy building or on the go. This is because sources of sand were mainly sand bars associated with glacial meltwaters; once glacial prohibition closed all the bars, the dunes quickly declined and vegetated.

Although sand is not exactly a priceless commodity unless you buy war surplus, sand has value, for example in areas of sales or promotion where grit and a toe in the door are major professional assets. Engineers prefer to use some of their sand in roads, where it at least outperforms silt or clay.



Bird's-eye view of part of Marshall County, Iowa. Large light-colored area is sand, probably glacial outwash. Sand bars of the modern Iowa river are at the upper right.

Detailed engineering studies of Iowa sands have not been done since the days of the Sioux, who discovered the sand was no good for either clay pots or arrowheads, and therefore let it lay. A more modern evaluation is to find out where it is, what it is, why it is where it is and why it is what it is. This allows us to map and predict and make intelligent use.

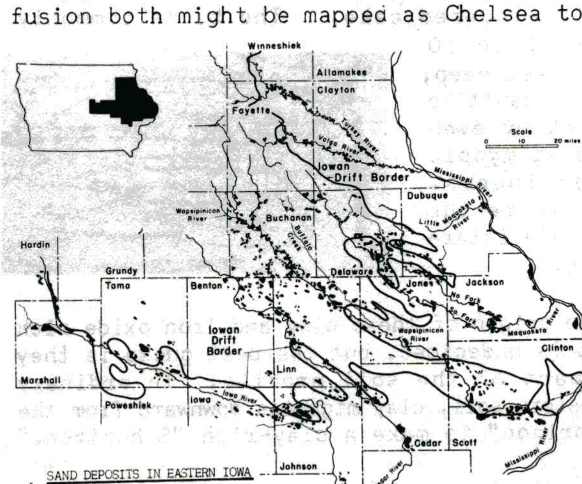
Eyes of the eagle

The first problem in mapping sand is to find the sand. With the aid of aerial photographs this becomes easy; sand areas are better drained and appear lighter, and the man truly gifted in photo interpretation can almost smell the sand burrs and feel prickles. Iowa sand dunes often look like longitudinal drifts aligned by a northwest wind. Terrace and glacio-fluvial deposits are detected by position and appearance.

Rule One when using aerial photographs is to cheat in every way possible. That is, use other clues for help. Two major sources of information are U.S.D.A. soil surveys and local geological survey literature. Soil Survey reports are mainly about surficial soils and have little or no engineering dope, but they are excellant first-hand information.

Many blue-eyed soil engineers have only recently learned the value of Soil Survey reports and tend to regard them as gospel. This is all right if you remember that gospel is forever tentative and subject to change.

For example, most of the sandy counties of eastern Iowa were surveyed 30 to 40 years ago, and while the maps are still very useful, nearly all the series names have since been revised or renamed. The Knox series (eolian sand) of one county has been mapped as Lindley series (glacial drift) in the next. To avoid renewal of confusion both might be mapped as Chelsea today?



SAND DEPOSITS IN EASTERN IOWA

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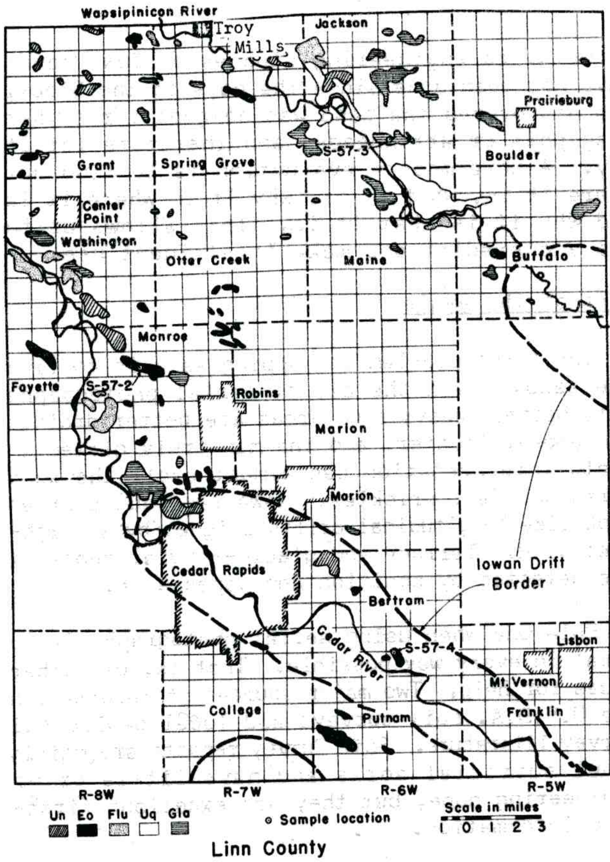
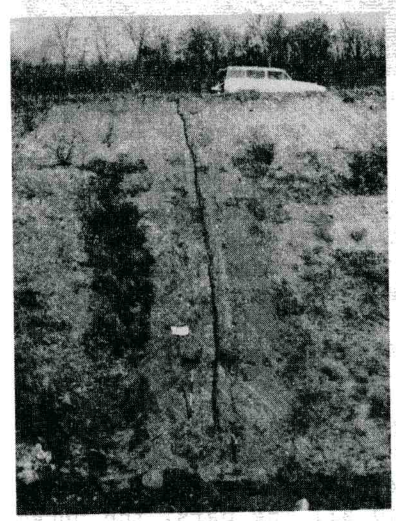


