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Soil Color

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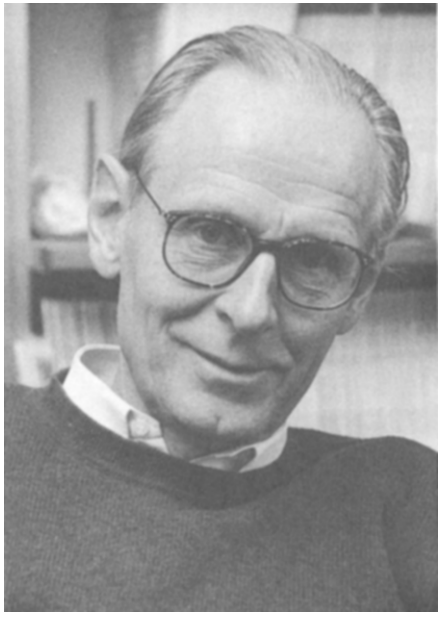

Udo Schwertmann

It is very appropriate that *Soil Color* be dedicated to Prof. Dr. Udo Schwertmann, who is internationally recognized for his research related to the genesis and properties of iron oxides. His work has produced major advances in the identification and characterization of these important pigmenting agents in soils and sediments. These advances have, in turn, made meaningful interpretations of soil color a reality.

Professor Schwertmann was born on 25 Nov. 1927 in Stade/Elbe, Germany. Following World War II, he became part of the movement to reorganize and revitalize the scientific community in postwar Germany. He received a university diploma in 1952, a Ph.D. degree in 1959, and the Docent degree (Habilitation) in 1961, all from the University of Hannover. In 1962, he was a Fulbright Scholar and carried out research at the University of Wisconsin, Madison. In 1964, he was appointed Professor and Head of the Institute for Soil Science in the Technical University of West Berlin. Finally, in 1969 he moved to his current position as Professor and Head of the Institute for Soil Science in the Technical University of Munich at Freising-Weihenstephan where, in addition to administrative and research responsibilities, he has taught a basic soil science course to approximately 200 students each year. During his tenure at T.U. München, Prof. Schwertmann has been a Visiting Research Scientist with the CSIRO, Division of Soils, in Adelaide, Australia (1972); a Visiting Research Scientist at the University of Natal in Pietermaritzburg, South Africa (1975); and a Distinguished Visiting Scholar at the University of South Australia in Adelaide (1981).

Professor Schwertmann's research has yielded more than 200 technical publications on soil clay mineralogy (including more than 100 articles related to the genesis, chemistry, and mineralogy of iron oxides), soil acidity, phosphate adsorption, and soil erosion. His work ranges widely from practical field demonstrations of conservation practices to basic laboratory studies of crystallography and mineral chemistry. Even his most abstract studies are

designed to better understand natural phenomena. His broad experience and eye toward nature have enabled him to contribute numerous book chapters, an erosion prediction handbook, and a basic soil science text that is now in its 13th edition.

Professor Schwertmann's technical achievements have brought honors and much respect from the scientific community. He is a member of numerous professional societies and advisory boards. His leadership activities have included service as Vice-President of the German Soil Science Society, Chairman of Commission VII of the International Society of Soil Science, and General Secretary and Vice-President of the Association Internationale pour l'Etude des Argiles (AIPEA). He is a former editor of *Zeitscrift für Pflanzenernährung und Bokenkunde* and has been a member of the editorial boards of *Clay Minerals, Clays and Clay Minerals, Advances in Soil Science,* and *Geoderma.* Professor Schwertmann has been keenly interested in science and research policies and has served as a referee and advisor to the Deutsche Forschungsgemeinschaft (German National Science Foundation), the German Ministry for Research and Technology, the German Society for Radiation and Environmental Research, and the Alexander von Humboldt Foundation. He is a recipient of the Paul Wagner Award, a member of the Deutsche Akademie der Naturforscher Leopoldina, and a Fellow of the American Society of Agronomy and the Soil Science Society of America. In 1992, he was named a Pioneer Lecturer by the Clay Minerals Society.

Professor Schwertmann's career accomplishments in teaching, research, and service have had a major influence on the discipline of soil science. His critical thinking, balanced evaluation of research findings, and infectious enthusiasm for science have made him a much sought-after counselor by both students and colleagues. These attributes, coupled with a warm personality and humble character, have made him widely appreciated as both a gentleman and a scholar.

