Shiraz University
Faculty of Agriculture

Ph. D. Thesis in Soil Science

MORPHOLOGY, GEOCHEMISTRY, MINERALOGY, AND MICROMORPHOLOGY OF SOILS OF HORMOZGAN PROVINCE IN RELATION TO PARENT MATERIALS

By
HAKIME ABBASLOU

Supervised by
ALI ABTAHI

JUNE 2012

IN THE NAME OF GOD

MORPHOLOGY, GEOCHEMISTRY, MINERALOGY, AND MICROMORPHOLOGY OF SOILS OF HORMOZGAN PROVINCE IN RELATION TO PARENT MATERIALS

BY

HAKIME ABBASLOU

THESIS

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph. D.)

IN

SOIL SCIENCE
SHIRAZ UNIVERSITY
SHIRAZ
ISLAMIC REPUBLIC OF IRAN

EVALUATED AND APPROVED BY THE THESIS COMMITTEE AS: EXCELLENT

A. ABTAHI, Ph. D., PROF. DEPT. OF SOIL SCIENCE, SHIRAZ UNIVERSITY (SUPERVISOR).

N. KARIMIAN, Ph. D., PROF. DEPT. OF SOIL SCIENCE, SHIRAZ UNIVERSITY.

F. MOORE, Ph. D., PROF. DEPT. OF EARTH SCIENCE, SHIRAZ UNIVERSITY.

M. BAGHERNEJAD, Ph. D., ASSOC. PROF. DEPT. OF SOIL SCIENCE, SHIRAZ UNIVERSITY.

F. KHORMALI, Ph. D., ASSOC. PROF. DEPT. OF SOIL SCIENCE, GORGAN UNIVERSITY.

H. OWLIAIE, Ph. D., ASISST. PROF. DEPT. OF SOIL SCIENCE, YASOUJ UNIVERSITY.

JUNE 2012

IN THE NAME OF GOD

In the name of God

Declaration

I, Hakime Abbaslou, Ph.D. student in Soil Science, Shiraz University, declare that this thesis is the result of my researches and I had written the exact references wherever I used other sources. I also declare that my research and the subject of my thesis are not repetitive and I guarantee that I will not disseminate its results and not make them accessible to others without the permission of Shiraz University. According to regulations of the moral and spiritual ownership, all rights reserved by Shiraz University.

……

June-2012

Dedication

To my family
For their love, support, and prayers

And

Finally, this thesis is dedicated to all the people who never stop believing in me.

Acknowledgements

First and above all, I praise God, the almighty for providing me this opportunity and granting me the capability to proceed successfully. This thesis appears in its current form due to the assistance and guidance of many people. I would therefore like to offer my sincere thanks to all of them.

I would like to express my sincere gratitude to my major professor, Dr. Ali Abtahi, for the continuous support of my Ph.D study and research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. His unflinching courage and conviction will always inspire me, and I hope to continue to work with his noble thoughts.

I would like to express my appreciation to Dr. Francisco Jose Martin Peinado for his support and providing necessary infrastructure and resources to accomplish my research during my stay in Granada University, Spain. He contributed in many ways to the success of this stay and made it an unforgettable experience for me.

I sincerely thank my Ph.D. Supervisory Committee, Dr. Najafali Karimian, Dr. Farid Moore, Dr. Majid Baghernejad, Dr. Farhad Khormali, Dr. Hamidreza Owliaie, for their encouragement, technical support and helpful discussions, and insightful comments.

My gratitude goes to many friends at Shiraz University, Dr Soheila Hashemi, Dr Mehdi Najafi, Dr. Maryam Mohammadikish, Dr. Mostafa Emadi, Samad Gholami, Hamidreza Jaberi, Safoora Fathi, Diba Asapoor, Reihane Soleimani, Mahrooz Rezaie, Sara Kharazmi, Fatemeh Javaheri, and Rezvan Rezaienejad, for providing invaluable assistance in many aspects and for all the fun we have had during the whole period of the study. I extend my thanks to colleagues and staff of the Soil Science Department, Shiraz University, who have contributed in many ways during the course of my stay. Also, I extend my thanks to all the office staffs, technicians and students of soil science department, Granada University (Spain) for their co-operations.

Last but not the least, my deepest gratitude goes to my beloved mother and also my sisters and my brother for their endless love, supporting and encouraging me throughout my life. To those who indirectly contributed in this research, your kindness means a lot to me. Thank you very much.

