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Identification and cause of decay of building materials used in the architectural heritage of Bizerte city (Tunisia)

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Monuments and historical buildings of Bizerte show a disturbing state of degradation. In order to propose a compatible materials for the restauration works such as stone of substitution and restauration mortars, a geological context was analysed with the objectif to localize historical quarries accompanied by a sedimentological study to identify the exploited geological formations. Petrophysical and chemical caracterisation of both stone and mortars have been carried out. With the aim to determine the origin of the erosion and the degree of stone decay, a combination of micro-destructive and non-destructive techniques have been used on-site and in-lab. Moisture measurements, ultrasonic velocity propagation and water absorption by Karsten pipe test together with polarized light and fluorescence optical microscopy, mercury intrusion porosimetry and ion chromatography analyses were carried out to perform petrophysical characterization of stone samples and determination of soluble salts. For the characterization of mortars, granulometric study was performed to determine the nature of components and their grain size distribution. Thin sections of mortar samples were examined for the petrographical and mineralogical characterization. X-ray diffraction (XRD) analysis of finely pulverized samples was performed in order to identify the mineral crystalline phases of the mortars. Thermal analyses [thermogravimetry (TG)] were performed in order to determine the nature of the binder and its properties. Porosity was determined following UNE-EN 1936 (2007) standart test.

Geological and petrographical study showed that historical buildings are essentially built with high porous bioclastic calcarenite partially cemented by calcite which is Wu¨rm in age and outcrops all along the northern coast of Bizerte where several historical quarries were identified. Occasionally, two other types of lithologies were used as building stones and they correspond to two varieties of oligocene sandstones (brown quartz-arenite cemented by iron oxide and ochre-green colored sandstone cemented by calcite) and an eocene white limestone corresponding to a fine-grained globigerine wackstone according to Dunham classification.

Results of the petrophysical study show that small variations in the petrographic characteristics of the building geomaterials, such as type and degree of cementation, porous network configuration and presence or absence of soluble salts leads to differential stone weathering.

Results of study's mortars show that original and restoration mortars have similar mineralogical composition but different grain size distribution and proportion of binder/agregats. They differ equally by the nature of raw materials as demonstrated by the thermal analyses. The study show that little variation of these parameters can affect the durability and the performance of mortars and can accelerate the degradation process of the building stones, especially the oligocene and eocene lithotypes.