Sand deposits in Linn County, Iowa. Eo = eolian; Flu = fluvial; Gla = glacio-fluvial; Un = unclassified, origin compound; Uq = undetermined quality, usually contains excess fines. Similar maps have been prepared for counties indicated on the preceding page.

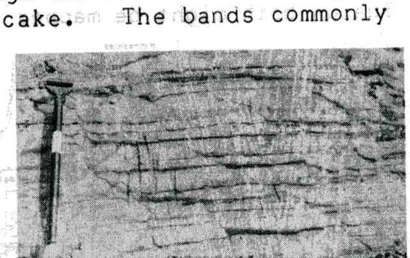


Fluvial sand deposit in a terrace of the Volga River, Fayette County, Iowa. Yo-ho-heave those clay-iron oxide bands occurring through much of the section.

A PEDOLOGICAL FOOTNOTE: MYSTERY OF THE SAND BANDS

Now is the time for all good men to go afield with rod and gun and auger and blade and see what can be dug up.

It so happens if you really dig those sand deposits you often find horizontal brown-eyed bands lacing through the sand like frosting in a multi-layered cake. The bands commonly extend 2 to 10 or 12 feet deep, so they can't be ignored by even the most myopic of engineers. Furthermore ,the bands are interesting.



The origin of these clay and iron oxide rich bands is undecided, but the best guess is they are part of the soil profile. In ordinary midwestern soil, clay migrates downward from the "A horizon" to make a clay-rich "B horizon." The bands may be analogous to B horizons, but why are they thin and repeated? One suggestion is that the bands represent former levels of saturation or water table. If so, the water table must have had some strange notions of level or lay of the land. Another idea is that the iron reacted with clay to plug the pores and start a band. The location of bands might then be related to original zones of fineness.

A third school of thought is the bands represent a cyclic precipitation, or so-called diffusion banding or Liesegang phenomemon. Reacting solutions of chemicals do this if oversatuation is required for the reaction to start. The reaction starts, uses up all the chemicals in the vicinity, and makes a band; then it won't start again until the same point of over-saturation is again reached farther down or farther out.

Yet another wild-eyed possibility is that the bands were there in the first place. A most unhappy thought, because it ruins speculation.

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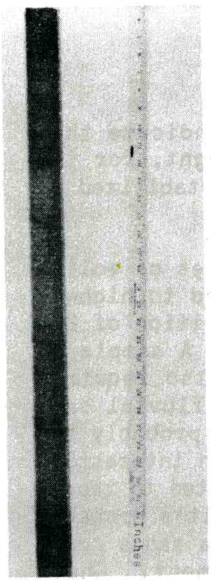
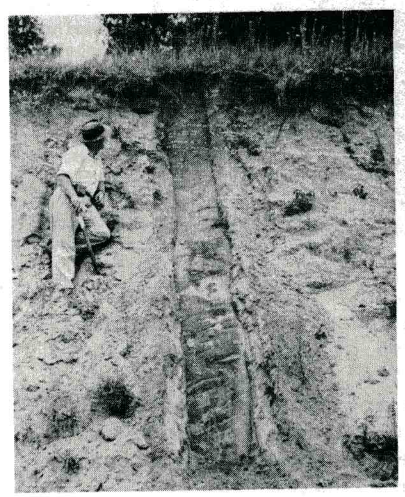
On secondary thought

