ABSTRACT. — The hilly territory of the eastern Emilia-Romagna up to the Apennine watershed, also comprising part of the Romagna Toscana, represents in Italy the main sandstones producer, along with the Pietra Serena of Firenzuola and Marradi and the Pietra Serena from the Savio valley. Minor districts, not less important for the local economy are also present, such as those exploiting the selenitic gypsum of Brisighella, Borgo Rivola, Borgo Tossignano, Bologna and the «Crystalline Alabaster» of Torriana, the San Marino calcarenites, the Montefeltro limestone and the Montovolo and Castel d’Aiano sandstones. We should not forget the historical-cultural heritage constituted by the now dismissed quarries of the Varignana, Sasso Marconi, Monghidoro, Castiglione dei Pepoli and Porretta sandstones, employed since the Villanovian, Etruscan, Roman, Medieval and Renaissance ages; as well as unique materials, locally employed, such as the Montecodruzzo limestone, the Spungone calcarenite, the Labante travertine, the euphotide gabbro and the Mantescas and San Zanobi serpentinites.

The aim of the authors is to give in this work some historical elements of knowledge on dimension and ornamental stones and not to put forward a research work regarding the geology and stratigraphy of the area.

KEY WORDS: Dimension and ornamental stones, quarries, petrography, employment.
INTRODUCTION

The territory located on the eastern side of the Emilia-Romagna region, in the area bounded by the via Emilia axis and the Toscoromagnolo Apennine ridge, preserves evidences of stone employment which since the Villanovian age are coming up to nowadays. All the different populations and cultures who inhabited these regions following one another, have found in the stone a proper material both to put into effect artistic and religious expressions and to build public and private works. The presence of stone materials in a city normally represents the synthesis between building stones occurring in the hinterland and rocks which have been imported even from very far places. They indifferently and powerfully fulfil both aesthetic tasks and structural requirements.

As far as we consider the cities examined in this paper, from Bologna to Imola, Faenza, Forli, Cesena up to Rimini, the most common building materials are sandstones, selenites and limestones, coming from nearby quarries and therefore easy to be found with reasonable purchase and transportation costs. Besides these «poor» materials, stones coming from the Venetian and Istrian quarries are harmoniously associated. The thick canal network connecting these cities to the Adriatic sea and to the Po river, together with the via Emilia and Romea, made it possible for these materials to be brought in large amounts and then employed mainly in factories with «very rich economy» and in important public buildings. As stated before, these were very expensive materials; we should remember that such an important site as San Petronio, wanted by all the city inhabitants and by the powerful art corporations of Bologna, was never completed, not even the façade covering, due to the high materials’ costs, here, more precisely, referring to the Istrionic stone, to the white and red limestones from Verona and to the Candoglia marbles. To the stone, employed in portals, in architectural frameworks, in capitals, in carved cornices, in doors and windows fastigia, was attributed the duty of underlining the elegance, the nobility or importance of a building. These employment criteria had an even stronger importance on minor buildings, where the building ordinary character did not imply and justify a dismissal of the usual procedure. Therefore, the stone employment was restricted to a few and precise architectural elements in building prospects, such as corner parastades, coats-of-arms or decorative elements of some kind of importance.

Mainly referring to and taking inspiration from the famous work by Rodolico (1953) «Le pietre delle città d’Italia» and restricting this treatment to the territory previously described, our principal aim was collecting elements of geological, petrographic and mineralogical knowledge, together with the employment of locally mined dimension stones, and to investigate the deterioration phenomena these materials have suffered since they have been employed in the urban environment. We think that the arguments we collected in this paper could help earth scientist and cultural heritage estimators to better understand the relationship existing between these cities and the surrounding land, and that a careful utilization of georesources can produce a general enrichment both economic and cultural.

LIST OF ORNAMENTAL STONES: GEOLOGY, PETROGRAPHY AND HISTORICAL EMPLOYMENT

The terrains outcropping in the investigated area (Fig. 1) are mainly represented by clastic sedimentary rocks and subordinately by evaporitic and carbonatic rocks while only a very small part consists of ophiolites.

The rocks which have been mined in the past and are nowadays mined in the active quarries of the Santerno and Savio river valleys, represent an important georesource for these mountain territories; they will be described according to a chronological order referring to the geological age of the belonging formation (Società Geologica Italiana, 1990).
Fig. 1 – Geological map showing the lithotypes outcropping in the investigated area and the main quarries we cited in the text (Modified after Bargossi et al., 2001).
A) The Sasso della Mantesca gabbros and serpentinites (Bologna)

GEOLOGICAL SETTING

Gabbros and serpentinites belonging to the Vara Supergroup ophiolites (external Liguride Domain), of Jurassic age, outcrop between the Idice and Sillaro river valleys scattered in the undifferentiated Chaotic Complex better known as «Argille Scaglione». These rocks, much more compact than the highly disrupted clays which include them, give rise to small relieves called «Sasso della Mantesca» and «Sasso di San Zanobi» (Grillini, 1977).

MINING ACTIVITY

Mining activity in the «Sasso della Mantesca» area in the watershed from the Sillaro and Idice valleys has gone on until 1940 and regarded the well known «euphotide» Gabbro, the «ranocchiaia Serpentinite» and the «serpentinitic Breccia».

MINERALOGICAL-PETROGRAPHIC CHARACTERS

Euphotide Gabbro

It’s a grey-greenish gabbro, coarse-grained (up to some centimetres) with granular hypidiotropic structure made up of albitized plagioclase crystals in which prehnite and chlorite plagues and veins, clay minerals’ granulations and strongly foliated, often chloritized and serpentinitized clinopyroxene (diallage) are present. Relicts of totally serpentinitized olivine have also been detected. The main accessory phases are represented by ilmenite, hematite and apatite (Fig. 2).

Serpentinites

They show cellular structure with large bastite aggregates in parallel and shining lamellae (lizardite) replacing the original orthopyroxene, embedded in a matrix made up of finer-grained serpentine and magnetite granulations (Fig. 3). Sometimes the rock is more or less intensively brecciated and re-cemented by the presence of yellow-light green-coloured chrysotile filling fractures and veins with a typical fibrous disposition which is perpendicular to the veins’ elongation. The «ranocchiaia» variety looks massive, with opaque magnetite which gives rise to oriented lineations embedding yellowish lizardite eyes. Chrysotile with a typical fibrous aspect in light veinlets scattered in a blackish matrix can also be observed. This ophiolitic lithotype

Fig. 2 – Photomicrograph of euphotide gabbro (Sasso della Mantesca); the lower part is made up of serpentinitized clinopyroxene diallage, the upper part of albitized plagioclase (N//).

Fig. 3 – Photomicrograph of serpentinite (Sasso della Mantesca) showing the typical cellular structure (N//).
frequently outcrops in the Ligurian-Emilian (La Spezia, Parma, Reggio Emilia, Bologna), Tuscan (the so called «Verde di Prato») Apennine and in the up Tiberina Valley nearby Anghiari and Pieve Santo Stefano.

