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STUDY OF NANOSCOPIC SIGNATURES OF DECAY OF MARBLE BUILT MONUMENT USING SCANNING EKECTRON IMAGING TEHCNOLOGY

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SHORT COMMUNICATION

The significance of rocks has been realized by mankind as a tool for ignition, dwelling and carving from prehistoric period. During the course of sequential development, monuments such as temples, built up from rocks have been considered as a tool for religious fervour [1] The rocks used for construction of monuments decay with time in any region and in any environment, but the intensity of decay vary from one region to other and from rock to rock. The decay process of rock is a complex phenomenon. It is controlled by factors that are intrinsic to rock as well as by influences that are external [2]. The intrinsic factors are concerned to the physical, chemical and mineralogical characters of building material of monuments. The extrinsic factors are mainly concerned to the environmental set up around the monuments. Any change in extrinsic factor controls the rate of decaying of building material of monuments. In other worlds, the physical, chemical and mineralogical quality of building material of monuments may undergo deterioration with the influence of meteorological (climate), atmospheric and terrestrial parameters. Petrography is the systematic study of intrinsic characters of rock [3]. With the help of advance imaging microscopes or nanoscope, images of intrinsic characters of rocks from milli to nano scale can be generated for easy delineation of alteration, if any, caused by agents of weathering that are extrinsic.

Deterioration in rock built monuments is caused by physical, chemical and biological weathering processes. Physical weathering is the breakdown of material entirely through mechanical method. Evidence of physical weathering in rock built monuments includes exfoliation, pitting, cracking, carving, cavitations, abrasion and mechanical collapse [4]. Chemical weathering involves changes that can alter both the chemical and mineralogical composition of rocks. Mineral constituents of rocks are attacked by water, oxygen and CO_2 of the atmosphere. These atmospheric components enforce the minerals to be dissolved and be removed in solution. The breakdown of the rock and mineral is very largely controlled by plants, animal, human and micro organism. The growth of micro vegetation on the stone surface of monument is one of the main factors responsible for weathering phenomenon through surface erosion. The main micro vegetation groups responsible for bio- deterioration of monuments are algae, fungi and mosses [5]. Physical breaks up of rock into fragments may result from burrowing animals. Growth of plants roots may aid in the widening of joint of monuments, while micro organism like algae and lichens may contribute to chemical weathering through the formation of organic acids. The cumulative efforts of all these weathering processes may cause decay of rock built monuments.

The present investigation is an attempt to identify the physical, chemical and biological weathering processes that causing deterioration in Shri Jagdish temple of Udaipur. Maharana Jagat Singh built this temple in 1651 A.D. Shri Jagdish temple is situated in the middle of the city (figure 1). It is raised on a tall terrace. This temple is dedicated to Lord Vishnu. Shri Jagdish temple is constructed with white marble. The entrance to the temple is a flanked by two massive stone elephants. The temple has a pyramidal spire (Sikhar), a vestibule (Mandap) and is decorated with friezes of dancers, musicians, elephants and horsemen. A big brass statue of Garuda, the vehicle of Lord Vishnu stands guard in front of the main shrine [6]. Shri Jagdish temple is situated at 588 m above MSL. The geographic co-ordinate of this temple is $24^{o}34'43.51''$N latitude and $73^{o}\ 41'2.5''$ E longitude. This city enjoys cold season from December to February and is followed by the hot season which last till about the middle of the June. Mid June to mid September constitute the south west Monsoon season. The average annual rain fall in this district is 650.3 mm. January is generally the coldest month with the mean daily temperature varies between 24.2^{0} C to 7.8^{0} C. The diurnal range of temperature is large particularly in the winter and summer months. Both day and night temperature rise rather rapidly after the end of February till May, which is the hottest month of the year. The mean daily maximum temperature in that month is 38.6^{0}C. Relative humidity is about 70% during monsoon period and decreased down to 20 to 25% in summer particularly in the afternoons

White marble has been traditionally used as a quality building material for construction of many monuments in Rajasthan. Shri Jagdish temple is one of them, constructed with white marble due to its local availability, workability and attractiveness. Unfortunately, this marble is also suffering from discoloration and disfigurement due to attack of agents of weathering. Small chips from weathered and fresh portions were collected from various part of temple in order to identify agents of weathering using Nanoscopic imaging techniques. Under this technique, Nanoscopic studies of weathered and fresh samples were carried out with the help of scanning electron microscope (SEM)and other petrographic imaging

techniques. These studies reveal that outer thin crust in weathered samples composed of dust, alteration product and algae growth. Micro cracks were noticed between fresh and weathered portion of sample. The crust formed by decayed or weathered material is capable of absorbing a greater amount of moisture from atmosphere that is the basic requirement for growth of algae. The secretion of oxalic acid from such algae has enhanced the rate of weathering manifold. Thus the combined actions of dust, sun insolation and algae have caused the discoloration and disfigurement of the temple

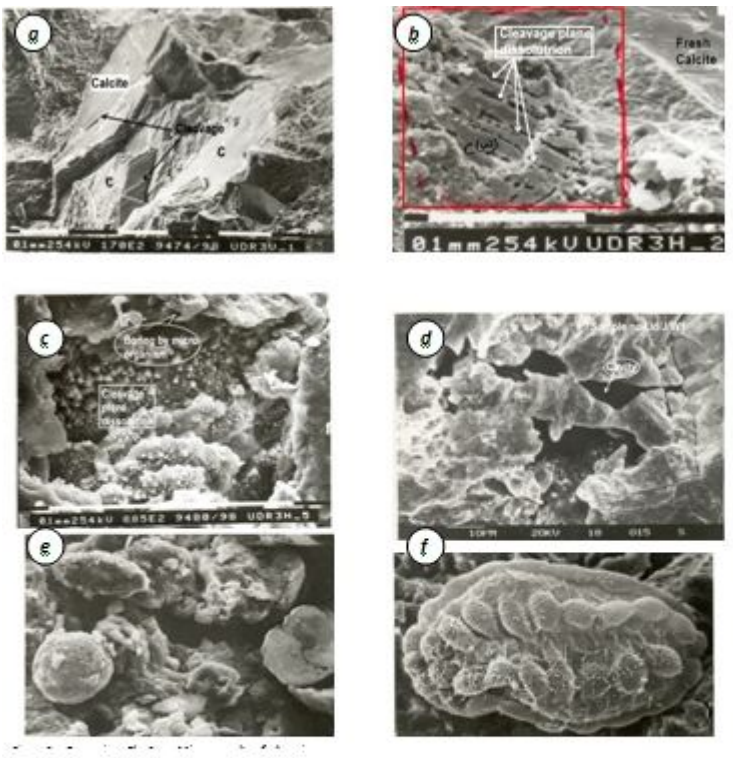

Figure1 *Scanning Electron Micrograph of showing*

a, Rhombohedra shape of fresh calcite with three sets cleavage *in Sample no Ud/R/3.* ***b,*** Cleavage plane dissolution of calcite in *Sample no Ud/R/3* . ***c,*** Cavity and dissolution along cleavage in *Sample no Ud/R/3.* ***d,*** *Disfigurement of surface due to formation of cavity in sample no Ud/J/W1.* ***e,*** cells of micro organism in *Sample no Ud/R/3.* ***f,*** High resolution micrograph of micro organism in *Sample no Ud/R/3.*

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