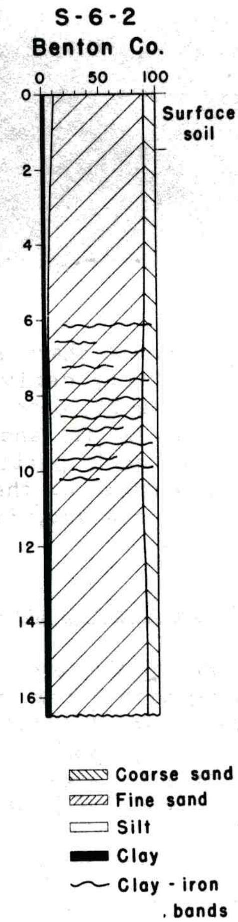
If the bands are truly secondary, they could be reproducible in the lab. Vertically held glass cylinders were filled with sand and leached downward with water or acid. Studies by the Agronomy Department used oxalic acid; other studies by us used distilled water or distilled water made acidic by bubbling with carbon dioxide, CO_2.



In all tests, bands were formed after one week. The CO_2-charged water gave the best overall development and visibly leached the upper few inches of sand. The question still remains: are the bands true rythmic precipitations or do the clay and iron stop wherever the sand is finer? Laboratory experiments favor the latter. Field samples of band and interband sands have shown no consistent relationship between band site and native fineness.



Roadcut in a 40-foot dune, Benton County, Iowa. There is an unusually heavy development of clay-iron oxide bands. Results of particle-size analyses are shown at the right.



STUDIES

From the view of the pocket gopher, who happens to be a rank engineer of the first water, sands are no good unless you use them.

Sampling

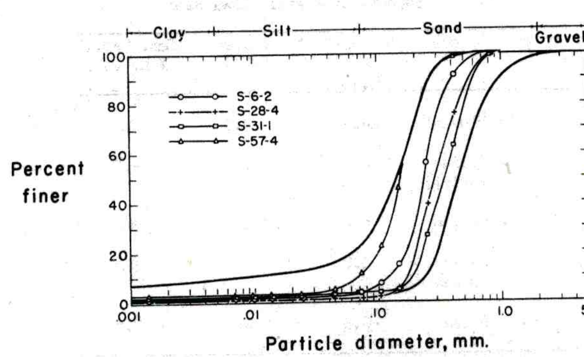
The most critical step for any soil laboratory is sampling, which is not done in the lab but in the field. A bad or non-representative sample is worse than worthless; it can ruin the mental health of the researcher, destroy his confidence in the orderly nature of the universe, or, if he has wasted over a year, reduce him to the homicidal righteousness of a Wyatt Earp.

Size

Sand, since it lacks intellect or initiative, is characterized mainly by its size. The quick way to measure size is with a stack of different mesh sieves, the coarser ones at the top, so each grain falls through as many sieves as its size will allow. Vigorous shaking helps keep things on an uneven keel and contributes valuable noises to keep up the researcher's general awareness. The amount of sand retained on each sieve is weighed, converted to percent, and plotted in a so-called cumulative curve.

The median diameter is the 50 percent size from a cumulative curve, and is a good way to express average size of a sand or soil. It turns out that eastern Iowa eolian sands associated with loess have a rather small median diameter. Those associated with glacial drift have not been blown around so much and are coarser.

This is also reflected in another measure called sorting. Well-sorted sands have been picked up and deposited so much the grains are



Cumulative curves showing particle sizes of four eastern Iowa sands. Heavy lines indicate the extreme range for 43 samples from different deposits.