**Serpentinitic Breccia (Ophicalcite)**

It is a breccia made up of green blackish-coloured serpentinite fragments bounded by a very thick calcite veins network (Fig. 4). Among the serpentinite fragments the previously described serpentine varieties and chrysotile veins fragments are both represented. Calcite is commonly coarse-grained, often occurring in isoriented crystals forming fibrous aggregates which crystallization is perpendicular to the veins elongation.

**HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION**

**Euphotide Gabbro**

The main employment of euphotide gabbros can be found in millstones along the Idice and Reno valleys in the Bologna province. This architectural material, with structural employment, can be found in Bologna in the «Palazzo della Questura» basis (1934), in road paving under the «Torresotti» circle door in Via Castiglione and in the external garden basal part of the «Stefaniano» Complex.

The typical coarse-grained structure and in particular the diargage pyroxene, often serpentinized and chloritized with evident cleavage planes, cause a selective deterioration with a deep rock disruption.

**Serpentinites**

The employment in Roman age is documented but limited; a great diffusion occurred in Romanic, Gothic and Renaissance age in Toscana and Liguria, defining the characteristic «pisano or toscano style» of Romanic churches with decorations alternating polychrome light and dark marbles. The application, mainly ornamental, in mirror-looking altars’ surfaces, cartouches, small columns and both wall and paving mosaic tarsia, arises from and is justified by its beautiful dark green colour.

The main deterioration morphologies, characteristic of this lithotype, are represented by a chromatic alteration revealed by a colour variation, turning into a grey-greenish, and by a partial disaggregation with detachment of bastite and lizardite crystals from the magnetite-formed groundmass, under minimum mechanical stress. The chrysotile, talc and calcite veins, occurring in particular in the serpentinitic breccia, can cause a thick net of cracks and preferential detachment surfaces to be produced.

**B) The Monghidoro Sandstone (Bologna)**

**GEOLOGICAL SETTING**

The Monghidoro Sandstone (Arenarie di Monghidoro) belongs to the external Liguride domain (Sambro Supergroup). This Formation signs the gradual change from the alternation of calcareous-marly and arenaceous-shaly turbidite successions from the underlying...
Monte Venere Formation (Maastrichtian-Paleocene) towards arenaceous turbidite sedimentation with a different sand/clay ratio, characteristic of both abyssal plain and outer fan environments. The top of the Formation is dated Upper Paleocene.

MINING ACTIVITY

The Monghidoro sandstones have been quarried near the Monghidoro village where three arenaceous horizons, dipping more or less parallel to the slope, are mined in the «Balzi del Carlino» quarry. The lower bed, about one meter thick, and the upper one about 50 cm thick are inter-divided by siltitic-muddy levels, show direct gradation (thinning upward) and are lamination free. Also in the locality Canovetta di Sopra near the S. Andrea Val Savena village these sandstones have been mined in the Canovetta quarry from an arenaceous horizon of about one meter medium thickness, dipping parallel to the slope with slight inclination, gradated and clearly lamination free.

MINERALOGICAL-PETROGRAPHIC CHARACTERS

The Monghidoro sandstones are classified as arkoses passing into lithic-arkoses, show colour ranging from light grey to yellowish and grainsize ranging from coarse to fine (Fig. 5). The siliciclastic component is dominant, with clasts of quartz, feldspars (orthoclase, plagioclase and microcline in abundance decreasing order), micas (muscovite, biotite and chlorite), igneous rocks fragments (haplites and acidic vulcanites) and rarely metamorphic rocks fragments (gneiss). The quartz-feldspar clasts present subangular lower sphericity morphology, while the phyllosilicates show a platy one. Carbonatic rocks fragments are quantitatively subordinate; they are micritic and spaticitic limestones with ellipsoidal morphology and curved rims. Accessory phases are mainly made up of opaque minerals (framboidal pyrite) and transparent minerals such as zircon and garnet.

The interstitial matrix among the clasts is filled by the siltitic component and by the spatictic carbonatic cement. The clastic component all together reveals a strong tendency towards the development of a sub-parallel isorientation with respect to the sandstone sedimentation plane, without formation of any level characterized by selective concentration.

HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION

Mining was carried out with artisan methods using hammers and wedges exploiting the rock veins; the caved material was used in loco for the construction of villages (with the characteristic tower-houses), of rural houses and for road paving.

The Monghidoro Sandstone nevertheless having a medium imbibition’s coefficient, shows, in the observed employments, an easy attitude to flaking and to the transformation into sand since it is particularly sensitive to the water disruption effect. Materials at work which display particular sedimentary structures, such as laminations or grain size heterogeneities, can cause after some time a differential deterioration with exfoliations and preferential detachments.
c) The Castiglione dei Pepoli Sandstone
(Bologna)

GEOLOGICAL SETTING

The Castiglione dei Pepoli Stone also called Monte Baducco Sandstone (Arenaria di Monte Baducco) belongs to the Miocene (Aquitanian-Langhian) Falterona-Cervarola Formation made up of quartz-feldspars sandstones, siltstones and claystones interbedded with thin hemipelagic carbonatic layers. In the mining areas of Monte Bagucci and Monte Gatta an anticline culmination, of nearly symmetric shape with subvertical orientation of the axial surface, extends.

The compressive tectonic acting in the area has deeply influenced, during different stages, this structure, which seems to have been deeply disrupted by multiple tectonic discontinuities represented by both direct and inverse faults.

MINING ACTIVITY

Among all the sandstones’ quarries located on the Castiglione dei Pepoli area and abandoned in 1960, the most representative is situated nearby the bridge on «Fosso della Chiesa Vecchia». The outcrop is made up of sandstones which colour ranges from grey-bluish to yellow-brown, organized in beds from decimetric to metric, interbedded to thin shaly layers. It was used to be mined in terraces and, notwithstanding the long neglecting period, the walls are still clean and vegetation free. The quarry front extends for about 50 meters with a frontal height of about 20 meters.

MINERALOGICAL-PETROGRAPHIC CHARACTERS

Mined sandstones are classified as lithic-arkoses and feldspatic litharenites. The siliciclastic component is characterized by a subangular morphology with low sphericity index and is made up of quartz, plagioclase and orthoclase grains (Fig. 6). To this component also belong phyllosilicatic clasts, well oriented and sometimes stretched, of muscovite, biotite and chlorite and polycrystalline rock fragments. Among rock fragments, extrabasinal carbonatic clasts commonly micritic and muddy are also present, less frequently spaticic rounded or elongated-shaped with curved rims. The presence of less common glauconite, flint and frambooidal pyrite has also been detected. Bioclasts are very scarce. The cement is made up of clear spaticitic calcite.

HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION

The Monte Baducco Sandstone has been employed in the Castiglione dei Pepoli area as ornamental building stone since the XIII-XIV century. At first, the employed stone was obtained by erratic blocks found in reclaimed lands which had been turned into farming. After the XV century the inhabitants were forced, by the raw material’s shortage and the already active mining centres’ distance, to mine the stone opening new different borrowing quarries from Monte Bagucci and Monte Gatta areas.

