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Pregledni članak

DIMENSION STONE DEPOSITS IN CROATIA

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The geology, petrographycal composition and properties of dimension stone deposits in Croatia are described. Dimension stone deposits in the conception of mobilistic view of the genesis and structure of Dinarides, as well as after stratigraphic units, are considered. Valuation of the dimension stones of the active quarries is exposed. The marketable categories of dimension stone in Croatia are different varietes of limestones and calcareous clastites, primarly of Cretaceous age, and to lesser degree of Jurassic and Paleogene. The greatest part of deposits is concentrated in the Adriatic carbonate platform or Adriaticum.

Ključne riječi: Arhitektonski kamen, Ležišta, Geologija, Petrografija, Svojstva, Hrvatska

Opisani su geologija, petrografski sastav i svojstva ležišta arhitektonskog kamena u Hrvatskoj. Ležišta arhitektonskog kamena razmatrana su prema koncepciji mobilističkog pogleda na genezu i građu Dinarida, kao i prema stratigrafskim jedinicama. Izloženo je vrednovanje arhitektonskog kamena aktivnih kamenoloma. Tržišne kategorije arhitektonskog kamena Hrvatske su različiti vapnenci i karbonatni klastiti, prvenstveno kredne starosti, a manje jurske i paleogenske. Najveći dio ležišta koncentriran je u Jadranskoj karbonatnoj platformi ili Adrijatiku.

Introduction

Dimension stone in Croatia in about 30 quarries, nowdays, exploit the following firms:
- »JADRAN-KAMEN« in Pučišća and Selca, exploits dimension stone on the island of Brač,
- »KAMEN« in Pazin, exploits dimension stone in Istria, and
- »KAMEN-SPLIT« in Split, exploits dimension stone in the continental parts of Dalmatia.

Apart from the mentioned firms, dimension stone exploit also »ZADRUGA« in Matulji, »GRAĐEVNO PODUZEĆE« in Korčula, and some private stone-masons on the islands of Brač and Korčula. From the year 1991 there are no data on the activities of the quarrying of the firm »KAMEN« in Obrovac.

In the nearer past (1950/60) dimension stone was exploited by 10 companies in 50 quarries:
- »GRANIT« in Zagreb, 11 quarries (Bizek near Zagreb, Marići and Romanovac near Obrovac, Velebit Portoro near Gospić, Bogomolja on the island of Hvar, Roza Val on the island of Vis, and the others),
- »INDUSTRIJA JADRANSKOG KAMENA I MRAMORA« in Split, 11 quarries (on the island of Brač, and the continental part of Dalmatia),
- »ISTARSKI RUDNICI NEMETALA« in Pula, 11 quarries (in the region of Istria),
- »KAMENOLOM« in Buje, 5 quarries (in the region of Istria),
- »KAMEN« in Pazin, 4 quarries (in the region of Istria),
- »SADRA« in Sinj, 4 quarries (in the region of Dalmatinska Zagora),
- »KOMBINAT VELEBIT« in Rijeka, 3 quarries,
- »ISTARSKI BOKSITI« in Rovinj, 2 quarries,
- »VRNIK« in Korčula, 2 quarries, and
- »KLESARSKA ZADRUGA« in Matulji, 1 quarry.

In the last 30 or more years the number of companies and quarries and accordingly the stone varieties have been considerably decreased. Dimension stone quarrying was primarilly stopped in deposits of the supporting coloured carbonate and clastic sediments. The mentioned deposits are regularly of small stretching and complex geological structure, with the impossibility of extraction the larger blocks for manufacturing and market. Part of these deposits, regarding the implementation of the new stone carving technology in thin plates-marmetes, would probably be reactivated. That wouldn't be the case in the touristic areas.

The data about our dimension stone deposits could occasionally be found in periodicals and literature.

So M ü l l e r (1984) for our regions writes literally this: »Zu behaupten, die gesamte Adriaküste sei ein einziger grosser Steinbruch, wäre nicht übertrieben. Sowohl auf der Halbinsel Istrien, als auch in der Umgebung von Split und Dubrovnik sowie auf mehreren der vorgelagerten Inseln reiht sich eine Abbaustelle an die andere: vorwiegend heller Kalkstein mit reichem Fossilbesatz.« At the same time, on the shematic map he marked a number of locations of the known stone deposits present on market today (Lucija, Grožnjan, Kanfanar, Kirmenjak, Vinkuran, Rozalit, Dolit, Oklad, Diokles, Adria Grigio, Veselje, Kupinovo, San Giorgio, Rasotica, Adria Verde), but also the deposits of dimension stones which are not present on market today (Kremenje, Bale, Marčana, Crna Krička, Mosor, Visočani).

The main part of the enumerated and mentioned dimension stone deposits is located in »the specially productive Istrian-Dalmatian belt Adriatic type of the Cretaceous age develope« (B i l b i j a et al. 1974).

Similar is with the presentation of our dimension stone in INSK (International Naturstein-Kartei) in 10 volumes (Müller, 1986):
- in the 6th volume of INSK the data on conglomerates Rozalit and Multikolor, breccias Romanovac and Oklad, and porous limestone Vinkuran unito are present,
- in the 7th volume the data on the coloured limestones Unarot, Rasotica and Crna Krička are present, and
- in the 8th volume are the data on the limestones Lucija, Adria Verde, Grožnjan, San Giorgio, Adria Grigio, Kanfanar, Kupinovo, Diokles and Dolit.

Among the different varieties of our dimension stone in Naturstein Lexikon (Mehling, 1986) are mentioned the following: Adria Grigio, Adria Verde, Dolit, Kanfanar, Multikolor, Marići, Kupinovo, Oklad, Plano, Rasotica, Romanovac, Rozalit, San Giorgio, Santa Lucia, Seget, Veselje, Vinkuran and Vrsine, as well as the types which are not present on market today: Bale, Belgris, Mirna, Salamin, Crne Kričke, Crni Velebit, Glavica, Granitelo, Mosor, Reštovo and Visočani.

The development of dimension stone industry is most evident in growth of stone blocks exploitation:

1955	exploited	6,289	m^3 of blocks
1960	exploited	7,665	m^3 of blocks
1965	exploited	11,060	m^3 of blocks
1970	exploited	15,071	m^3 of blocks
1975	exploited	22,360	m^3 of blocks
1980	exploited	35,360	m^3 of blocks
1985	exploited	44,120	m^3 of blocks
1990	exploited	48,374	m^3 of blocks

Of the greatest importance in the forementioned industry are the following companies:
- »KAMEN« in Pazin (21,510 m^3 of the exploited blocks in 1985, and 21,825 m^3 in 1990), and
- »JADRAN-KAMEN« on the island of Brač (19,150 m^3 of the exploited blocks in 1985, and 22,184 m^3 in 1990).

The dimension stone industry in Croatia with quarrying and processing of natural resources in the world relation is insignificant, neither 50,000 m^3/year in compared to about 10,000,000 m^3/year total world production. Only one marketable category of dimension stone in Croatia is calcareous stone, different varieties of limestones and clastites. This is the limitation factor of larger expansion on the world market today.