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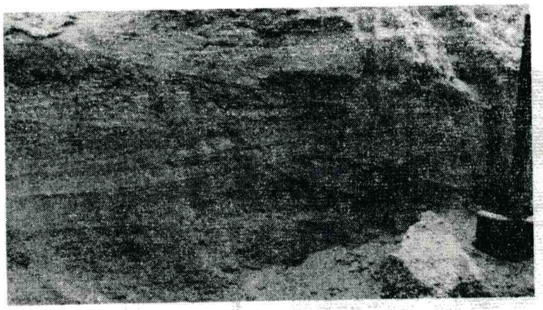
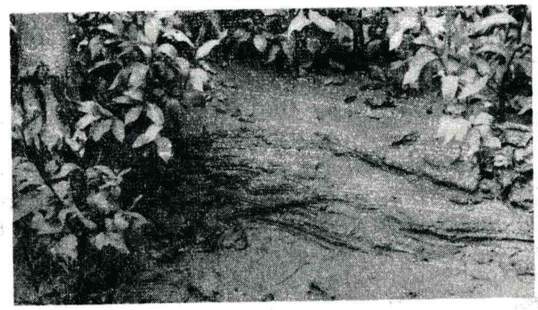


Fluvial sands often show lenslike "cross-bedding" caused by deposition from flowing water.



Bedding in dune sands is faint and difficult to see. The best place to look is on gently eroded surfaces.

mostly one size. Loessial eolian sands are better sorted (have a lower sorting coefficient) than locally derived glacial eolian sands. Fluvial sands, deposited by running water, are coarsest of all and are poorest sorted. The wider range in particle sizes of fluvial sands is also shown by the bedding, which is really sorting on a very fine scale.

Minerals and chemistry

Practically everything underfoot is a mineral, along with a few things in the foot, and sand grains are identified with a polarized light microscope which makes them appear in vivid color and black-and-white. Iowa sands so viewed are about 70 to 80 percent quartz, 15 to 20 percent feldspars, 3 percent rock fragments, 1 to 2 percent heavy minerals, and 1 to 5 percent silt and clay. Many quartz grains are coated with iron oxides or clay minerals. Iron oxide coatings are more readily measured by a chemical test for "free iron." Sand shot through with bands has much more free iron.

Sand deposits are so permeable they are easily leached of carbonates, with the end result that they are slightly acidic. Iowa sands tested have a pH of 6.4 to 6.9. They also have a trace of colloidal-size organic matter. Major clay mineral, montmorillonite.

Cement Requirements of Eastern Iowa Sands

Sample No.	Origin	% coarse sand (>0.42mm)	% clay (<5u)	Cem. Req., % by vol.
S-31-1	Fluvial	24.9	4.5	7.5
S-28-4	Eolian (drift)	16.6	2.1	9.0
S-6-2	Eolian	6.2	2.3	8.5
S-6-2a	Eolian, banded	3.2	6.1	9.0
S-57-4	Eolian	0.8	3.7	8.5

SOIL STABILIZATION

Data hot off the lab sheets indicate that the sand surveys are not for naught, for the sands are among the most readily stabilized of all Iowa soils.

Tests on three different samples of eolian sand show that it can be converted to highway base course material with the addition of 8.5 to 9.0 percent portland cement. A sample of eolian sand rich in clay bands also requires 9.0 percent cement. A sample of fluvial sand requires only 7.5 percent cement, probably because it is coarser, which gives an interesting contrast. Since samples were selected to represent the extreme range of sands, it's probably safe to say nearly all eastern Iowa sands could be stabilized with 9 percent cement. Check tests may be made by new short-cut methods especially devised for sandy soils by the Portland Cement Association.

ACKNOWLEDGEMENTS AND REFERENCES SIGHTED

Our cover glamour pin-up is that famous international beauty and irresistable charmer, Miss Ann D., rumored to be close friend and fiancee of Ye Olde RLH. The cover picture middle right, shows White Sands, New Mexico, courtesy U. S. Department of Interior.

Further enlightenment is available from "Fine Sands in east-central Iowa," by A. E. (Wicked) Wickstrom, Karl Riggs and D. T. Davidson, Iowa Academy of Science Proceedings 62: 298-317, 1955. For more dope on more counties, plus a literature review and laboratory band experiments, see the thesis "Fine sands in eastern Iowa," by A. E. Wickstrom, Iowa State College Library, 1957. This was also put out in a limited edition as a progress report; contact Ye Olde Editor.

Work on eastern Iowa sands was completed under Iowa Highway Research Board Project HR1 with funds from the Iowa State Highway Commission.

RLH

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