Abstract

Morphology, geochemistry, Mineralogy, and Micromorphology of soils of Hormozgan province in relation to parent materials

By

Hakime Abbaslou

Geochemical, mineralogical, and micromorphological characteristics of soils and relevant parent rocks were assessed in the region lying between southern parts of Zagros and Persian Gulf to Oman Sea (Hormozgan province, Iran). The objectives of this study were to identify the variations in physical, chemical, and mineralogical composition of soils, study the micromorphology and soil development, and address element distribution of soils in the context of their weathering, soil forming process and geology to describe the impacts of parent material and soil evolution on soil characteristics. X-ray diffraction (XRD), thin section studies, Transmission Electron Microscope with EDX, X-ray fluorescence (XRF), Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) were used to obtain the desired data. The studied area has an arid climate with predominant sedimentary and basic igneous parent rocks. Soils were classified as Regosols, Leptisols, Arenosols, Cambisols, Solonchaks, Gleysols, Gypsisols, Calcisols, and Luvisols. Primary minerals consisting of quartz, feldspar, mica, apatite, amphiboles and secondary minerals including evaporitic minerals (halite, gypsum, calcite, and dolomite) and phylosilicate minerals (Illite, sepiolite, and 14 A°-phyllosilicates) were identified in the studied soils. The clay minerals analysis showed an order of abundance as: chlorite ≈ palygorskite > Illite > mixed layer> smectite>> kaolinite. Concentrations of elements in soil and parent material were mostly in the proposed range of world's soil average and relevant parent material by different references. Furthermore, slight elemental differences between soil horizons indicated that most soils are poorly developed and also represented the similarity of trace element contents between soils and parent materials. In addition to high contents of alkali and alkali earth elements of the soils with high amount of sand and silt fraction, both the Chemical Index of Alteration values (4.61 to 67.40), Chemical Index of Weathering values (4.82 to 71.73) and also high Product of Weathering Index (PWI) and Weathering Index of Parker (WIP) contents, suggest a relatively mild weathering source area.

TABLE OF CONTENTS

CONTENTS **PAGE**

CONTENTS **PAGE**

LIST OF TABLES

TABLES **PAGE**

LIST OF FIGURES

FIGURES **PAGE**

CHAPTER I
INTRODUCTION AND OBJECTIVES

1- Introduction and objectives

Soil as one of the most important natural resources, has a substantial effect in ecosystems of the world. Civilization development has had a close relationship with soil quality and soil utilization. Much and unreasonable use of lands such as overgrazing and woodcutting are responsible for most of the desertification of rangelands. Cultivation practices inducing accelerated water and wind erosion are most responsible in the rain-fed croplands, and improper water management leading to salinization is the cause of the deterioration of irrigated lands. In addition to vegetation deterioration, erosion, and salinization, desertification effects can be seen in loss of soil fertility, soil compaction, and soil crusting. Urbanization, mining, and recreation are having adverse effects on the land of the same kind as is seen on range, dry farming, and irrigated lands. Combating desertification can be done successfully using techniques already known if financial resources are available and the political will to act is present. Soil studies and land

evaluation are the most important preferences in programming plans and determining utility policies according to capability and potential of lands.

In regard with soil characteristics and soil development degree effect on agriculture activities, natural resources, desertification, land use, engineering, and so on, therefore investigation of soil pedogenesis and development are institutional and fundamental studies. Most of soil characteristics including shrink-swell potential, cation exchange, aeration, infiltration, and soil fertility parameters depend on type and amount of minerals, especially clay minerals. Throughout the world, mineralogy composition is base and potency of soil productivity. Recognition and investigation types of soil minerals and pathway of development and transformation, in addition attain condition of pedogenesis and evolution of soil development is helpful to open a wide view in use and condition of land use and land controlling. Widespread studies in arid and semi-arid regions show that palygorskite, smectite, chlorite, illite, kaolinite and vermiculite are the dominant clay minerals (Eswaran and Barzanji; 1974; Khademi and Mermut, 1998; Owliaie et al. 2006).

Soil micromorphology study undisturbed soil samples with microscopy and ultramicroscopy techniques were carried out in order to investigate soil constitution and also spatial and time relations with each other. In soil Micromorphology, soil constitutions are investigating in regard with size, shape, orientation and concentration. Micromorphology describes quantity amount of soil constituents and also way of orientation and distribution as a valid criteria in soil process evaluation and soil reaction to different land uses (Stoops, 2003).