Essential preferences to existence of dimension stone deposits

The definitions of dimension stone: »Building stone that is quarried and prepared in regularly shaped blocks accordnig to specifications« (Bates and Jackson, 1980) and »Stone which is marketed in blocks or slabs of a specified size. Much of it is used for building, either for structural purposes, or for cladding, facing or flagging. The minerals in dimension stones should be stable in humid atmosphere, and the rock should be crystalline or well consolidated. Individual blocks should be free of weakness planes, and if the stone is to be used for structural purposes it should be strong. The principal rock types used as dimension stone are granite, diorite, syenite, sandstone, limestone, some ironstones, gneiss, slate and serpentine. When a rock mass is being considered for working as a dimension stone, it is important that a sufficiently plentiful supply of material of the same colour and texture is available, and that the stone can be worked with the minimum of blasting, a process that is liable to introduce cracks into otherwise intact blocks. Stone to be used for statuary purposes should generally be attractive, not too hard, even-grained and workable by hand. Marble is probably the best-known stone used by sculptors« (Dineley et al., 1976) incoporate the basic demands which rock mass should meet for the existence of exploitable deposits.

The essencial preferences to the origin of the dimension stone deposit are genetic processes and postgenetic occurances. They make condition on:
- decorativity of the stone,
- physical-mechanical properties, and
- rock mass integrity or spacial distribution of the primary and secondary discontinuities.

Dimension stone decorativity depends on the whole range of genetic and postgenetic factors, such as:
- quantity and spacial distribution idiochromatic or coloured minerals (hematite, limonite, epidote, chlorite, etc.),
- pigment finely dispersed in alochromatic minerals (hematite in orthoclase),
- pigment differently generated and arranged in stone (graphite in marbl, bitumen in limestone),
- existence of minerals of the special luster (sericite of pearly luster),
- shell fragments and debris different shapes, dimensions, uniformity and heterogenity, and
- marked texture and fabric characteristics, such as schistosity (without parting along the schistosity planes), eyed structures, feldspar porphyroblasts, stylolites, intersections of the coloured veins (with calcite or other minerals filled fractures), microfolds, etc.

Physical-mechanical properties of the stone depend especially on:
- mineral composition and the characteristics of minerals,
- textural elements, especially on spacial distribution of minerals, its shape and dimensions, in clastic sediments on the composition of particles and the characteristics of cement,
- in sedimentary rocks on the degree of lithification,
- intergranular bond,
- defects in crystals, as well as crypto and micro defects in stone, hidden or visible by microscope, as well as macroscopically visible defects (fine fissures),
- porosity and the size of pore space, and
- the freshness of stone.

The rock mass integrity depends on discontinuities which stipulate natural fragmentation and separation in blocks of different shape and size. Discontinuities are primary or syngenetic and secondary or postgenetic.

Primary discontinuities are:
- in magmatic rocks cooling joints,
- in sedimentary rocks bedding planes, and primary sedimentary structures (sequences, biostrome, bioherme etc), and
- in metamorphic rocks foliated planes.

Secondary discontinuities are all the fractures of tectonic origin.

All the given suppositions should be supplemented by two fundamental claims: durability of stone and stability of its colour, under the influence of exogen natural and technogenic factors in conditions of urban environment.

Finally, the important factors are the economic exploitation of the manufactured stone blocks, as well as their attractability on the home and world market.

On the basis of the given preferences and demands comes out that it is not simple on fields to find areas suitable for exploitation of dimension stone, or limits their deposits, as well as find the potential productive zones.

Outline of geology

Croatia is characterised by the variety of petrographic composition and geological structure, but with great differencies in spreading of the particular rocks. The spread of magmatic and metamorphic rocks in comparision to sedimentary and especially to carbonatic rocks, is small. The spread of magmatic and metamorphic rocks, and postgenetic processes in them are the main restrictive factors of finding the dimension stone deposit of silicatic composition, as well as marble. As opposed to that, spread of the carbonate sediments of different stratigraphic unit represent the basis of the present dimension stone industry, with the rich tradition of exploitation and usage of dimension stone from the ancient times.

Even the superficial look at the simplified geological map of Croatia (after Kranjec, 1974) is sufficient for seeing the differencies between geology and petrographic composition of the particular areas (fig. 1). These differences are present in spreading of the particular stratigraphic units, as well as in petrographic composition. The regional division of Croatia is based on these differences, and the whole territory Crnković (1974) divided into 5 regions.

Taking into consideration the mobilistic view of the genesis and structure of Dinarides (Herak, 1991), from the point of view of the potential productivity of lithostratigraphic units, Croatia can be devided into 6 regions (fig. 2):
- The region of Hrvatsko Zagorje, or northwestern part of Croatia, covers the area between the Sava and Drava Rivers, on the east it spreads till the Česma River towards north as far as to Koprivnica,
- The region of Slavonija, or northeastern part of Croatia, covers the area between the Sava and Drava Rivers, east of Česma River,
- The region of Banija and Kordun, or Karlovac area, covers the teritory south of the Sava River, southeast and south of Karlovac,
- The region of Gorski Kotar-Lika-Primorje, covers the territory of Gorski Kotar, Lika and Primorje,
- The region of Istria, covers the territory of Istria, and
- The region of Dalmatia, covers the coastal area and islands, as well as Dalmatinska Zagora.

The region of Hrvatsko Zagorje

The region is conspicuously marked with Mountains Medvednica, Kalnik, Macelj, Ivanščica and Ravna gora, of different petrographic composition and the large range of stratigraphic units, from Paleozoic to Quaternary.

On the Mt. Medvednica dominate the greenschists (para and ortho metamorphites), and argillites, marbleized limestones and marbles. Limestones and dolomites of the Triassic age can be found at the Mts. Medvednica, Ivanščica, Kalnik and Ravna gora, while clastites and carbonate sediments with eruptives at the Mts. Medvednica, Ivanščica and Kalnik. Along the rims of the mountains it is very important development of clastic and carbonate sediments of Neogene, especially Miocene age.

After Herak (1991) this area belongs to structural complex of the Inner Dinarides or Supradinaricum. The border area of Dinarides and Alpides is on the north, while on the east are Pannonian structures of Pre-Alpine structural complexes. Some of the presented Herak's thoughts on the situation of the area, are the following:
- »... some parts of the Inner Dinaridic area take position virtually different from the place of their origin ...«,
- »... lack of the clear inner zoning, that is the consequence of the neotectonic desintegration of the prime covering structures, which existence prooves the numerous marked but also masked phenomena of alochtony ...«,
- »... appearance of ultramaphites in ... Mts. Medvednica and Kalnik are in alochtonic position.«,
- »... the structure of the Inner Dinarides (Supradinaricum) is very heterogenious, that causes the difficulties in the internal classification ...«

show that in this area, except the »young« sediments of the Neogene, we can not expect the rock mass wholeness and also not dimension stone deposits. In this respects, potentially are productive only the carbonate sediments of Miocene (Crnković et al. 1974/75). Those are lithothamnion limestones of the south-western part of Mt. Medvednica and the rim of Mt. Ravna gora in the area of Vinica.

The region of Slavonia

The marked petrographic element of the Slavonian Mountains (Papuk, Psunj, Krndija and Moslavačka gora) is Crystalline. In the part of the Slavonian Mountains Jamičić (1988) separated three complexes; those of »Radlovac«, »Papuk« and »Psunj«, which consist of magmatic and metamorphic rocks of the wide range of textures and compositions. For this area is important the existence of series of orogenesis (Baycal, Caledonian, Laramian) to which are linked prograde and retrograde metamorphoses as well as the corresponding tectonics.

