

**CHEMICAL AND PHYSICAL STABILITY  
OF CALCAREOUS SANDS  
USED FOR PUTTING GREEN CONSTRUCTION**

Annual Report  
submitted to the  
United States Golf Association  
Green Section Research Committee

November 2, 1998

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## Introduction

A calcareous sand can be defined as any sand (soil with at least 85% of particles between 0.05 - 2 mm in diameter) that contains at least 1%  $\text{CaCO}_3$  (calcium carbonate, or calcite) on a weight basis. These sands exist in various places around the U.S. and the world due to pedogenic processes. In areas where they exist they are often used for construction of golf course putting greens and other sand-based root zone media. Because of either perceived or real problems associated with these sands, their use is discouraged. However, transport costs of non-calcareous materials often make calcareous sands the only choice in some areas. The potential problems associated with these materials are not well defined or understood. In general, the types of problems that may occur are related to undesirable soil physical properties (aeration, hydraulic conductivity, water holding capacity) as compared to USGA recommendations. Greens built with these sands that meet USGA recommendations at the time of construction may deteriorate due to weathering or mineral transport in the soil profile. Greens that have reduced hydraulic conductivity, reduced air-filled porosity, and perhaps even visual layers of mineral precipitates have been reported by superintendents and USGA agronomists. However, there are no reported systematic investigations into the occurrence or nature of these problems. It is the objective of this research project to determine if performance characteristics of putting greens decline as a result of weathering of calcareous sands, and to determine the mechanism of this weathering and the subsequent performance decline. Ultimately, we hope to provide guidelines for formulating recommendations concerning suitability for use of various sands for putting green construction.

## Research Initiated, Progress and Results

Two primary approaches are being used in this project. The first is a column study that investigates the weathering potential of various sands under controlled conditions. The second is a field survey which involves collection of intact cores from putting greens constructed of calcareous sands.

The column study includes three different sands. One sand, to serve as a control, will be a silica sand containing no calcite. The other two sands will have varying calcite contents so that a range of materials will exist. Initially, we were planning on using two materials with calcite contents in the range of 5 - 10% and 20 - 40 % by weight. Identification of these sands has resulted in an unexpected new component to the project: classification of materials that are perceived to be calcareous. We have collected over thirty sands from various sources throughout the country, and have found most contain less than 10% calcite. Although we have collected samples that were reportedly highly calcareous based on recommendations of various individuals, we have not yet identified a material that we consider high in calcite that meets USGA particle size recommendations. In many cases, the recommended sands were never previously analyzed for calcite content, but based on pH and reaction to acid they were thought to be highly calcareous. In a sand that contains little to no organic matter or other active chemical components, a small amount of calcite could result in a relatively high pH. A sand with a pH of 8.0 might be considered on the surface to be highly calcareous, when in fact it is not. For example, one sample we received had a pH of 8.1, but a calcite content of only 3%. We have

expanded our search and are currently collecting new samples and characterizing them. One sample from Hawaii contains in excess of 85% calcite, but is too fine in gradation. In addition, this coral derived sand is atypical of most sands used in this country. We have recently solicited samples from suppliers in Florida that should be derived primarily from limestone, but have not yet received these. Table 1 shows particle size distribution and calcium carbonate equivalent of several of the samples we have collected. Note that calcite content is expressed as "CaCO<sub>3</sub> equivalent" on a percent by weight basis. The analytical procedure digests all carbonates in the sample, not just calcium carbonate. Calculations assume that all of the carbonate is from CaCO<sub>3</sub>, which in the case of sands is reasonable, but may introduce a slight error. Therefore, the presence of any carbonate is reported as if it were calcium carbonate, hence the terminology "CaCO<sub>3</sub> equivalent".