The presence of gypsum in soils affects most of their properties, causing several physical, chemical, and fertility problems (Mashali, 1996). This is especially important in soils from semi-arid and arid areas, where gypsum behaves as a semi-soluble soil constituent and where its presence beyond a given threshold affects plant growth and their

productivity (FAO, 1990). Soils present different types of gypsum accumulations in micromorphological studies (Poch et al. 1998).

Distinction between pedogenic and geogenic carbonate is of great importance, e.g., in soil classification, and more recently with regard to carbon sequestration (Monger and Gallegos, 2000) and has been discussed many times in literature. Pedogenic carbonate can give a wealth of information regarding the environmental conditions during its formation, mainly on the pedoclimate. Together with clay mineralogical data it can be used to separate pedogenic from postpedogenic processes thus having important applications in palaeosol studies (Levine and Ciolkosz, 1983; Harden, 1982; Harrison et al. 1990). Different soil properties and parent material in regard with physic-chemical properties and mineralogy will be beneficial in rebuilding and understanding paleoclimate conditions (Khormali et al. 2005).

The concentrations of trace elements in residual soils depend mainly upon the bedrock type, from which the soil parent material is derived, and pedogenic processes acting upon it (Mitchell, 1964). The influence of the parent material on trace elements tends to decrease with soil development (Zhang et al. 2002).

Geochemistry data can be used to define ranges of soil properties for soil series or mapping units, including taxonomic placement (Burt et al. 2001). It has been useful in characterizing pedon and landscape processes such as direction or extent of weathering and determining the nature or origins of parent materials (Muhs et al. 2001). Geochemical data are also useful in relation with pedogenesis, soil classification and taxonomy, soil reclamation and amendment (, Burt et al. 2000; Wilson et al. 2008). Recent efforts in analysis of trace and major elements (geochemistry) have provided necessary data to soil survey users in a variety of areas.

Hormozgan province has partly severe limitations in soil depth, salinity, fertility and climate. Also nearly 13.78% and 30.26% of total lands are overlaid with salt domes and gypsum formations, respectively.

In addition major parts of Hormozgan province are relevant to miscellaneous, hill and mountainous land types. In spite of severe limitations and few capable lands with arid climate, have variety soils developed from different parent materials. Being part of arid environment with diverse parent materials and also few comprehensive studies regarding physico-chemical properties, mineralogy, geochemistry, and pathway of soil development express the importance and necessity of research. Therefore, the main objectives of this study were to:

(1) study the formation and development of soils derived from variety of parent materials under arid and hyper arid climates;

(2) investigate the detail mineralogical analysis of soils and sedimentary rocks of Hormozgan province to establish the contribution made by sedimentary material to arid soils developed on evaporates and alluvium materials;

(3) study the mineralogy of different grain size particles (sand, silt, and clay) in arid region with light textures to distinction of provenance and resultant factors on distribution and types of minerals;

(4) study of soil micromorphology and also investigation on present phenomena in soil and its relations with soil characteristics;

(5) quantify the geochemical composition of the soil and parent rocks in order to assess the influence of inherited lithogenic factors on the content of major elements and their fate during weathering and pedogenesis in arid soils;

(6) assess the background concentrations of trace metals in different studied soils, and

(7) evaluate the soil properties and estimate potential trace element bioavailability to investigate soil quality.

CHAPTER II
LITERATURE REVIEW

2. Literature Review

2.1. The origin and formation of minerals in soils and parent rocks

In order to address society's needs related to soil resources, it is important to understand the landscape distribution of soil minerals and the processes responsible for their occurrence (Graham and O'Geen, 2010).

The resulting wide variety of soils and soil minerals plays a critical role in ecosystem function, land management, and quality of life. Soil minerals can be used to help understand soil pedogenesis (Owliaie et al. 2006; Graham and O'Geen, 2010). Inherent soil fertility issues are often directly linked to soil mineralogy (Page et al. 1967; Murashkina et al. 2007). Soil water behavior and irrigation management, so critical in arid and semi-arid soils, are controlled to a large degree by the amount and kind of soil clays (Al-Omran et al. 2005). Soil aggregation and carbon