With the monotoniously gray and uniform grainly granites of the Mt. Moslavačka gora, potentially

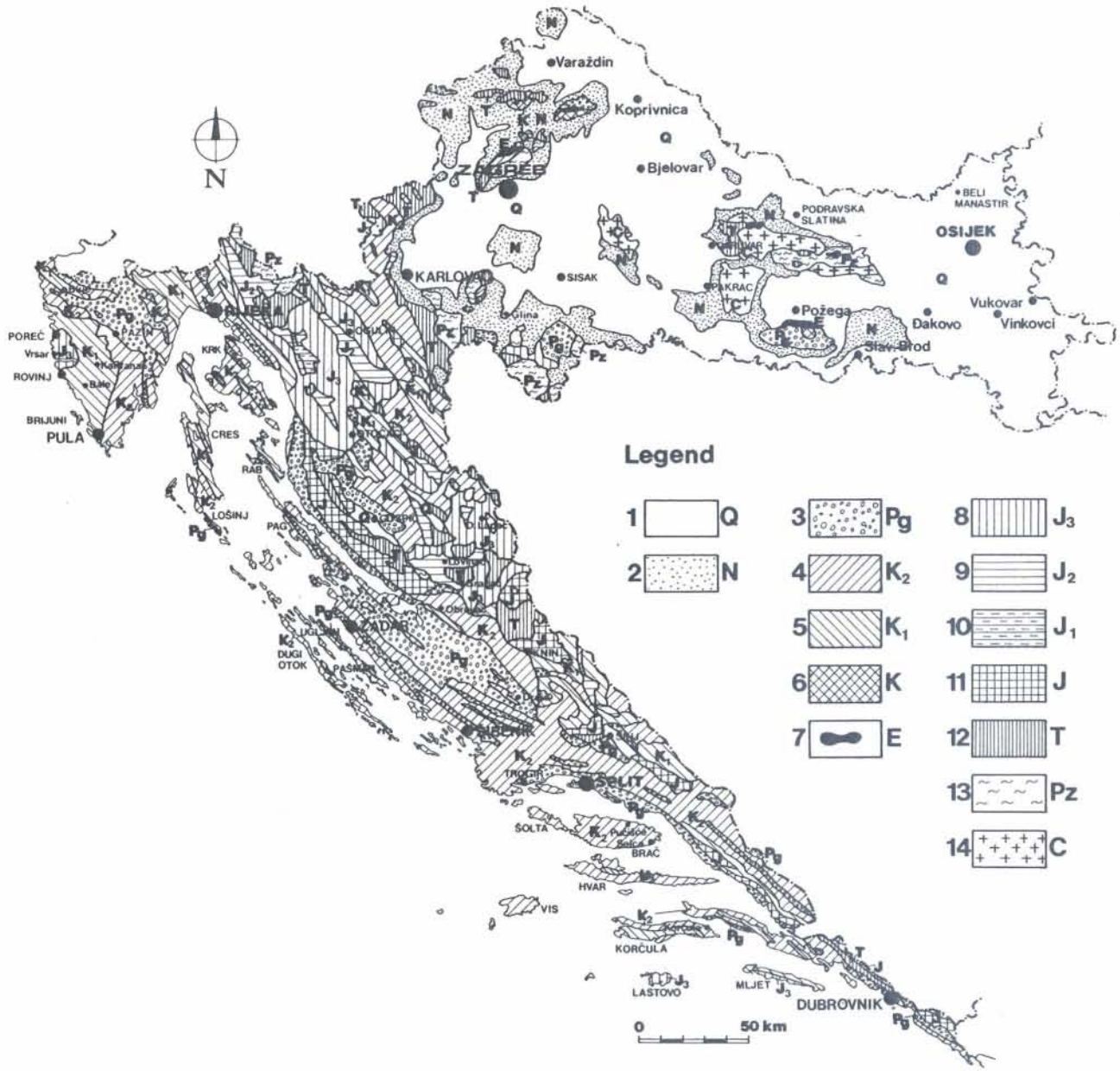


Fig. 1 Generalized geological map of Croatia (after Kranjec, 1974)

1 (Q) Quaternary (Holocene and Pleistocene, unconsolidated clastic sediments, loess)
2 (N) neogene (Pliocene and Miocene, unconsolidated and consolidated clastic sediments, marls, limestones)
3 (Pg) Paleogene (Oligocene, Eocene and Paleocene, consolidated clastic sediments, limestones, marls, flysch, molasse)
4 (K_2) Upper Cretaceous (significantly developed rudist limestones, dolomites, marls, cherts, flysch)
5 (K_1) Lower Cretaceous (limestones, dolomites, clastites)
6 (K) Cretaceous, generally
7 (E) Eruptive rocks (andesite, basalte, diabase)
8 (J_3) Upper Jurassic (limestones, dolomites, marls, clastites)
9 (J_2) Middle Jurassic (limestones, dolomites, marls, clastites)
10 (J_1) Lower Jurassic (limestones, dolomites, clastites)
11 (J) Jurassic, generally
12 (T) Triassic (limestones, dolomites, clastites)
13 (Pz) Paleozoic (greenschists, phyllites, argillites, marmoraceous limestones, dolomites, clastites)
14 (C) Crystalline (granites, gneisses, amphibolites)

perspective for the dimension stone deposits could be considered granites and gneisses of the »Papuk complex«.

After Herak (1991) this area belongs to Pannonian structures of Pre-Alpine structural complexes. They were exposed to strong compression and corresponding desintegration until then of homogenious structural unity. This was the one of the preconditions for the later (Neogenic) differentiated movement of the particular parts, and for the partial changes of the stretching some of them.

Southern and western of these structures, there is the structural complex of Inner Dinarides (Supradinaridic). The border line between those two complexes is placed south of the Slavonia's Mountains, west of Mt. Moslavačka gora, to east of Mt. Kalnik (Herak et al. 1990).

Fig. 2 Generalized geotectonic belts of Dinarides (after Herak, 1991) with marked regions of dimension stone deposits

1 The joint area of the Dinarides and Alpides
2 Pre-Alpine Structural complexes. Pannonian structures
3 Structural complex of the Inner Dinarides (Supradinaricum)
4 Structural complex of the Dinaric carbonate platform (Dinaricum)
5 Structural complex of the Adriatic carbonate platform (Adriaticum)

By prospections and researches the existence of the whole »oases« of the rock mass are estimated in the areas of Mts. Moslavačka gora and Papuk. Howewer, the consequences of the still presented processes, which in the geological past took place here, are evident in the mentioned »oases«. So Jovičić et al. (1992) describes the tectonics of the »Zebrato« granite deposit: »... Tectonic disturbances are evident through the intensive cracking. ... The complex tectonic elements devide the deposit in the separate units-blocks ... with restriction and narrowing of the exploitable fields ... and worsen geological conditions of the deposit and negatively influence to the blockage.«

The region of Banija and Kordun

The area in its southwestern part is clearly marked with the interrupted zone of clastites of Younger Paleozoic, general striking NW-SE. The Triassic sediments and the narrow ophiolitic zones of the Jurassic with especially complex structure are of the same stretching (Majer, 1984, and Majer and Lugović, 1985). The significiant proportion take the flysch and molasse of Eocene, and the clastic sediments of Pliocene.