During this process, we have experimented with techniques for calcite determination. Initially, samples were analyzed by the Utah State University Analytical Laboratory. We began analyzing these ourselves at WSU for expediency. The procedure used at USU is time consuming, and their lab is not equipped to handle large numbers of samples on a timely basis due to the large demand they have from other clients. We have investigated various acid digestion procedures in which calcite content is measured by loss of mass (due to evolution of CO<sub>2</sub>) or change in pH. Grinding samples and varying sample sizes, reagent volumes, and digestion times have all been evaluated to maximize accuracy and reproducibility as compared to the USU lab. Although the procedure has not been finalized, we have determined that a method using HCl and measuring change in mass seems to be both most accurate and most efficient. Optimum sample size and reagent volume seem to vary with the sand. The procedure should be finalized soon, and may include using multiple sample sizes and reagent volumes for each sample in order to maximize accuracy.

After procedures are finalized and the sands are selected, the column study will begin. In addition to sand types, the effects of acidification and water quality will be studied. Application of ammonium fertilizers leads to soil acidification, and we hypothesize that this is critical in any weathering that may occur. We will produce acidification through additions of a dilute acid, as opposed to fertilizer. The columns will not contain plants, nor any of the associated biological activity. Because of this, fertilizer reaction in the soil may be altered as compared to field conditions, and the acidifying effect may not be realized. Acid will be added at two rates to mimic typical and accelerated fertilization rates. Bicarbonates present in water may also have an important impact on the system by promoting precipitation of calcium and other minerals. In many areas where calcareous sands occur, bicarbonate content of irrigation water is elevated. To address this, two bicarbonate levels will be used: no bicarbonate and 1 meq/L residual bicarbonate (as sodium bicarbonate). Presence of residual bicarbonate means that bicarbonate is present in amounts in excess of what is needed to promote Ca precipitation. Irrigation solutions will be delivered automatically through a drip irrigation system in the greenhouse. This system has been assembled and calibrated. Analyses outlined in the proposal include scanning electron microscope examination of sand grains, measurement of pH and electrical conductivity of percolate, and calcite content and particle size distribution of various segments of the sand cores. Measurement of hydraulic conductivity of these cores was proposed, but this has been changed to

capillary and non-capillary porosity following discussions at research monitoring visits earlier this year.

For the field survey portion of the project, cores have been collected from three golf courses to date. The first two courses, located in northern Utah, were constructed using the same sand (approximately 6% calcite). One course was built in 1989 and the other in 1993. Samples from one Texas course that has experienced problems that may be due to a calcareous sand were collected and submitted by Jim Moore. These have not been analyzed yet because we are waiting until more golf course samples are collected. Variations in depths of the cores will be considered before deciding how to partition the samples by depth.

### **Proposed Future Research Schedule**

Sands to be used in the column study will hopefully be identified by the end of the year. Once this is done, the column study will start, and the first set of samples will be collected and analyzed in the late summer of 1999. The column study will continue with the remaining samples to be collected in the winter or spring of 2000. Identification and sampling of additional golf course greens constructed with calcareous sands will continue with the assistance of the USGA Green Section staff.

Table 1. Particle size distribution and calcium carbonate equivalent of selected sand samples.

Sample origin (state)	Particle size (mm)							CaCO <sub>3</sub> equivalent (% by weight)
	2 - 3.4	1 - 2	0.5 - 1	0.25 - 0.5	0.15 - 0.25	0.05 - 0.15	< 0.05	
	-----Percent by weight-----							
Arizona*	0	12	50	32	6	0	0	2.0
Hawaii*	0	1	4	38	51	5	0	86.3
Idaho	0	0	35	58	14	2	1	0.0
Minnesota	0	2	35	46	17	0	0	2.0
Minnesota	0	1	24	56	18	0	0	5.5
Minnesota	0	0	7	92	1	0	0	2.1
Nevada	1	6	29	47	16	0	0	10.4
Utah*	0	8	29	28	23	12	0	5.3
Washington	1	4	24	59	10	1	0	1.3
Washington	0	2	29	52	14	2	0	4.8
USGA	3% max.				20% max.	5% max	8% max	
	10% max 1 - 3.4 mm		60% min. 0.25 - 1 mm			10% max < 0.15 mm		

\* Samples do not meet USGA particle size specifications