JERRY M. BIGHAM, *editor*
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FOREWORD

Soil is a natural resource with tremendous spatial variability in characteristics because of differencs in parent material, age, climate, topography and vegetation. One of the distinguishing characteristics of soil is color. Color has been a keystone of all major soil classification systems. It has been used extensively as a parameter in studies of soil genesis. Even in the age of advanced instrumentation, color remains an important soil characteristic. Remote sensing techniques to map soils rely on the reflection of radiation from surfaces of differing colors as a basis to differentiate soils.

Several components contribute to soil color. This special publication is designed to provide a concise description of the role each component plays in determining the color of a soil. Students, soil scientists, and researchers interested in the study of color should find the publication equally useful.

DARRELL W. NELSON, *president*
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PREFACE

The color of a soil, sediment, or rock is usually one of its most outstanding morphological characteristics. As such, color is often the first property recorded in a detailed description by an earth scientist and may be the only feature granted any significance by a layperson. Accordingly, the U.S. Soil Survey Staff (1981) has stated that "color is one of the most useful properties for soil identification and appraisal." This viewpoint is supported by the fact that color and color terms play an important role in all major systems of soil classification.

Despite the purported significance of soil color, the subject is treated largely as an afterthought in most soil science textbooks. This apparent oversight reflects the simple reality that color has remained something of a mystery to most earth scientists. The enigma is partially due to the fact that color science is a complex discipline that cuts across the boundaries of physiology, psychology, physics, chemistry, and mineralogy. There is also a widespread perception that color, and especially soil color, cannot be measured with any great degree of precision or accuracy. Despite these uncertainties, colors and color patterns have been carefully recorded and correlated for many years by both pedologists and geologists. This persistence reflects the belief that color provides a link between an easily observed property and an underlying genetic process or some other more important soil characteristic. Unfortunately, the nature of the linkage is often unclear. Many earth scientists would still agree with C.F. Shaw who noted in 1937 that "although much has been said regarding soil color, like the weather, little has been done about it."

The primary objective of a symposium sponsored by Div. S-5 (Soil Genesis, Morphology, and Classification) and Div. S-9 (Soil Mineralogy) at the 1990 annual meeting of the Soil Science Society of America in San Antonio was to demonstrate that something *has* been done about soil color. Most of the papers presented at that symposium are included in the present publication and address three major topics: (i) color science and advances in the measurement of soil color, (ii) properties and genetic significance of important pigmenting agents in soils, and (iii) geomorphic and geologic factors influencing the formation/inheritance of soil color.

The introductory chapter by R.W. Simonson provides a first-hand account of the many, creative efforts that ultimately led to the development of our widely used field color charts. Students of soil science history will enjoy his descriptions of key personalities and events. Chapter 2 by J. Torrent and V. Barrón gives a straightforward discussion of color theory and demonstrates that precise measurements of soil color can be achieved in the laboratory. In chapter 3 of this section, D.F. Post and his co-authors take modern color technology to the field and test correlations with standard measurements of color by soil scientists.

Chapters 4, 5, and 6 are concerned with important pigmenting agents in soils. In chapter 4, U. Schwertmann provides a thorough review of our current state of knowledge concerning iron oxides, which are usually the most powerful sources of color in soils and sediments. The ensuing chapter by D.G. Schulze and his co-authors answers several longstanding questions concerning relationships between soil color and the nature and content of organic matter. In the final chapter of this group, D.S. Fanning and others describe the potential use of color as a means of recognizing latent acid sulfate materials and understanding the genesis of acid sulfate soils.

Chapter 7, by J.L. Richardson and R.B. Daniels, considers stratigraphic and hydraulic influences on the development of soil color and presents a model for the genesis of redoxomorphic features in soils subjected to seasonally anaerobic conditions. The final chapter in the text, by R.H. Blodgett and co-authors, provides a fresh look at the complex origins of pigmentation in sedimentary red beds. A comprehensive review of the literature on this subject is included and should make this chapter widely appreciated by geologists and pedologists alike.

The primary goal of this text and the original 1990 symposium was to provide an update on our state of knowledge concerning the origin and measurement of soil color. It is sincerely hoped that this publication will be of interest to practicing field scientists as well as academicians. In both cases, a better understanding of soil color should serve to satisfy basic elements of curiosity and advance future scientific inquiry.

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