This area belongs to the former described Supradinaridic.

In regards to the complex geological structure and the petrographic composition, including the sedi-

Fig. 3 Dimension stone deposits in Croatia

The region of Hrvatsko Zagorje
NEOGENE
b) *quarries out of exploitation*
1 Vinica
2 Pisana Pečina
3 Ruopanec
4 Bizek and Vrapče potok

The region of Slavonia
GRANITE-GNEISS
b) *quarry out of exploitation*
1 Samarica
c) *deposits on exploration*
2 Metla – Ravna Gora
3 Jankovac – Radetina

The region of Gorski Kotar – Lika – Primorje
CARBONIFEROUS
b) *quarry out of exploitation*
1 Brušani
TRIASSIC
b) *quarry out of exploitation*
2 Saint Rok
JURASSIC
b) *quarries out of exploitation*
3 Cvituša – Lovinac
4 Gradina – Ričice
5 Gospić
6 Brinje
7 Donji Lapac
CRETACEOUS
antique quarry
8 Prozor
a) *quarry on exploitation*
9 Romanovac – Tulovac
b) *quarries out of exploitation*
10 Muškovci
11 Reštovo
PALEOGENE
b) *quarry out of exploitation*
12 Bunić

The region of Istria
JURASSIC
a) *quarries on exploitation*
1 Kirmenjak
2 Valkarin
CRETACEOUS
a) *quarries on exploitation*
3 Kanfanar
4 Selina
5 Grožnjan – Kornerija
6 Saint Lucija
7 Valtura
8 Vinkuran (Cava Romana)

ments of Paleogene and Neogene, there is no possibility of finding dimension stone deposits in this area. The presented statements we base on the description of some, for our consideration, eventually interesting rocks (Majer and Lugović, 1985): »... the major part of amphibolite ... has ... clearly marked foliation ... the whole rock mass is divided into smaller blocks of differentiated movements ... some parts suffered intensive deformations ...«

The region of Gorski Kotar, Lika and Primorje

It is clearly marked with the general striking of the lithostratigraphic members NW-SE, as well as the predominant sediments of Mesozoic. The northwestern part, Gorski Kotar and Lika characterize the clastic sediments, as well as dolomites and limestones of the Younger Paleozoic. In Mesozoic, from Triassic to Cretaceous prevaile the carbonate sediments of marine shallow environments, limestones and dolomites. Lithiotis limestone of Liassic, as well as rudist limestones of Upper Cretaceous indicate the shallow environments. In some parts of Gorski Kotar and Lika dolomites are continually present from the Upper Triassic through Jurassic. The sediments of Paleogene are present in the lesser degree.

After Herak (1991) this area belongs to Structural complex of the Dinaridic carbonate platform (Dinaricum). It is rather difficult preciselly differentiate the relation between Dinaric carbonate platform (Dinaricum) and Adriatic carbonate platform (Adriaticum). The reason is the complex overthrust relations and because the units of Dinaricum are placed directly on the elements of Adriaticum on some localities.

For that structural complex are characteristic the overthrust structure, namely, with the overthrust complexes of the Paleozoic and Triassic on the Jurassic carbonate complexes.

On the basis of the presented data, this area, regardless to favourable genetic conditions in formation of the wide range of different varieties of limestone, postgenetic occurences, that is to say, tectonic units of the overthrust structure and disturbancy, are the limiting factors of finding and existence of dimension stone deposits. If there are some deposits, they are characterized by the unfavourable geological conditions.

The region of Istria

The significant stratigraphic-structural element is Jurassic-Cretaceous anticline with carbonate sediments from Upper Jurassic to Lower and Upper Cretaceous. By the north is placed Buje anticline. The remarkable surfaces cover clastic and carbonate sediments of Paleocene and Eocene. The favourable condition of Jurassic-Cretaceous anticline are subhorizontal layers.

After Herak (1991) this area belongs to the Adriatic carbonate platform or Adriaticum. This platform due to its main features has much in common with Dinaricum, so that some of the authors take them as an integral unity. Regardless to some common elements named by Herak, this area and from the point of view of the productive zones and dimension stone deposits, justifies its separation. After Olujić et al. (1972) differently from the conception of Herak (1991) this area represents autochton. From the continental part of Istria, Adriatic stretches across the Kvarner Islands to the southeast, partly surrounding seaside Dinaricum from the southwest.

In this area all the other stratigraphic units except flysch are potentially productive. Dimension stone deposits are placed in the limestones of Jurassic, Lower and Upper Cretaceous as well as in limestones and carbonate clastites of Paleogene.

The region of Dalmatia

It is clearly marked with the significant part of Cretaceous carbonate sediments and carbonate clastites and flysch of Paleogene. The Jurassic sediments are slightly represented on the furtherest south island Lastovo and Mljet, while the sediments of Triassic and Jurassic are represented in the northern part of the region.

This area presents the continuation of Adriaticum. It is structurally different from Istria, and can be divided into three zones. The southern part includes mainly the islands, and it is characterized by clearly

b) *quarries out of exploitation*
9 Krk (island)
10 Goli otok (island)

EOCENE
b) *quarry out of exploitation*
11 Lupoglav

The region of Dalmatia

JURASSIC
b) *quarries out of exploitation*
1 Trilj
2 Crna Krička
c) *deposit in exploration*
3 Česma

CRETACEOUS
a) *quarries on exploitation*
4 Dolit
5 Seget
6 Vrsine
7 Plano
8 Fantazija
9 Sivac, Punta, Barbakan, Kupinovo
10 Zečevo, Glave
11 Žaganj Dolac
12 Dragonjik
13 Humac
b) *quarries out of exploitation*
14 Dicmo
15 Voluja
16 Okrug
17 Mosor
18 Dubrave
19 Krševine, Krtoline
20 Labotovo
21 Vrnik
22 Visočani
c) *deposit on exploration*
23 Borišina
24 Vrdovo

PALEOGENE
a) *quarries on exploitation*
25 Marići
26 Pakovo selo
27 Radošići (Multikolor, Alkasin)
28 Putišići
29 Benkovac

marked anticlines. For that anticlines is characteristic regularly slighter slope of its northern layers. The central part is characterized by ovethrust structures formed by the sediments of Cretaceous and Paleogene. The northern part is of the complex structure with the greater participation of the sediments of Triassic and Jurassic.

The main productive lithostratigraphic member of this area is the rudiste limestones of Upper Cretaceous, although are present a numerous deposits the other stratigraphic levels too.

Dimension stone deposits

Dimension stone deposits will be described according to regions (fig. 3), and separated into three groups:
- deposits of current exploitation,
- deposits of temporary exploitation, not exploitable at the present time, and
- deposits in the phase of exploration.

The region of Hrvatsko Zagorje

From the point of view of dimension stone exploitation, in this region are only the limestones of Miocene age of interest. At the present time there are no active quarries here, while in the past dimension stone was exploited in four deposits.