In sandstones employed outdoor, typical deterioration morphologies have been observed on surfaces, such as disruption with a consequent progressive transformation of the material into sand. These sandstones, when employed in wet, northward-looking places tend to show a strong biologic deterioration with green-coloured algal coatings formation and different lichen species colonization, some
of which display strong colours ranging from grey to red up to deep yellow.

d) The Porretta Sandstone (Bologna)

**GEOLOGICAL SETTING**

The Porretta Sandstone (Arenarie di Porretta), presently referred to as Arenarie di Suviana, belongs to the terrigenous turbidite formations of the Tuscan Domain’s Cervarola Group. Above the Suviana Marls characterized by bad-stratified marls and silty-marls, in the Porretta Terme area (Bologna) we pass into the Porretta Sandstones made up of a some hundreds-metres-thick succession of middle-Miocene arenaceous turbidites.

**MINING ACTIVITY**

The rock was mined from different quarries located south-western of the Porretta Terme village (Madonna del Ponte, della Costa, della Puzzola and di San Rocco); some of these quarries are no more visible since they have been hidden by the new buildings of the thermal resort. The Madonna del Ponte quarry, next to the homonymous church, is the better preserved one and makes it possible for the high wall, made up of sandstone metric verticalized strata, which total thickness is about 60 metres, to be observed. In the quarry, where signs left by the past mining activity are still visible, the sandstone strata outline erosive contacts and amalgamations with sudden granulometric changes and intraformational clay inclusions. Lenticular geometries, plane-parallel laminations, groove casts and bioturbations are also present (Agostini, 1994). Moreover, decimetric lithoclases are characteristic, with crystallization of calcite and of the famous Porretta’s hopper quartz, filled by yellowish clay.

**MINERALOGICAL-PETROGRAPHIC CHARACTERS**

The «Macigno di Porretta» is a dark grey-coloured, medium-grained lithic arkose, with white mica (muscovite) lamellae oriented parallel to the stratification planes (Fig. 7). From a petrographic point of view, it mainly consists of quartz, feldspars and phyllosilicate grains with a minor amount of siliciclastic rocks fragments. A certain amount of extrabasinal carbonatic clasts is also present. The carbonatic cement generally tends to occlude the interstices among grains.

**HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION**

This sandstone has been widely employed up to the last century in building works realized in Porretta such as the «Madonna del Ponte» church and along the Reno valley up to Bologna.

These sandstones, in case of outdoor employment, result particularly sensitive to the deterioration agents which can give rise to manufacture decay, sometimes not reversible. The result mainly consists of exfoliations and detachments caused by inflation, cracking and along strata fractures, turning into sand and efflorescences.

E) The Bismantova Formation

Montovolo Stone (Bologna)
Castel d’Aiano Sandstone (Bologna)

![Fig. 7 – Photomicrograph of lithic arkose (Porretta), with abundant quartz, feldspar and phyllosilicate clasts showing an oriented texture (N\(//\)).](image-url)
GEOLICAL SETTING

In the Vergato surroundings (Bologna), in the Reno valley, the lower-middle Miocene Bismantova Formation locally referred now to as Bismantova Group belonging to the Epiligurian Domain outcrops. This Formation includes the Upper Burdigalian-Lower Langhian calcarenites of the Bismantova Stone Member (Montovolo Stone) and the coeval biocalcarenites and calcareous sandstones of the Pantano and Sasso Baldino Members (Castel d’Aiano Sandstone).

MINING ACTIVITY

Montovolo Stone – The two main quarries, both active until few decades ago, are located southern of Vergato, on Montovolo, and are called Vecchi Quarry (Cava Vecchi) and Berardi’s Quarry (Cava dei Berardi). Even from the adjoining Monte Vigese, mainly in the Greglio and Cardeda localities, great amounts of sandstones were quarried from blocks sloughed from the walls. The stone, in massive strata up to few metres thick, was mined and worked with traditional manual methods inherited from the Comacine masters working in this area during the Middle Ages, of which remain, as proof, numerous villages with tower-houses and churches (Bargossi et al., 2000b).

Castel d’Aiano Sandstone – The only active quarries of these sandstones, belonging to the Sasso Baldino Member, located western of Vergato, are the Furnace Quarry (Cava Fornace) and the Evangelists Quarry (Cava Evangelisti) of Rocca di Roffeno nearby Castel d’Aiano. The Evangelists Quarry, set up on a large gravitational mass movement, develops on bad-defined terraces. In the near zone of the Vergato area in the 19th century the quarries of «Spezzola di Sopra» and the «Barelli’s Quarry» were also active, both set up on sandstones belonging to the Pantano Member (Pilone, 2000).

MINERALOGICAL-PETROGRAPHIC CHARACTERS

The Montovolo Stone, better known in the literature as «Ophiolitic Molassa» is a calcarenite which colour ranges from grey-bluish to yellowish when oxidized and which grainsize ranges from fine-medium-grained to coarse-grained (Fig. 8). It looks massive except for the isoriented disposition of lamellar-shaped minerals and elongated biosomes and a low grade of thickening with a moderate amount of points-like contacts between the skeleton grains. It turned out to be mainly made up of a bioclastic component represented by benthonic and plantonic foraminifers’ shells and also by echinoderms, bryozoans, and alga and bivalves fragments. Fragments of micritic carbonatic rocks are rarer to be found. The siliciclastic component is made up of quartz, feldspars and micas. The matrix made up of a carbonatic cement doesn’t totally obliterate pores and is represented mainly by micrite passing into spatite along the carbonatic clasts grain boundaries.

The Castel d’Aiano sandstones are grey-blue-coloured calcarenites in the fresh rock passing into a yellow-brown colour in the alteration zones along litoclases; they show a homogeneous structure, lamination free, medium-fine-grained with the presence of bioturbations. Compared to the Montovolo Stone, they display a reasonable amount of clay minerals (smectite, illite and kaolinite) which

![Fig. 8 – Photomicrograph of the Montovolo stone, a calcarenite characterized by abundant bioclastic component (N//).](image-url)
concentrate inside the clastic carbonatic extrabasinal component (Fig. 9).

HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION

Among works carried out with the Montovolo Stone we remind the «Santa Maria della Consolazione» Sanctuary, on the top of Montovolo, of the XIII century, built on the remnants of a more ancient IX-X century proto-Romanic church of which only the underground crypt remains, and the «Santa Caterina d’Alessandria» Oratory, next to the Sanctuary, a XIII century Romanic style chapel. A grey-coloured «molassa» sandstone has been used as façade covering for the «Santa Maria di Galliera» church in Bologna (1491) and for the two giants supporting the balcony of the XVII century Davia-Bargellini Palace (Rodolico, 1953). More recently the Montovolo Stone has been used for the external facing of the Government Palace of Bologna (1932-'33), at the present day the police headquarters (Questura), and for the façade covering of Santa Maria Assunta (Riola), a church of the Finnish architect Alvar Aalto ended in 1978.

