CHAPTER I

INTRODUCTION

Introduction

1.1 Preliminary considerations

It is now well established that clays are essentially composed of extremely small crystalline particles of one or more numbers of a small group of minerals, known as clay minerals. All clay minerals are predominantly hydrous aluminium silicates. The aluminium atoms in some minerals are replaced either wholly or partly, by Mg or Fe. Sometimes alkali and alkaline earth metals are also found to be present in some clay minerals.

Clay minerals play an important role in various fields of scientific and technological interests. The study of clay minerals is of great interest to the agriculturists and soil scientists. The occurrence and properties of clay minerals govern the soil fertilization and the plant nutrition to a large extent. Hence such a study of the clay minerals is of special importance in agriculture. Besides agriculture, such study is also useful to the construction engineers. The physical properties of a soil largely depend on the prevalence and kind of the clay minerals present therein. Hence the physical properties of these clay minerals present in the soil will largely be responsible for the stability of the structures built on it. Clays are also very important in certain industries. In oil industry certain clays have important catalytic activity. They are also used as drilling muds. It is widely used in foundry industry for moulding purposes. But of all the industrial uses of clays, the use in ceramic industry stands first. It is the most essential and important raw material in ceramics.

In most of the cases of industrial uses of clays, they are either subjected to heat treatment or to simple dehydration at ordinary atmospheric conditions. In view of these facts, dehydration and the effect of heat on clay minerals as well as the products thereof, are considered to constitute an important field of study. Hence a study of dehydration namely the effect of heat treatment and the consequent changes in their structural and physical properties are of great importance to the users of clays. In fact considerable amount of work has already been done and is still being carried out by a host of workers in this field of ceramic technology. The results of such investigations are very much useful in understanding their behaviour and interpreting them to adjust the industrial operations involved in their uses. Apart from this, such studies help in determining the structure of the clay minerals and their products. Besides this, end products of heat treatment are affected by the rate and range of heat treatment at intermediate stages. Thus study of the intermediate products is of great importance.

Different types of clay minerals are always present in clays. Among these different types of clay minerals, kaolin group is the most important. This group of clay minerals is an essential constituent of most of the clay materials and is most abundantly prevalent in natural deposits. There are four distinct minerals which have been recognised as belonging to kaolin group of clay minerals. These four members of the group are nacrite, dickite, kaolinite and halloysite. All these members are hydrated alumino-silicates and their chemical analyses conform closely to the ideal oxide ratios $Al_2O_3 : SiO_2 : H_2O = 1 : 2 : 2$. Among these four members, kaolinite and halloysite occupy the most important place in clay mineralogy. Kaolinite is present in almost all clay deposits to some extent and often constitute the major part of the clay fraction. Compared to kaolinite, halloysite is less prevalent in clay deposits whereas the other two members are still less frequently found to occur in natural deposits. The four members of the kaolin group are structurally very similar. All of them have layer structure and are built up by the superposition in various ways of a basic unit layer, called kaolin layer. This basic unit layer has the structural formula $Al_4\ Si_4O_{10}(OH)_8$ or in terms of oxide $Al_2O_32SiO_22H_2O$. The difference among the members consists in the way in which the unit layers are stacked and in the number of unit layers per unit cell. The number of layers decreases from six in nacrite to two in dickite and one in kaolinite. The fourth member, namely halloysite exhibits, as will be discussed in section 1.3 some pecularity of structures.

Although halloysite shows the same alumina : silica ratio as for kaolinite, its water content is higher and the stacking sequence of the layer is highly random. From a study of the randomness in the arrangement of the kaolinite-halloysite type Brindley and Robinson[1] have observed that kaolinite and halloysite represent the end members of a series in which the disorder increases from kaolinite to halloysite. Besides, halloysite exhibits a tubular structure. All these pecularities have made halloysite an interesting mineral of this series.

1.2 Structure and structure defects in kaolinite

1.2.1 Structure of kaolinite

Kaolinite is the simplest member of the kaolin group of clay