Vinica

The deposit is situated on the eastern hillside of Mt. Ravna Gora, west of Varaždin. The stone of this area was exploited in the ancient times. It's considered to be the stone of Varaždin's baroque. The stone of Vinica in the past was known even across the borders of our country. Among the depo-

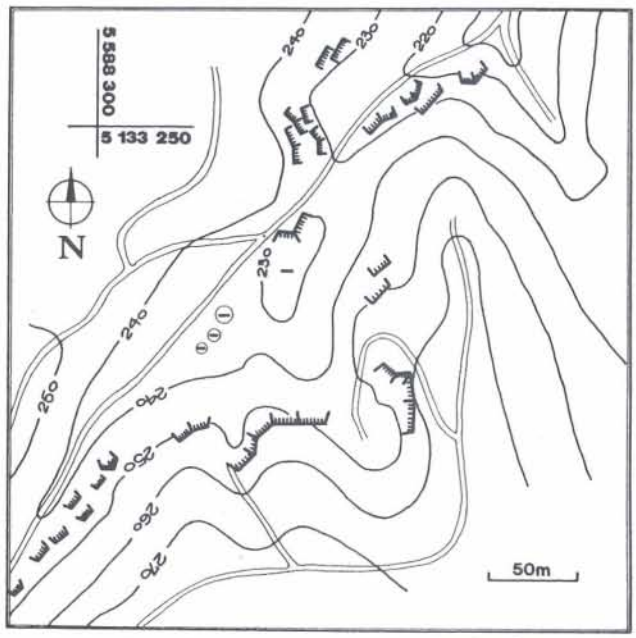


Fig. 4 The dimension stone deposit Vinica, location Jezero, predominant Lithotamnion limestone, the positions of numerous old hillside quarries

sits of Lithotamnion limestones of Badenian age, Kieslinger (1932) mentions: »... Von altösterreichischen Vorkommen seien nur erwähnt: Brünn (in Mähren), Mokritz (in Krain) und Vinica (in Kroatien).«

There are generally two distinguished types of the yellowgrayish exploitable stone in the deposit:
- porous and soft limestone, recentlly called **Vinicit,** and
- macroporous and megaporous Lithotamnion limestone.

Petrographically are the carbonate rocks of Vinica determined as: biomicrite and biomicrudite (prevail), recrystallized biomicrite, biosparite, biosparrudite and clayish biomicrite.

The deposit could be devided into three parts: Pečina and Kočevec (predominant Vinicit), and Jezero (predominant Lithotamnion limestone) with about 20 old quarries out of exploitation at the present time (fig. 4).

Pisana pečina

The deposit is placed on the southwestern hillside of Mt. Ivanščica, western of Novi Marof, along the ridge stretching E-W. The old quarries with remnants of block extraction are cut in the ridge at some places. In deposit exist 8 layers of different thickness (fig. 5).

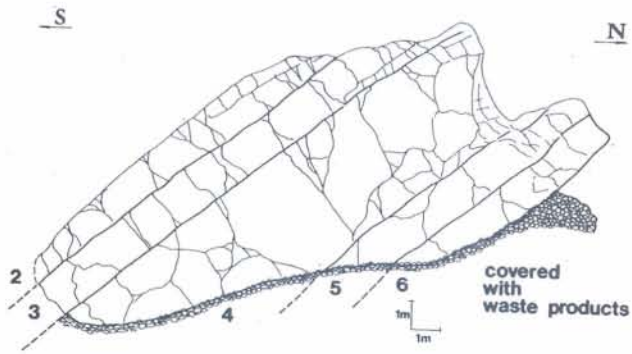


Fig. 5 The dimension stone deposit Pisana pečina, old quarry, vertical section, layers from 2 to 6, layers 1, 7 and 8 absent on this place of deposit, layer 1 eroded, and layers 7 and 8 covered by waste products

Limestones are yellowgrayish and gray colour, porous, soft and shelly. Petrographically are determined as intrabiosparite, intrabiosparrudite and intrabiomicrosparite.

Ruopanec

In limestones of Badenian age in the Mt. Varaždinsko topličko gorje western of Varaždinske toplice (Varaždin spa) there are old quarries with the remnants of block extraction. Badenian is represented by grayish and yellowgrayish, porous and soft limestones. Petrographically are determined as biomicrite, biosparite, biomicrudite and biosparrudite.

Bizek and Vrapče potok

Clastic and limestone sediments of Miocene surround Mt. Medvednica from the western, southern and eastern side. Like dimension stone, Lithotamnion limestone was exploited only in the southwestern hillside of Mt. Medvednica, west of Zagreb, in the quarries of Bizek and Vrapče potok. In not so distant past Lithotamnion limestone represented the building stone of the city of Zagreb, known as

Bizek stone. Its characteristics in deposits and on buildings, as well as the influence of the polluted air of urban surroundings on limestone with the formation of plaster was in detail elaborated by Marić (1938).

Nowdays dimension stone is not exploited in these deposits, because these areas are situated in the Natural Park of Mt. Medvednica.

The region of Slavonia

For dimension stone exploitation in this region of the greatest interest are primarily magmatic and metamorphic rocks of Crystalline. Those are granites and gneisses.

Samarica

The numerous old quarries exist in granites of Mt. Moslavačka gora. In the quarry Samarica, south of Bjelovar, in the past granite was exploited as dimension stone. Granite is fine-grained and of evenly gray colour without special decorativity. For the deposit is of importance the existence of the thick surface weathering crust.

Metla-Ravna gora

On the southern slopes of Metla, northeast of Pakrac, experimental exploitation has been carried out. After Jovičić et al. (1992) the quarry is open in porphyroblastic granites (fig. 6). Granite is of greengrayish and pinkgrayish colour and on the subsoil weathering part browngrayish colour. It is characterized by porphyroblastic texture and the marked foliation of mica. Slabs cut opposite or vertical to foliation are of striped appereance, with marked feldspate porphyroblastes and foliation of mica. Because of that granite was comercially called **Zebrato.**

Fig. 6 The dimension stone deposit Zebrato, Ravna gora, experimental exploration stone-pit of granite (photo: D. Jovičić)

Jankovac-Radetina

An old little quarry with some small left blocks of granite is placed west of Jankovci on Mt. Papuk. Because of the fact that this location is placed in the Natural park of Jankovci, the explorations are carried out in the eastern part. In the Creek Radetina detailed porphyroblastic granite-gneisses of gray and sometimes of pinkgrayish colour can be found.

The region of Banija and Kordun

According to our knowledge in this region in the past there were no dimension stone exploitation, neither, with respect to geology, exists such a possibility.

The region of Gorski Kotar-Lika-Primorje

The main characteristics of this region are great spreading of sedimentary rocks of the Mesozoic, a slight presence of sediments of the Younger Paleozoic (Carboniferous, Permian), and the Cenozoic (Eocene, Oligocene) with the general striking of lithostratigraphic units NW-SE with inclination to WNW-ESE in the southern part of region, as well as the complex tectonic framework (fig. 1).

Apart from rare exceptions, the greatest part of dimension stone deposits exploited in the past, or potentially prospective areas are placed in Lika.

CARBONIFEROUS

Clastic sediments, redish sandstones and fine-grained conglomerates were exploited in the surroundings of **Brušani** in Lika, and locally used in the building of houses as ashlar.