The Castel d’Aiano Sandstone, known also as Vergato Stone (Pietra di Vergato) or Grey Sandstone (Arenaria Grigia), has found employment in the «Santa Maria di Roffeno» Abbey, consecrated in the XI century, and between the XII and the XVI century in tower-houses, towers, parish churches and rural houses in the Vergato area.

One of the most beautiful examples of employment of the Bismantova Formation sandstones is represented by the «Palazzo dei Capitani della Montagna» covering, a XIV-XV century palace in Vergato, rebuilt first in 1885 and then after the Second World War (Fig. 10). The Montovolo Stone, which is characterized by an imbibition’s coefficient of 1.6%, and even more so the Castel d’Aiano Sandstone with a 3.1%, are particularly attacked in outdoor environment by washing out rains and by rising humidity.

Between the more common deterioration morphologies, we can outline visible flakes and powdered material. The phyllosilicatic component in contact with water swells and spreads freeing the siliclastic minerals to create, in the superficial portions, common deterioration morphologies such as breaking up and splintering, up to a complete pulverization of the material.
F) The San Marino Formation

San Marino Sandstone (San Marino Republic)
Montefeltro Limestone (Pesaro-Urbino)

GEOLOGICAL SETTING

In the area of Romagna and Marche the Epiligurian Domain is characterized in the late Burdigalian to Langhian by the deposition in a platform environment of the San Marino Formation, equivalent to the Bismantova Formation. This Formation presents at the bottom shallow marine deposits with biocalcirudites, passing into massive organogenous limestones and at the top into calcarenites with oblique stratification and increasing in the siliciclastic component which characterizes the overhanging Monte Fumaiolo Formation.

MINING ACTIVITY

The Monte Titano area has been the object of an intense mining activity and local stone working since the stone-cutter San Marino, native of Arbe in Dalmatia, took refuge there during the Diocletian Empire. Nowadays boulders and blocks of the San Marino Sandstone are mined, obtained by sawing in building excavations made in the San Marino Republic territory. The Montefeltro Limestone of the San Marino Formation is mined in Val Marecchia in the Le Ceti quarry in Santa Maria Maddalena, Novafeltria (Pesaro-Urbino).

MINERALOGICAL-PETROGRAPHIC CHARACTERS

The San Marino Sandstone are whitish and yellowish calcirudites, bryozoans, corals, echinoids and bivalves rich with a minor quartz-feldspar siliciclastic component and with scarce carbonatic cement giving the rock a very high porosity (Fig. 11).

The Montefeltro Limestone is a pseudonodular organogenous limestone brown-yellowish-coloured with greenish and ash-coloured spots. They are made up of an organogenous component similar to that of the San Marino Sandstones, without siliciclastic component and very good cementation made by micritic and spatitic calcite obliterating pores (Fig. 12).

HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION

The San Marino Sandstone has found large employment mainly in the city of Rimini. In the Romanic-gothic «Arengo Palace» of Communal age, the basis and capitals of pillars are built in San Marino Sandstone. This sandstone finds also employment in the string-
course of the XVI century Palazzo Lettimi, in Palazzo Garampi decorations and partly in the covering of Sant'Antonio little temple. Also in the XVI and XVII century we can observe the employment of these sandstones in the Bonadradra and Gioia Palaces. In the Renaissance monuments wanted by Sigismondo Malatesta, in the central arc of the façade and in some parts of the Malatestian Temple covering, Leon Battista Alberti used the Montefeltro Limestone mined in the Verucchio and Scorticata quarries in Val Marecchia (Rodolico, 1953).

As far as we consider the deterioration of these materials, it looks clear that the San Marino Sandstone, when employed outdoor, tend to turn into sand since it is bad cemented while the Montefeltro Limestones due to their pseudo-nodular structure can give rise to stone elements’ detachment in correspondence of inter-nodular sutures.

G) The Marnoso-arenacea Formation

Pietra Serena, Pietraforte Colombino, Albarese

GEOLOGICAL SETTING

The Marnoso-arenacea Formation sandstones belong to the Umbro-Romagnolo Domain. This formation represents the filling of an Apennine foredeep basin, which developed between Langhian and Tortonian. The filling of this basin is made up of turbidites mainly produced by Alpine clastic contributions from N-NW associated to carbonatic platform contributions from SE and to mixed types ones from the South-Western Apennine relieves. Litharenites strata of terrigenous origin (the dominant lithotype), intrabasinal origin strata made up of calcarenites (Colombine) and mixed origin strata made up of hybrid arenites (Contessa type) have been distinguished.

In the Firenzuola district, the first stratum important in order to be mined is the Contessa one, the more characteristic guide layer of the Marnoso-arenacea Formation, which has been called by quarrymen Colombino in the Santerno valley and Albarese in the Savio valley in the Forlì-Cesena province. Another layer called Masso Grosso lies about 700-800 meters above the underlying Contessa layer. After about one hundred meters of turbiditic strata which can’t be exploited, we encounter a series of strata called Filaretti, which are traded together with the Masso Grosso and called with the generic name of Pietra Serena.

MINING ACTIVITY

In the Firenzuola area, mining activity has developed since the XV century and continued up to the 60s in quarries located along the Santerno river-bed nearby Molino Tinti and Molino Pianaccia. The incoming of modern mining technologies has brought about an enormous increase in the mining activity which has nowadays gained remarkable quotations both in the national and international markets. The mining basins located in the Firenze province, where actually the Pietra Serena di Firenzuola sandstones are mined and worked, are situated north-western of an uninhabited village called Brento Sanico, in the Rovigo torrent valley, in Peglio, along the Diaterna torrent, in Giugnola nearby Piancaldoli and in Palazzuolo sul Senio (Bargossi et al., 2002b). On the other hand, in Marradi are mined sandstones called Pietra Serena di Marradi.

The Pietraforte Colombino is actually mined NE of Firenzuola in Tirli locality, next to the abandoned village of Colcedra di Tirli.

In the Forlì-Cesena province, in the Torrent Para mining basin, in Mazzi locality and nearby Alfero, sandstones called Albarese and Pietra Serena della Val Savio are actually mined (Bargossi et al., 2000a). Even between the Montone and Bidente valleys in Galeata, sandstones belonging to the Marnoso-arenacea Formation have been mined in the past.

MINERALOGICAL-PETROGRAPHIC CHARACTERS

Sandstones called Pietra Serena show fine-medium grainsize and grey-bluish colour, with white mica lamellae (muscovite) which are
arranged parallel to the stratification planes and
give rise to silvery reflexes along surfaces
worked by natural split or on «al verso» cut
slabs. The finer-grained varieties can
eventually display centimetric laminations.
From a petrographic point of view, these
sandstones have been classified in the lithic
arkoses, feldsparic litharenites and litharenites
compositional fields. They are mainly made up
of quartz, feldspar and phyllosilicate grains
together with minor amounts of siliciclastic
rock fragments (Fig. 13). Moderate amounts of
extrabasinal carbonatic clasts and rare
intrabasinal bioclasts are also present. The
carbonatic cement, mainly spaticitic and
subordinately micritic, tends to obstruct the
interstices between grains, creating lithotypes
characterized by a roughly modest imbibition
coefficient ranging from 1.2 to 2.3%.

