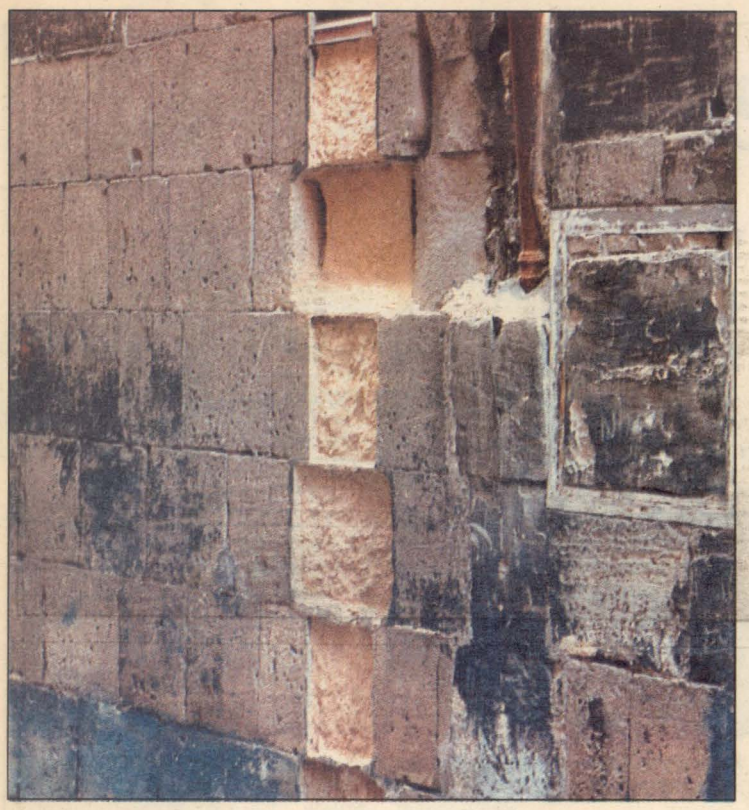

WEATHERING of poor quality dimension stone

Natural weathering processes affecting limestone

by **Lino Bianco, BA, BE&A (Hons.), M.Sc. (Leicester), A&CE**

ALTHOUGH rock types do not vary, rock material varies with the environment of deposition and the subsequent mineralogical and tectonic history. Departing from this environment encourages natural weathering processes.

Dimension stones extracted from the Globigerina formation weather more rapidly if used, say, in the British Isles. The main naturally occurring forms of weathering are physical and chemical. A discussion of the causes and remedies related to weathering and deterioration of Lower Globigerina Limestone can be found in a paper read by architectural consultant Mr Michael Ellul, then Head of the antiquities section at the Ministry of Public Works, in a symposium held in Athens.

Climatic, hydrospheric, and topographical controls govern the natural weathering processes of building and monumental stone.

Within a given climate the following are critical to any weathering process:

1. precipitation, including its intensity, duration, and frequency,
2. evaporation, and
3. temperature changes: both diurnal and seasonal.

The importance of hydrospheric controls in the deterioration and subsequent breakdown of the host rock material is evident in the crystallisation processes taking place during physical weathering.

Physical weathering

The significant role played by topographic controls is visible in sloping sites. Such sites are more prone to weathering. The greater the slope, the easier it is for material to be eroded. The fabric and host rock material is subject to infiltration and/or flow of surface run-off.

The geometry and orientation of the sites affect the rate of evaporation and the microclimate.

Work carried out by authors such as Peltier (1950) and Sanders and Fookes (1970) emphasises the close dependence of physical weathering processes on climatic conditions. Physical weathering results in the break-up of the limestone into smaller fragments.

Neither mineralogical nor chemical changes take place (Rieche, 1950). Alternate cycles of wetting and drying, and of heating and cooling, build up stresses within the fabric. Flaws in the fabric and discontinuities in the surface are weak areas and hence potential regions where rapture may take place.

All physical weathering processes are essentially short-term, cyclical processes. The main ones are crystallisation and thermal gradients.

It has long been recognised that crystallisation of salt is a major cause of deterioration, especially in the Globigerina limestone (de Boisgelin, 1805). Salts attacking buildings may be derived from chlorides in groundwater, sea-spray, and atmospheric dust.

If sulphates are present in the ground, they may act as another source of salts reaching the buildings. Salts, on crystallising, may generate forces within the fabric much larger than the tensile strength of the host material.

The pressures generated by crystallisation of salts may be in the range of 2 to 20 MPa (Ollier, 1984). Uptake of water in the fabric causes swelling of some minerals followed by expansion of the host material (Nishioka and Harada, 1958). The expansive stresses of water wedge open fractures. Expansion is larger if the host material is chemically weathered.

Applying the Institute of Geological Sciences classification of limestones by calcium carbonate content (Cox et al, 1977), the Globigerina limestone may be considered to be of very low purity (Murray, 1890, and Bianco, 1993).

The impurities include various minerals. These minerals have different coefficients of thermal expansion. Differential expansion generates inter and intra particle stresses.These may develop microcracks which will lead to breakdown of the cementing fabric.

Chemical weathering

Chemical weathering requires the following processes to take place concurrently (Loughnan, 1969) :

a. The disintegration of the mineral structure of the parent rock such that ions and molecules are liberated;

b. The removal of some of these elements in solution;

c. Chemical reaction of elements in solution with water, oxygen, or other elements present in the atmosphere to form new minerals. With respect to the environment these minerals may be either in a stable or metastable state.

Solution rates are a function of a number of factors. These include temperature, velocity of flow, pH of the solvent, wind direction, and gradient of site.