TRIASSIC

The smaller part of Triassic sediments belongs to clastic development, but the greater to carbonate,

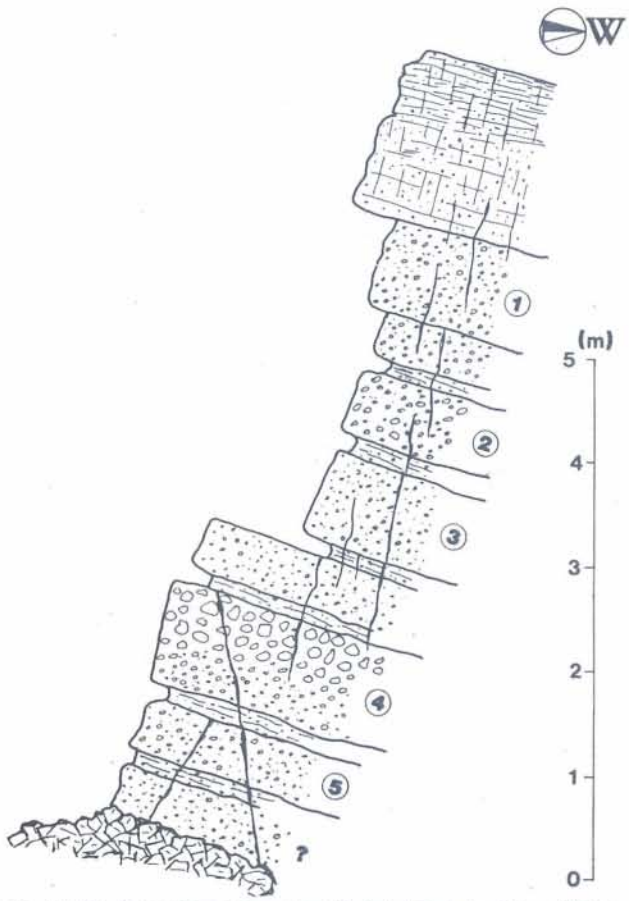


Fig. 7 The dimension stone deposit Saint Rok in Lika, hillside quarry, in carbonate conglomerate, vertical section, (after Crnković et al., 1979/80), exploited layers:
1 medium-grained conglomerate
2 coarse-grained conglomerate
3 fine-grained conglomerate
4 fine to coarse-grained conglomerate
5 medium-grained conglomerate

mainly to dolomites. In the big area of dolomites is illusory trying to find the possible dimension stone deposits.

In the vicinity of **Saint Rok** in Lika, in nearer past, the carbonate conglomerates as dimension stone were exploited. Conglomerates are of reddish to gray colour. In rock mass five exploiting layers of thickness from 0.5 to 1.0 m, can be separated (fig. 7).

JURASSIC

Of the greatest spreading in this region are carbonate sedimentary rocks, limestones and dolomites of the Jurassic. Dimension stone deposit are situated in limestones of the Lower and Upper Jurassic.

The remarkable member of Lower Jurassic (Middle Lias) is very decorative **Lithiotis limestone.** Lithiotis limestone is dense, dark-gray to black with longish white remnants of the shell Lithiotis problematica. This limestone is petrographically determined as biomicrudit i. e. coquina. Regularly in under wall and/or hanging wall there are dense dark-gray to black limestones, sometimes with the larger, whitish skeleton debris. Those limestones are petrographically determined as biomicrites, biopelmicrites, biomicrudites and biointrasparites. Pigment of the enumerated limestones is bituminous matter, and consequently of the strictly restricted usage for interior coverings.

Lithiotis limestones with the belonging rocks were exploited in the following quarries:

- Cvituša, near Lovinac, layer 1.2 m of thickness (fig. 8), and
- Gradina, near Ričice, layer 3 m of thickness.

As perspective can be separated the areas Mazin-Lapac and on Alan, north of Obrovac.

The stone, on market known as **Velebit Portoro,** was exploited in the vicinity of Gospić, in nearer past. It is the dense limestone of brown-gray, dark-gray to brown-black colour. The special decorativity to the stone gives the interesection of whitish, yellowish, brownish and redish veins, that daple it. The deposit consists of 6 layers, in total 3.75 m of thickness. Petrographically are determined as micrites, pelmicrites, biomicrites, oointrasparites and dolomitic dismicrites.

Of the Upper Jurassic age are dense, dark-gray, partly oolitic limestones, west of Brinje. The layers are 30–80 cm of thickness. The polished surface of oolitic variety is of the spawnly appearance. Petrographically are determined as oosparite and biomicrite/biosparite. The deposit is of the restricted area.

Near Donji Lapac, the stone commercially known as **Unarot** was exploited. It is red to red-brownish limestone, partly of the conglomeratic appearance. In calcite matrix are the oval intraclasts or mud pebble. Petrographically is determined as intrasparite.

CRETACEOUS

Near Prozor, southeast of Otočac, on the occasion of archaeological excavation, the ancient quarry was discovered (Šarić, 1980). The site is earlier known and in literature described as carved in rock »stone benches« and »wathering-places carved in stone«.

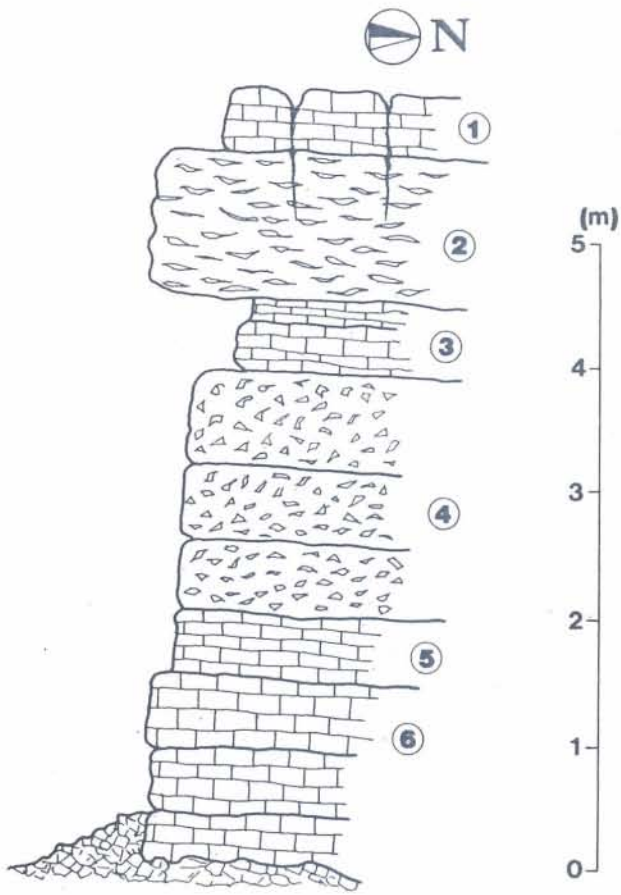


Fig. 8 The dimension stone deposit Cvituša near Lovinac in Lika, hillside quarry in limestones, vertical section, (after Crnković et al., 1979/80), exploited layers:
1 dark-gray limestone, biomicrite
2 Lithiotis limestone, biomicrudit
3 porous dark-gray to black limestone, waste
4 layers of gray shally limestones, biomicrudite, biointrasparite
5 dark-gray to black limestone, biopelmicrite
6 gray limestone, biointrasparite

The ancient quarry is illustrated in detail (fig. 9). The quarry is opened in brown-grayish brecciform limestone, dappled with whitish and redish veins, and petrographically determined as brecciated micrite and biomicrite.