Sandstones known as Colombino and
Albarese, medium-fine-grained, dark grey-
coloured, can be laminated in the finer varieties
and display dark veins (synsedimentary sills)
and spaticitic calcite veins crossing the stratum.
Petrographically speaking, they are classified
as hybrid arenites and biocalcarenites (Fig. 14).
They are mainly made up of an intrabasinal
carbonatic component formed by foraminifers’
shells with corals, brachiopods and echinoids
fragments. Grains of quartz, feldspars, and
phylllosilicates and siliciclastic rock fragments
are also present, but subordinate. The cement,
made up of spaticitic calcite and micrite films,
results to be undoubtedly more abundant than
in the Pietra Serena and causes the rock to be
categorized by a low imbibition coefficient
(0.2-0.6 %).

HISTORICAL AND PRESENT-DAY EMPLOYMENT,
DETERIORATION AND PRESERVATION

The compositional and physical-mechanical
characteristics suggest an employment of
Colombino and Albarese in flag-stones and
external paving even subjected to intense
trampling. On the contrary, the Pietra Serena
results to be more suitable for external
coverings and architectonic manufacture or for
all indoor employments, the last representing
the ideal collocation.

Historical examples of the Pietra Serena
employments can be found in all the Tosco-
romagnolo Apennine valleys. We can mention
as an example the Fortress (Fig. 15) and
defensive walls with the Fiorentina and
Bolognese doors, designed by Sangallo in
Firenzuela, Palazzo Alidosi in Castel del Rio,
Palazzo dei Capitani in Palazzuolo sul Senio
and the Santa Maria Assunta Basilica in Bagno
di Romagna (Bargossi et al., 2002a).
Moreover, we would like to remember that sandstones called «Masegna», coming from Piancaldoli and Marradi were employed in the Bolognese area and that the so called «Macigno» sandstones were employed in Faenza in the Zauli-Naldi House and in Forlì in the XVII century Orsi-Mangelli Palace (Rodolico, 1953).

Whenever they are employed, sandstones, like all worked stone materials, are subjected to the action of disturbing agents of various nature and origin: mechanical, physical and chemical actions such as the oxidation, hydration and acid aggression phenomena and those made by bio-deteriorating agents. All these processes together can produce during time not only modifications of the aesthetic characteristics of the manufacture, but also a decay, which sometimes is no more reversible, of the technical properties. Following consequences mainly consist in exfoliations and detachments due to swelling, along strata fissuring and cracking, turning into sand and efflorescences.

**H) The Gessoso-solfifera Formation**

The «Vena del Gesso» Selenitic Gypsum (Bologna, Ravenna)

Torriana (Rimini) Selenitic Gypsum

**GEOLOGICAL SETTING**

The selenites belong to the Gessoso-solfifera Formation, outcropping roughly continuously in the Bolognese and Romagnolo Pedeapennine and in isolated strips in the Reggio Emilia and Rimini hinterlands. This formation originates from the evaporitic environment typical of the Messinian period and is subdivided in one selenitic *facies*, developed in the Vena del Gesso Basin, and another balatino-clay-solfiferous one, characterized by microcrystals and sandy gypsum grains. The selenitic *facies* is made up of a series of gypsum strata (with maximum thickness up to 20 meters) separated by bituminous, thickly laminated claystones levels; characteristic is the typical disposition of twinned gypsum crystals, the appearance of which gives rise to the names «swallow tail» or «arrow-head», with tail points upwards («Regola del Mottura»).

**MINING ACTIVITY**

The main quarries were located along the so called «Vena del Gesso», mainly in Romagna in Brisighella, Borgo Rivola and Borgo Tossignano and in the Bolognese area in Castel del Britti, il Farneto, la Croara and Zola Predosa. We should also mention the Epiligurian evaporitic deposits with the «Montebello di Torriana» quarry near to the San Marino Republic, which brings out a very good macrocrystalline gypsum nicely yellow-silver-coloured, much sought-after for sculptures and ornamental works, and the
«Vezzano sul Crostolo» quarry in the Reggio Emilia province with blocks and scattered reworked (clastic) gypsum crystals, among which the sericolite variety can be found.

**MINERALOGICAL-PETROGRAPHIC CHARACTERS**

Gypsum, bihydrate calcium sulphate, shows a perfect cleavage, a vitreous aspect which looks translucent, porcelain-looking or sericeous depending on the variety. In fact, different varieties have been recognized: macrocrystalline, microcrystalline, sericolite, balatino and alabastrine. The macrocrystalline gypsum (selenite), is made up of clear, centimetric to decimetric crystals, swallow tail or arrow-head twinned, bearing clay impurities among the interstices (Fig. 16).

**HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION**

Since the Roman age, selenite interested the urban work trade in Faenza, Imola and especially in Bologna where an important theatre of Republican age was widened during the Neronian age by construction of a series of radial walls in selenite. During the Upper Middle ages we had the first selenite employment as cutting stone in the first wall circle which brought to Bologna the name of «silver city», very probably dating up to Teodorico times. During Common age gypsum blocks were re-used for the basements and the foundations of the numerous Bolognese towers (Fig. 17), for rivers’ embankments, pillars wood basis, door-posts, window-backs, archivolts, supporting corbels and capitals.

The main deterioration morphology is represented by a differential deterioration due to both the compositional and structural heterogeneity of the stone, with macrocrystalline gypsum crystals embedded in a clayey, easily alterable matrix. In the back-draft portions, crusts and concretions of limited extension have been detected, preferentially developed in an orthogonal direction with respect to the surface, so to assume a stalactite or stalagmite-like shape.

**Fig. 16 – Photomicrograph of selenite, showing a gypsum megacryst, arrow-head twinned (N//).**

**Fig. 17 – Garisenda Tower (Bologna), XII-XIII century.** The foundations, the basement covering and the archivolt are realized with large selenite blocks. The main deterioration morphologies are represented by differential deterioration and superficial karren erosion.
i) The Montecodruzzo Stone (Cesena)

GEOLOGICAL SETTING

Outcrops belonging to the Messinian «Gessoso-solfifera» Formation of balatino-clay-solfiferous facies have been mined along centuries to be employed in local building trade in the Cesena hinterland between the Savio and Pisciatello river valleys. They are grey-coloured, brecciate-looking limestones and dolomite-limestones interested by synsedimentary sliding and associated to balatino and seletinic gypsum.

MINING ACTIVITY

The quarries which provided these brecciate Messinian limestones are located in Montevecchio, Monteaguzzo (Il Sassone locality), Montecodruzzo (La Greppia locality) and Fosso di Ca’ Spinelli.

