IN THE NAME OF GOD

MINERALOGY, MICROMORPHOLOGY AND DEVELOPMENT OF THE SOILS IN ARID AND SEMIARID REGIONS OF FARS PROVINCE, SOUTHERN IRAN

BY

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THESIS

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Dedication

To my dear wife, Arezu

for her love, patience, sacrifice and encouragement

To my dear mother and father

for their loving guidance, support and prayers

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ABSTRACT

Mineralogy, Micromorphology and Development of the Soils in Arid and Semi-arid Regions of Fars Province, Southern Iran

By

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The present study on clay mineralogy and micromorphology of calcareous soils of arid and semiarid regions of Fars Province, southern Iran, were carried out in order to investigate: (1) the origin, evolution and distribution of clay minerals in soils and parent rocks; (2) micromorphology and evolution of soils under arid and semiarid conditions; and (3) climatic evolution of the Tethys region of southern Iran. Based on the previous soil survey maps of the Fars Province, 75 soil series in 30 important plains were selected for this study. Pits were dug, described and classified. Thirty four representative pedons and 8 parent rock samples were selected for further mineralogical and micromorphological studies. The following results were obtained:

(1) The climatic evolution of the Tethys in southern Iran, as concluded from clay mineralogy of parent rocks revealed that the presence of a high amount of kaolinite in Lower Cretaceous sediments

and the absence or little occurrence of chlorite, smectite, palygorskite and illite are in accordance with warm and humid climate of that period. Lower amounts of kaolinite and the occurrence of smectite in Upper Cretaceous sediments indicate the gradual shift from a warm and humid to more seasonal climate. Kaolinite disappearance and presence of some palygorskite and smectite in the late Paleocene sediments indicates an increase in aridity which continued to the present time.

(2) Detrital input is probably the dominant factor responsible for the presence of large amounts of kaolinite in Cretaceous rocks. Chlorite, illite, associated quartz and feldspar are also mainly inherited in rocks. *In situ* neoformation during the Tertiary shallow saline and alkaline environment is the dominant cause of palygorskite occurrence in sedimentary rocks. Smectite appears to be mostly of detrital origin in rocks and can originate from soils developed under a warm to temperate climate characterized by alternating humid and dry seasons. There was no smectite detected in Lower Cretaceous sediments, probably due to warm and humid environment of that period.

(3) Clay mineral distribution in soils revealed that the presence of some kaolinite in north-western parts of Fars Province is due to inheritance from the surrounding kaolinite bearing Cretaceous rocks. Illite and chlorite abundance in the soils are largely due to their presence in parent rocks. Smectite is detected in trace amounts in arid soils of the southern, south-eastern, south-western and northern parts, while increases in north-western areas where the soil available moisture is higher. There is a reverse correlation between palygorskite and smectite with regard to the soil available moisture and

palygorskite is low over P/ET° (ratio of mean annual precipitation to mean annual reference crop evapotranspiration) of greater than 0.4. This indicates that palygorskite is highly unstable above P/ET° of 0.4 and weathers mainly to smectite. Palygorskite is considered to be inherited in plateau soils of the arid regions, whereas its occurrence in saline and alkaline soils and soils high in gypsum is mainly of authigenic origin. Rare occurrence of vermiculite in the studied calcareous soils is probably related to its instability under high pH, low Al activity, high Si and Mg of the soils studied.

(4) Studied argillic horizons, meet the requirements for an argillic horizon in Soil Taxonomy. Evidence of clay illuviation is deduced from the greater ratios of fine clay to total clay in the argillic horizons than in the overlying eluvial horizon. The shrink/swell characteristics on wetting and drying are the main factors explaining the destruction of clay coatings, because these features are best preserved in lighter textured soils formed on more stable geomorphic surfaces.

Horizon decalcification is the dominant factor in the evolution of calcareous soils with argillic horizons. Decalcification and clay translocation probably occurred during a past less arid climate, followed by a recarbonatation during subsequent dryer periods. Nevertheless, calcite depletion pedofeatures in the upper horizons of some profiles point to a still active movement of carbonates. The degree of development of the argillic horizons ranges from well developed, with strong decalcification, to weakly developed with little or no decalcified zones and formed in coarser grained parent materials or in those developed in previously Na-rich saline and alkaline conditions.

The proposed micromorphological index (MISECA) for evaluation of the argillic horizons in a highly calcareous environment expresses their degree of development and is strongly correlated with free Fe_2O_3, the colour index, the clay illuviation index and smectite/(chlorite+illite) ratio. Using this index, the argillic horizons of the area can be classified from weakly to well-developed.

A new subgroup *Gypsic Haploxeralfs* is suggested for inclusion in Soil Taxonomy for Haploxeralfs with a gypsic horizon within 100 cm depth from the soil surface and underlying an argillic horizon with or without a calcic horizon. Moreover, to accommodate Argiustolls with a calcic horizon underlying the argillic horizon within 100 cm depth from the soil surface, the new subgroup *Calcic Argiustolls* is also suggested for inclusion in Soil Taxonomy.

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