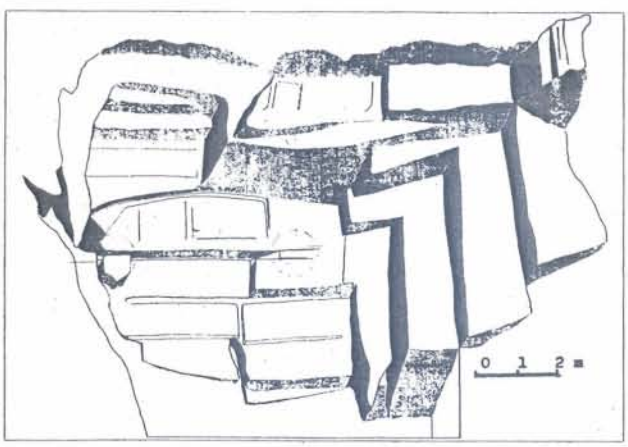


Fig. 9 The ancient quarry near Prozor, axonometric drawing after Šarić (1980), a visual impression of »stone benches« on the rock mass

North of Obrovac, in the sediments of Lower Cretaceous are exploited the stones on market known as **Romanovac** and **Tulovac** or **Kastania.** After Jovičić et al. (1988) this stones belong to dense brecciated limestone and limestone breccias. The Romanovac type is of redish, while Tulovac of dark brownisgray colour. The boath types are intersected with the veins of calcite. Petrographically are determined as micrites, intramicrites and intrabiomicrites.

Limestone breccia Muškovci was exploited southwest of Gračac. The breccia is of brown-gray colour, with intersection of whitish and redish veins.

The yellow-gray brecciaform limestone of Upper Cretaceous age was exploited west of Karlovac in **Reštovo.**

In sediments of the Lower Cretaceous, as potentially productive areas can be separated Markovićevo, northeast of Otočac, and Glavica, along the road Otočac – Dabar (Crnković et al., 1979/80), where the decorative brecciaform limestones of brown-gray, gray and brownish colour, intersected with whitish veins and lenses of calcite, can be found.

The stone is according to its appearance similar to the matherials of the ancient quarry near Prozor. The space disposition of natural discontinuities on the location of Markovićevo is unfavourable (fig. 10). But regardless to this fact, the stone blocks separated along measured natural discontinuities according to its shape and magnitude are unfavourable (fig. 11), but also favourable (fig. 12).

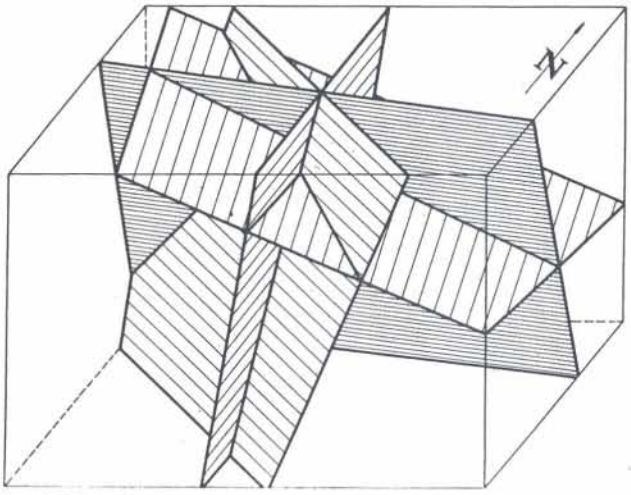


Fig. 10 Potentially productive area Markovićevo, unfavourable space disposition of natural discontinuities – planes of fractures (after Crnković et. al., 1979/80)

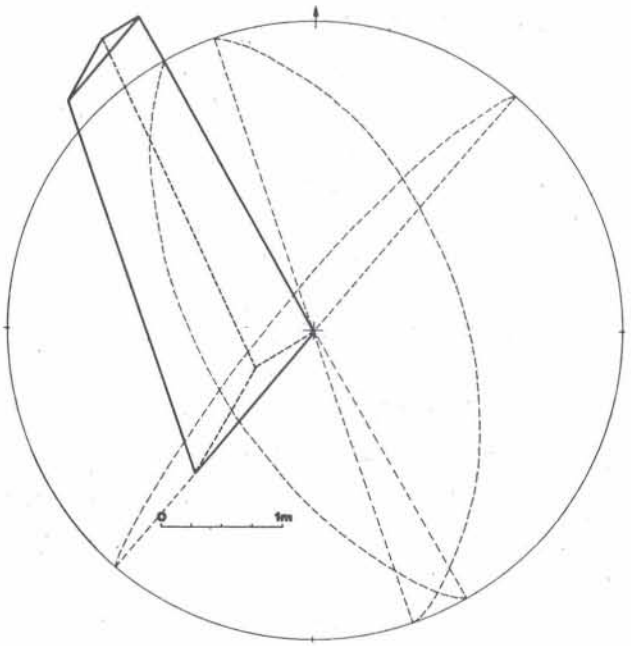


Fig. 11 Potentially productive area Markovićevo, unfavourable shape of block separated along measured natural discontinutues, the block is three-sided prism

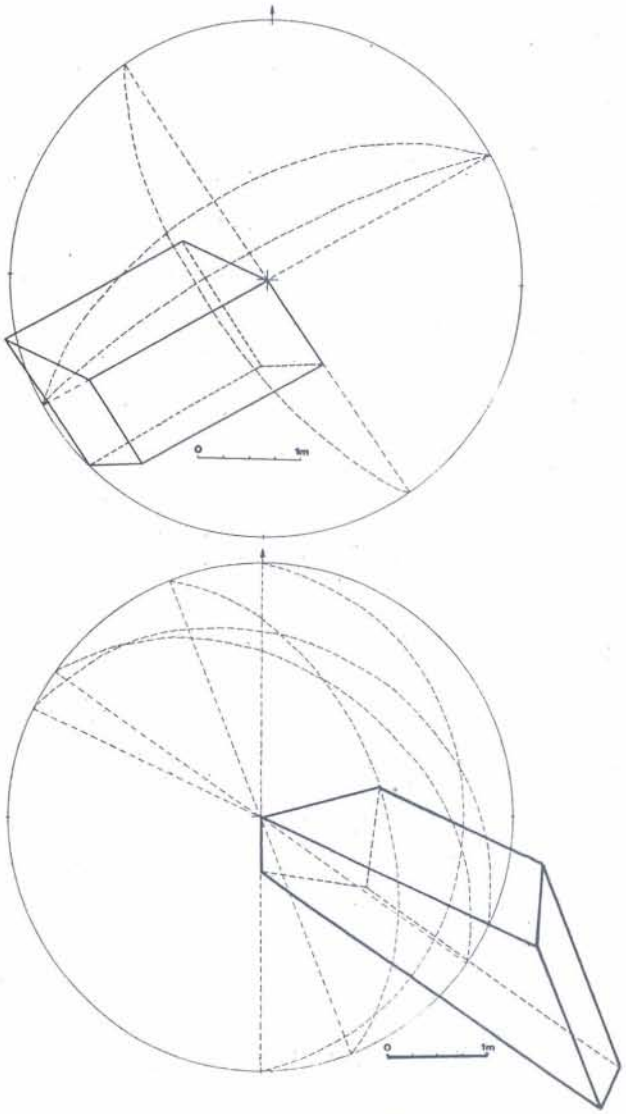


Fig. 12 Potentially productive area Markovićevo, favourable shape and magnitude of blocks separated along measured natural discontinuities

PALEOGENE

The sediments of Paleogene that cover smaller area are mostly clastic. Limestone are rarer.