The Montecodruzzo quarry in Gorgoscuro locality brought up the Gorgoscuro limestone, so called by Veggiani (1964), and attributed by R.E.R. (1982) to the Lower Pliocene calcareous-arenaceous Olistotomes.

MINERALOGICAL-PETROGRAPHIC CHARACTERS

They are brecciate whitish-coloured marly limestones, with elements made up of aphanitic limestone (micrite), fossil micro-fauna free, which almost always include small gypsum plagues or crystals, plunged in a marly-calcareous cement where sometimes we can find scattered quartz and mica grains (Fig. 18). Some of these elements show a lumpy structure with small gypsum plague inclusions and thin greyish and greenish clay veinlets.

HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION

The Cesena hinterland limestone exploitation goes back to a remote age, but its maximum development occurred in 1400 and 1500 during the domination period of Malatesta, who wisely used this local stone which resulted to be quite resistant and tough. In many localities of the Cesena hills (Montecodruzzo, Longiano, Montiano, Montevecchio) this limestone has mainly been employed in poor art works such as sinks, drinking troughs for livestock, rural houses benches and corners, as well as in modest public works. The same material has been found employed in Cesena, with a decorative structural usage, in columns, capitals, basements and architectural frizes of religious buildings and nobler palaces. Realized in Montecodruzzo limestone are the historical hall and the staircase of the Malatestian Library, the San Francesco monastery columns, the Santa Tobia lateral chapel of Duomo and columns and archivolts of the Albizzi palace in Cesena.

The first cause of its deterioration is the working the stone has suffered. Since it is a relatively soft limestone, it was worked manually by tools such as axes or cleavers, while for the stronger parts hammer and bit were employed. This led to microcracks formation, which meteoric alteration enhanced creating true exfoliations and disgregation of the material.

Fig. 18 – Photomicrograph of the Montecodruzzo Stone where dusty micritic fragments are visible, cemented by skeletal, syntaxial gypsum (N/).
L) The Sasso Marconi Sandstone (Bologna)

GEOLOGICAL SETTING

The Intrapennine Bolognese Basin sandstones belong to the Epiligurian Domain. They are Pliocene shallow marine deposits which at the bottom consist of clays with marly limestones and laminated limestones intercalations. After a gap, the sedimentation restarts in the lower Pliocene with terrigenous partly continental and partly fan-delta deposits re-elaborated by waves.

MINING ACTIVITY

The Sasso Marconi Sandstone was mined exclusively in the Sasso Marconi territory south-western of Bologna. In the area, made up of a huge arenaceous block of delta deposits belonging to the Pliocene Intrapennine Basin, two quarries have been detected, an underground one against Monte Sasso on the right bank of the Reno river, the other one open air on Monte Mario in Battedizzo, a Sasso Marconi's hamlet. The rock was mined by manual systems using hammers, bits and wedges, with a documented activity between the XIII and the XVII century. This mining activity gave rise to a wide local market related to the realization of architectural and decorative elements for palaces façades and churches in the city of Bologna (Esposito, 1999).

MINERALOGICAL-PETROGRAPHIC CHARACTERS

The Sasso Marconi sandstones can be classified as terrigenous arenites passing into medium-grained hybrid arenites with plane-parallel stratification, crossed laminations and thin clay and conglomeratic intercalations, showing yellowish colour and scarce cementation (Fig. 19). The calciclastic component is constituted by micritic rock fragments and spaticitic calcite. Bivalves and foraminifers fragment are also present. The siliciclastic component is mainly made up of quartz, K-feldspar, plagioclase, often chloritized biotite, muscovite and fine-grained magmatic, metamorphic and siliciclastic rock fragments. The cement, which doesn't occlude the interstices between grains, is made up of spaticitic and micritic calcite and looks pigmented by iron oxides.

HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION

The Sasso Marconi Sandstone together with the Varignana Sandstone has found large employment in the city of Bologna between the XIII and XVII century. The sandstone represented in the past the main building material employed in the historical Bolognese building trade, since it was easily available in the area, «docile» for the chisel, and brought to the city with low energies waste. Whole stonecutters generations have mined the sandstone for all different usages. The stone had the duty to dignify the building and therefore its employment was mainly directed towards the underlining of the building elegance, nobility and importance; the stone was often reserved to frames, capitals, columns, carved cornices, doors and windows fastigia (Grillini, 1998).

These sandstones result to be characterized by high imbibition coefficient (3,8%) and porosity values, with a scarce cementation degree. These characteristics can give rise to
intense deterioration phenomena whenever manufactures are exposed in outdoor environment and can interact with beating rain and rising humidity. The deterioration morphologies of these sandstones are similar to those described for the Varignana Sandstone, to which the reader is referenced.

M) The Spungone Calcarenite (Forlì-Cesena, Ravenna)

GEOLOGICAL SETTING

The «Spungone» constitutes discontinuous calcarenite bodies aligned in a composite horizon which is associated to the Lower Pliocene clayey successions, between the Marzeno and Savio river valleys. It can be placed at the base of, or interbedded to, the Pliocene Argille Azzurre formation, belonging to the Umbro-romagnolo Domain. It is a lithostratigraphic unit in which bioherma facies with biologically-built limestones can be recognized as well as biostroma bringing organogenous fragments, which have been mobilized from pre-existent calcareous bodies, and siliciclastic materials. Remains of this ancient submerged reef, which resistance to erosion gives rise to marked and clearly visible relieves, with particular shapes emerging among the surrounding hills, are present in the Faenza area eastern of Lamone approximately where the «Vena del Gesso» ends, and develop nearly parallel to the via Emilia, interesting different localities (Ceparano, Castellaccio della Pietra, Cerreto, Rio Cozzi, Bagnolo di Castrocaro, Sadurano, Rocca delle Caminate, Meldola, Teodorano, Fratta Terme, Monte Casale, Bertinoro, Capocolle).

MINING ACTIVITY

The word «Spungone», dialectal neologism from «spungò», which reminds of a white-yellowish-coloured rock and plentiful spongy due to the cavities abundance, is still used in the scientific literature. In the Faenza area the Spungone is also called «albanello», «pietra mora» or «pietra della Samoggia».

The Spungone mining activity has developed since ancient times in all the hilly romagnola area bounded by the Lamone and Savio valleys. Also in the Rimini hinterlands, Pliocene-aged calcareous tuffs similar to the Spungone have been mined in the «Colle di Covignano» area.

MINERALOGICAL-PETROGRAPHIC CHARACTERS

From a lithological point of view, the Spungone bioherma facies are made up of organogenous limestones very rich in fossil remains, among which calcareous alga (rodolites), foraminifers (nummulites and Amphistegina), bryozoans, molluscs (Pectinidae, Ostrea and brachiopods) and echinoids, embedded by micrite (Fig. 20).

The biostroma facies are made up of bioclastic and hybrid calcruidges and calcarenites with a variable cementation degree.

HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION

The finding of Spungone-made tools (manual grindstones and millers) which can be brought back to the late Bronze Age outlines that already the prehistoric populations, settled down in the Lamone, Montone and Bidente
river valleys, somehow exploited this stone. Since the second half of and during all the I century B.C., the spungone was largely employed for the roman Faventia’s building art, in columns, capitals, architraves and orthogonal blocks for town walls. Even in Forlì, the roman bridge «dei Morattini», demolished in 1850, was mainly built in spungone; with the same stone were also realized the foundations of both the San Mercuriali basilica and bell-tower. During all the Middle Ages it was used not only as re-employment material, coming from roman age architectures, but also as quarry material for other nature houses and buildings, such as fortresses and castles, churches and representation buildings. Its employment was limited to precise elements such as corner ashlars of noble palaces, columns basements, well-curbs, drip-stones and other plan elements of churches’ façades, portals, bridges, and basement structures of various nature buildings. The numerous defensive strongholds built in the XIV and XV century as surrounding territories defence, have all been erected on spungone spurs, using this stone also as building material: examples of the latter are the Ceparano’s tower, the «Castellaccio della Pietra», the Castrocaro castle, the «Rocca delle Caminate» tower and the Bertinoro fortress. We should remember above all the Terra del Sole stronghold, which Cosimo I de’ Medici founded in 1564 following the harmonic establishment of Renaissance «ideal cities», where the spungone represents the most widely employed stone (Fig. 21). Being cut in huge squared hewn stones, it has been employed outdoor in the Porta Fiorentina, Porta Romana and in the corners of the brick-made town-walls. Rough-hewed spungone blocks constitute the doors’ internal hanging walls and the perimetrical cornices of the ancient paving realized in river pebbles. Moreover, the spungone has been used for sculptural works, such as the two lions originally located outside the Pretorio Palace, still in Terra del Sole. Last, we mention the bridge on Bidente in Meldola, of roman origin, called «the Venetians’», since it was restored by the Serenissima Republic between 1503 and 1509; it is brick-made, but for the basal pillars and the supporting arches, perfectly squared hewn stones of spungone have been employed.

The rock’s consistence is not homogenous; in fact, we pass from extremely friable situations due to sand prevailing, towards situations of more solidity anywhere the carbonatic cement and biologically-built components are predominant. The main deterioration morphologies consist of pitting and alveolatization, with an accentuation of the typical natural stone’s vacuole structure. Moreover, a differential deterioration, which in particular outlines the stratified pseudoparallel structure, has been detected. In the disrupted portions and in the stone’s alveoli, a biologic incrustation frequently develops, with musk
and lichens and a diffuse occurrence of vegetation such as caper-bushes and ivy-mantles.

N) The Varignana Sandstone (Bologna)

GEOLOGICAL SETTING

The Varignana Sandstone Formation belongs to the «Sabbie Gialle», which is part of the neoautochthonous basins at the front of the Northern Apennines. Above the Argille Azzurre and the Spungone calcarenites, the Pleistocene Sabbie Gialle Formation deposits, made up of yellowish sands with clayey intercalations of marine and saltish environments passing to littoral yellow sands with conglomerate beds. Laying on these, continental gravelly-sandy deposits appear, belonging to the Olmatello Formation, to which the Monte Poggiolo Conglomerates of the Forlivese area, with the associated Palaeolithic industry, are probably to be referred.

MINING ACTIVITY

Sandstones belonging to the Sabbie Gialle were mined up to the XVII century, from some quarries located in the hilly area between Bologna and Castel San Pietro. The first quarries, of Medieval Age, were opened southern of the city of Bologna outside Porta San Mamolo in Via di Roncrio and outside Porta Castiglione between Santa Margherita al Colle and Barbiano. Later, new quarries were opened in the Varignana area, where two open air quarries can still be visited: the Malvezzi quarry with a 15 meters wall and the Cavalleggeri quarry with an about 3 meters wall. In these quarries, under semi-coherent yellow sands, sandstone strata occur, lithified enough to justify their employment as building stones (Pedrazzi, 1999).

MINERALOGICAL-PETROGRAPHIC CHARACTERS

The Varignana Sandstone are classified as hybrid arenites passing into calcilithytes; their grainsize ranges from fine to very fine, they show a typical yellowish colour and cross laminations. The calcilastic component is made up of micritic grains and spatitic calcite crystals. Dusty yellowish-coloured micrite has also been detected. Bioclasts are represented by relict structures of foraminifers’ shells, mainly *Globigerinae*. The siliciclastic component is made up of quartz, plagioclase, K-feldspars (orthoclase and microcline), micas (biotite ± chlorite and muscovite). Metamorphic rocks’ fragments, siltites, flint-stones, argillites, and basic vulcanites’ ones are probably coming from the Apennine Ophiolites dismantling processes. Accessory minerals are represented by garnet, epidote, spinel, pyrite, glauconite, zircon andapatite. The matrix and the cement are mainly carbonatic but they don’t totally obstruct the rock porosity (Fig. 22).

In the Cavalleggeri quarry, flat-tiles conglomeratic intercalations, up to decimetric thick, can be observed, characterized by a bimodal grainsize distribution and a grain-sustained structure. The conglomeratic clasts’ dimension is 2-3 cm; they mainly constitute of micrites, biomicrites, siltites and spatties, while the fine-grained arenaceous «matrix» presents the same petrographic characters of the surrounding rock (Fig. 23).

Fig. 22 – Photomicrograph of the Varignana Sandstone, a very fine-grained hybrid arenite with random foraminifers shells (N/\).
HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION

The employment of these yellowish sandstones in the Bolognese territory has been documented since the VIII and VI centuries B.C., in the proto-«felsine» («from Bologna») oriental stelae employed as funerary ensigns, and in the monolithic cylindrical VII century B.C. altars, finely decorated. Since the XIII century the Varignana Sandstone has been commonly employed in buildings, as for example in the communal Palace’s portico pillars, where sandstone ashlars were alternated to brick rows, and in the monumental window by Alessi. In 1390 in the Loggia della Mercanzia, sandstones capitals were built; yellow sandstones were largely used in the Palazzo Bevilacqua ashlar, in the Palazzo del Podestà façade (Fig. 24) and in the Fava (Sabetta et al., 2001-2002) and Ghisilieri’s Palaces courtyards. The sandstone employment continued till the XVI century, in the Bentivoglio, Malvezzi-Campeggi, Fantuzzi palaces, in Palazzo Poggi University seat, in the Archiginnasio portico and in the Palazzo Bocchi ashlar-work (Rodolico, 1953).