Balance between physical and chemical weathering

Physical and chemical weathering often occur concurrently in nature. Though their respective mechanisms are independent, they frequently occur together. Either one is usually dominant in a particular climatic set-up. Studying weathered igneous rocks of South Africa, Weinert (1964) proposed the following relationship between the type of weathering process and climatic factors :

Agents which encourage natural weathering

Table 1: Defects associated with natural weathering

AGENTS	DEFECTS
Natural defects	soft beds within the quarry; inherent microcracks in the sediment due to earth movement.
Workmanship	extraction methods; processing methods; improper selection of dimension stone; dimension stone laid on edge or face bedding; poor detailing.
Choice of materials	dimension stone not suitable for the design requirement; use of materials with properties incompatible with those of the dimension stone being used.

N :– [(12 * EJ) / Pa]

where Ej : potential evaporation during the warmest month (January);

Pa : mean annual precipitation;

He found that if (N > 5) then physical weathering is the main weathering process, and if (N < 5) then chemical weathering is the main weathering process.

The dynamics of natural weathering, whether physical, chemical, or both, is accelerated by either natural defects inherent in the building fabric, or poor workmanship, or improper choice of materials, or any combination of these agents. Defects associated with each of these agents are given in Table 1.

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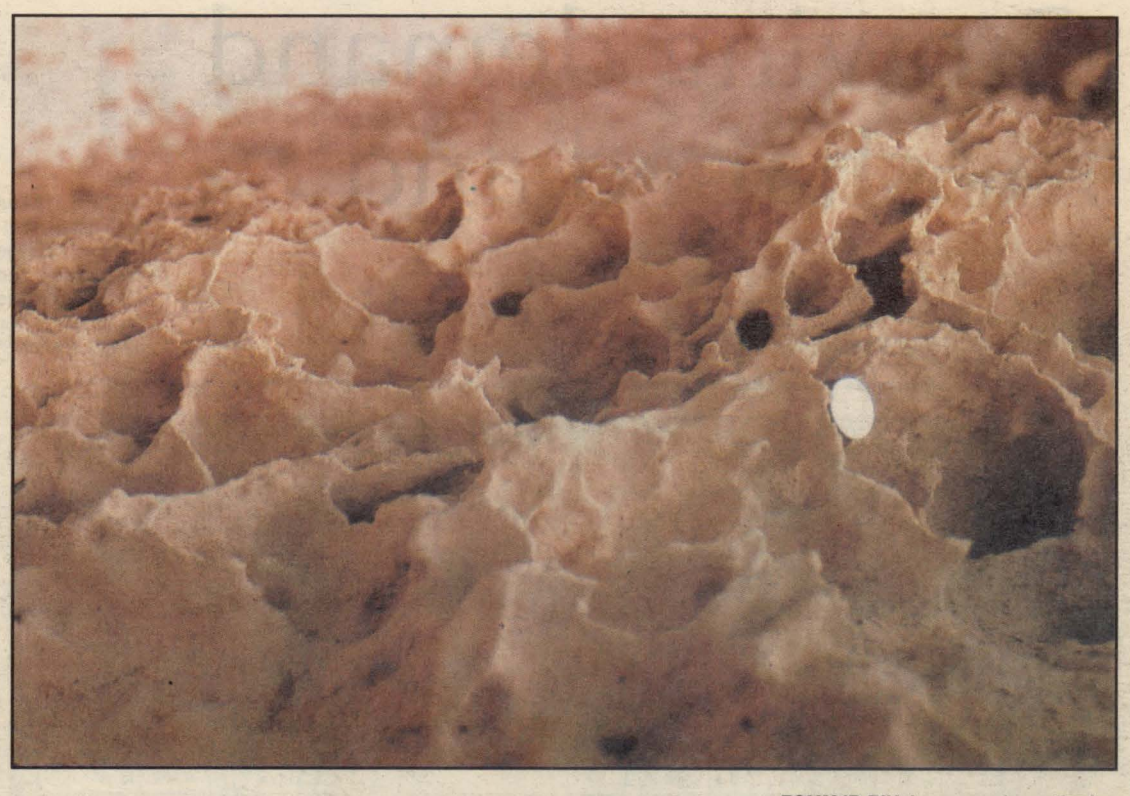

FOMM IR-RIH, honeycomb weathering of Globigerina Limestone (coin diameter 30mm)

Restoration of bastions

A NEW SECTION is being set up shortly within the Works Department Ministry to deal the restoration of bastions. Besides, plans for the restoration of the Wignacourt aqueduct at Mriehel have been drawn up, which will include the rebuilding of that part of the aqueduct near the Fleur-de-Lys roundabout, which had collapsed years ago.

This was announced recently by Environment Minister Francis Zammit Dimech during the presentation of certificates to private contractors and officials from various government departments and parastatal bodies who followed a course on modern methods of excavation work. These courses, of which eight were held, were organised by the Works Department with the help of consultants from an English company, Hydrex Equipment Ltd, which specialises in machinery used for road works.

Before presenting the certificates, Dr Zammit Dimech said the policy of the government is to provide training not only to its employees and those in parastatal companies, but also to all those involved in government contracts, "because only in that way can we start achieving a professional mentality in all we do".

He said that in the past road works, including the digging and filling of trenches, used to be done "in a most primitive" way, with no planning and causing damage to streets.

Over the past few years Government has taken measures to create a new mentality among all those involved in works of this kind. "These measures have already started leaving the desired results," the minister said, "because these works are being done more seriously and with the use of the most modern machinery." He said that as it has been decided that only contractors who are awarded a certificate will be considered for this type of work, courses of this kind will now be held more frequently.

Referring to the setting-up of the section dealing with the restoration of bastions, Dr Zammit Dimech said that the idea is that workers assigned to this section will be given proper training, even abroad, if necessary.