The Varignana Sandstone with high imbibition coefficient values (5.4%) and scarce cementation degree, when exposed to beating rains and rising humidity, results not to be a long lasting material. The deterioration morphologies which have mostly been detected are concretions and black crusts. Two are the main processes attacking these sandstones: dissolution of part of the carbonatic component and subsequent recrystallization on the surface in protected area which are not washing-away subjected (back-draft zones). Rain and condensation water, particularly enriched in CO₂ and H₂SO₄ (the so called acid rain), penetrate the sandstones, causing the dissolution of minimum amounts of the stone soluble components, which are then dragged and re-deposited on the surface during evaporation. The calcium carbonate recrystallizes again as calcite, but above all as calcium sulphate (gypsum). In this way a
black-coloured strong concretion (black crust) has formed, developing orthogonal to the surface, which, at the recrystallization time, encloses smog bearing waste-gases unburned products and atmospheric particles.

Other recurring morphologies are due to the particular sedimentary structures present in the yellow Varignana Sandstone, which constitute preferential detachment surfaces or planes. In fact, the heterogeneous grainsize, alternating «fine-grained» to «medium-coarse-grained» sandy portions, often determines a laminated structure and the remarkable occurrence of «conglomeratic lenses» with siliceous, carbonatic and siltitic clasts, ranging from 20 to 30 mm in diameter, well-rounded clasts and pseudoparallel lying. These, during time, can represent cutting surfaces or planes when the rock has been put running. Along these mineralogical-petrographic and sedimentary discontinuities, characterized by different porosity, the meteoric acid water can cause a selective dissolution of the carbonatic cement, with a consequent loss in cohesion and following detachment of the conglomeratic portions, with the formation of some typical deterioration morphologies such as alveolatization and pitting, involving vacuoles and pores of different shape and size.

O) The Labante Travertine (Bologna)

GEOLOGICAL SETTING

Western of Vergato (Bologna), on the right side of the Reno valley, the Bismantova Sandstones Formation is interested by deep cracks from which springs gush out. The calcium bicarbonate waters, in a subaerial environment, give rise, by precipitation, to encrusting Holocene limestones (calcareous tuffs, travertines), cementing the vegetation next to the spring.

MINING ACTIVITY

Ancient proofs reveal that a travertine was mined in Santa Maria di Labante locality nearby Vergato. The quarry, now dismissed, brought up a porous stone called travertine or Pietra di Labante, even if less compact if compared to central Italy travertines. In addition to the Santa Maria di Labante quarry, there’s another one near Castel d’Aiano, always occurring near to springs, streams and waterfalls rich in carbonatic waters.

MINERALOGICAL-PETROGRAPHIC CHARACTERS

It is a calcareous Tuff, white-yellowish tending towards rosy coloured, characterized by a fibrous concretion-made structure, passing into vacuous, with an undistinguishable stratification where you can nevertheless recognise thin bands differentiated by impurities concentrations, mainly vegetables. The cavernous aspect is partly due to the vanishing, by decomposition, of vegetables fragments encrusted by calcium carbonate. The carbonatic component is made up of dusty micritic calcite passing into spatite on vacuoles boundaries (Fig. 25).

HISTORICAL AND PRESENT-DAY EMPLOYMENT, DETERIORATION AND PRESERVATION

Since the Etruscan age, the local travertine was mainly employed in the sacred places of settlements, in temples and especially in tombs.

Fig. 25 – Photomicrograph of the Labante travertine (NX). Micritic dusty crystals forming a concretion-made structure with abundant macropores.
Very probably, Etruscans considered it a very rich and valuable material, since it was difficult to find. In the Etruscan city of Misa, in the Reno valley, traces of paving in squared travertine blocks, houses foundations, columns, stelae and cippi have been found. At the western and northern sides of the city two sepulchres are displaced, with large case tombs in travertine slabs, sometimes surmounted by travertine cippi. We also remember the Etruscan necropolis of Giardini Margherita in Bologna, with small sepulchres and an important case tomb double-weathered covered built in travertine blocks, which has been reassembled on the finding place.

This travertine, cut into blocks, has also been employed, up to the 60s, in the mining area surrounding localities in buildings such as churches, bell-towers and cemeteries (Fig. 26).

The deterioration morphologies in travertine mainly refer to black crusts and to a diffuse biological growth. The black crusts especially develop in moulding back-drafts causing, during time, real concretions, orthogonal to the surface. The biological growth, characterized by lower plants such as musk and alga, develops in travertine vacuoles where soil, dust and meteoric water collect, creating a fertile soil, a real «pedologic substrate».

**CONCLUSIVE REMARKS**

Descriptive reports on dimension stones described in this paper allow us to put forward some conclusive remarks that, according to us, could have some importance both in the mining activity exploitation and in the cultural heritage and architectural fields.

Information which have been collected about ancient quarries, where dimension stones employed in historical cities were mined, represent a useful knowledge base for art historians and for those who have to make restoration interventions both conservative and substitutive towards the monumental and architectural heritage. We stress that dimension stones represent unique materials which should be jealously protected otherwise it would no more be possible in the future to carry out substitutions with original stone elements. For additional geological and petrographic data and physical-mechanical characterization of the materials the reader is referred to Bargossi et al. (2001).

The knowledge of present-day productive districts in the dimension stones field in this sector of the Emilia-Romagna and Romagna Toscana regions, for what concerns mainly sandstones and secondarily selenites, should give rise to the consciousness that the georesources exploitation, provided that achieved with respect for the environment and in harmony with the mountain territory, represents a unique economic source for communities which otherwise would be depressed. This kind of activities must be understood and encouraged in order to improve both mining activities and dimension stones...

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Fig. 26 – Chiesa di San Cristoforo in S. Maria di Labante (Vergato-Bologna). Hanging walls and corner hewn stones of the bell-tower and of the church realized in Labante travertine. The basement and the bifora-windows are built in Castel d’Aiano Sandstone.
working, and supported to obtain petrographic and physical-mechanical characterization data, absolutely necessary to gain the European Community quality-mark «CE Mark». These data are essential to bring on the market products of guaranteed quality which could be chosen for the correct employment according to scientific criteria; in order to guarantee lasting, every rock must be employed in situations consistent with its specific characteristics.

Regarding the territory valorisation should also be encouraged those activities that, referring to «geosites» quarries and «architectural emergences» monuments where dimension stones have been employed, realize didactic or tourist-cultural itineraries in order to directly enjoy the cultural and landscape heritage. We should keep into mind that some quarries’ fronts showing particular geological structural situations must be protected and preserved in order to make it possible for everybody to behold and study them.

Finally, a further element that shouldn’t be neglected is the preservation of the art of carving the stone, art which in our territory has ancient traditions going back to the «magistri muratores», coming from the Lombardia-Ticino area and better known as «Comacine masters», of Latin culture, acknowledged and protected by the Rotari and Liutprando edict. Periodically many efforts have been made to hand down this tradition, carrying out courses of building restoration where the manual working techniques of sandstones were treated; nowadays still persist stone-cutter artisans working in our Apennine valleys. Also in this case, we are talking about unique activities strongly bounded to the historical-cultural tradition of the territory which must absolutely not be wasted; on the contrary they should be encouraged creating a permanent school for sandstone’s stone-cutters.

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