Not far from Bunići, northeast of Lički Osik, were exploited yellow-grayish foraminiferal limestone as ashlars. Petrographically is determined as cataclastized biomicrite/biosparite.

As potentially productive areas in sediments of the Paleogene we can separate Oštrac west of Kosinj-

ski Bakovac and Kosinjski Bakovac, where redish, pinkish, pink-grayish, yellow-gray and of the »coffee with milk colour« limestone breccias intersected with pinkish veins can be found.

The region of Istria

The region of Istria is built up of sedimentary rocks of the Upper Jurassic, Lower and Upper Cretaceous, Paleocene and Eocene, and of Quaternary (fig. 13).

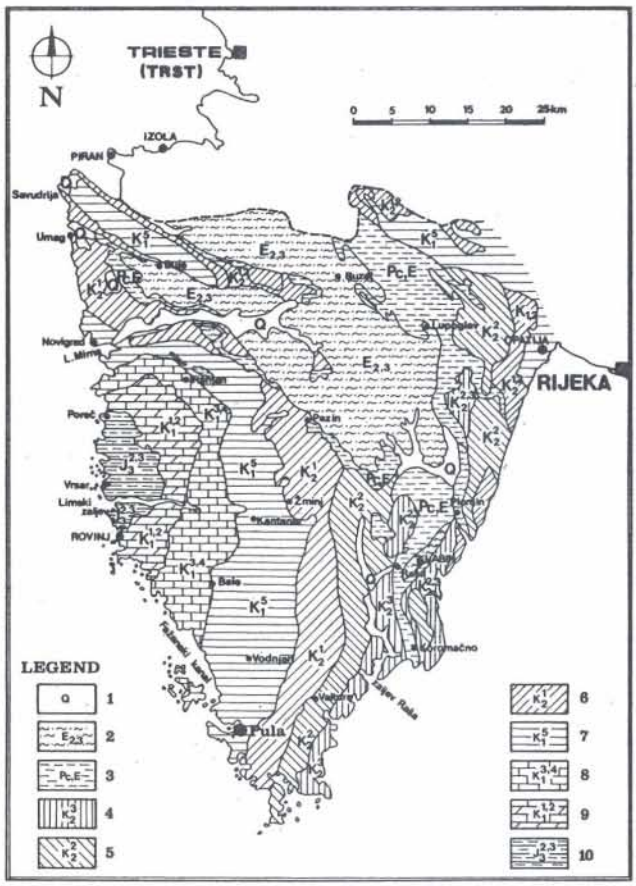


Fig. 13 Geological map of Istria (after Polšak, 1970; Polšak and Šikić, 1973)

1 Q Quaternary
2 $E_{2,3}$ Eocene (Middle, Upper)
3 Pc,E Paleocene–Eocene
4 K_2^3 Upper Cretaceous (Senonian)
5 K_2^2 Upper Cretaceous (Turonian)
6 K_2^1 Upper Cretaceous (Cenomanian)
7 K_1^5 Lower Cretaceous (Albian)
8 $K_1^{3,4}$ Lower Cretaceous (Barremian–Aptian)
9 $K_1^{1,2}$ Lower Cretaceous (Valanginian–Hauterivian)
10 $K_3^{2,3}$ Upper Jurasic (Kimeridgian–Tithonian)

Upper Jurassic limestones form the core of the Jurassic-Cretaceous anticline and they are at the same time the oldest strata found at the surface in Istria.

Lower Cretaceous sediments lay concordant on Jurassic limestones. They consist of limestones interchangeably for early-diagenetic and late-genetic dolomites.

Upper Cretaceous limestones have typical neritic elements of sedimentation in shallow sea water with an expansive development of rudistic fauna.

Paleocene sediments are discordant and transgresive to the eroded surface of Cretaceous limestones, and Eocene sediments was sedimented continuously on Paleocene.

Quaternary sediments were formed by mechanical, chemical and biochemical weathering of carbonate and flysch base.

Some of the characteristics of geology important for dimension stone deposits can be partly explainable from tectonic outline of Istria. In tectonic structure of Istria together with Jurassic-Cretaceous anticline are conspicous the tectonic break Savudrija-Buzet or anticline Buje and thrust nappe structures of Mts. Ćićarija and Učka along the direction Koromačno-Labin-Lupoglav (fig. 14). Tectonic lines with the prominent horizontal shifts practically segmentated the area of Istria. The striking horizontal movements from the point of view of dimension stone deposits are important because the exploitable beds are interrupted and shifted horizontally. Therefore their continuation after interruption, regularly, need not be searched along the vertical cuts, but in the latheral sense.

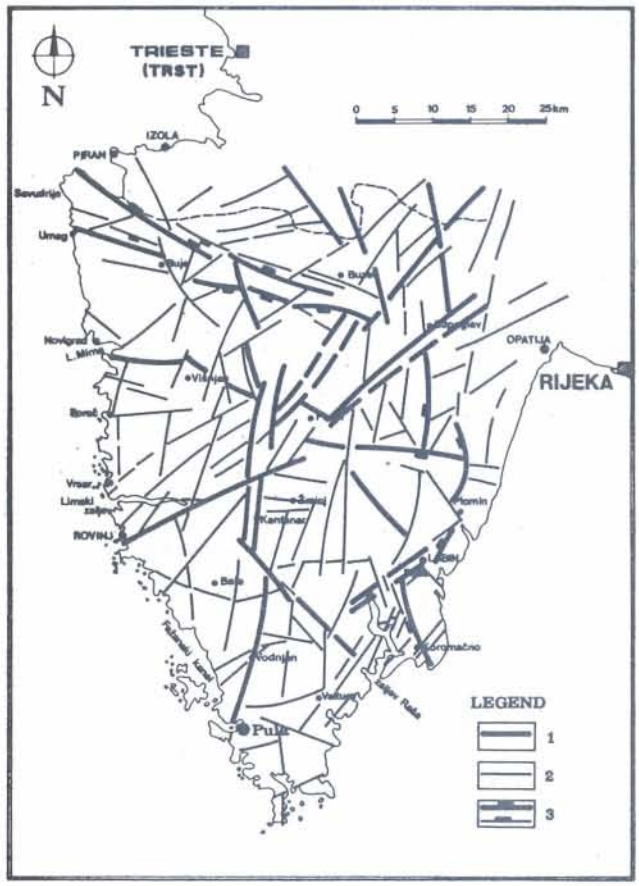


Fig. 14 Tectonic map of Istria on the base of satellite photos

1 Tectonic lines separate larger tectonic structures
2 Faults separate larger blocks along which these has been lateral displacements
3 Faults marked with relative downward blocks

The region of Istria is characterized by the numerous dimension stone deposits which are situated in limestones and clastites of Upper Jurassic including Lower and Upper Cretaceous till Eocene (fig. 15).

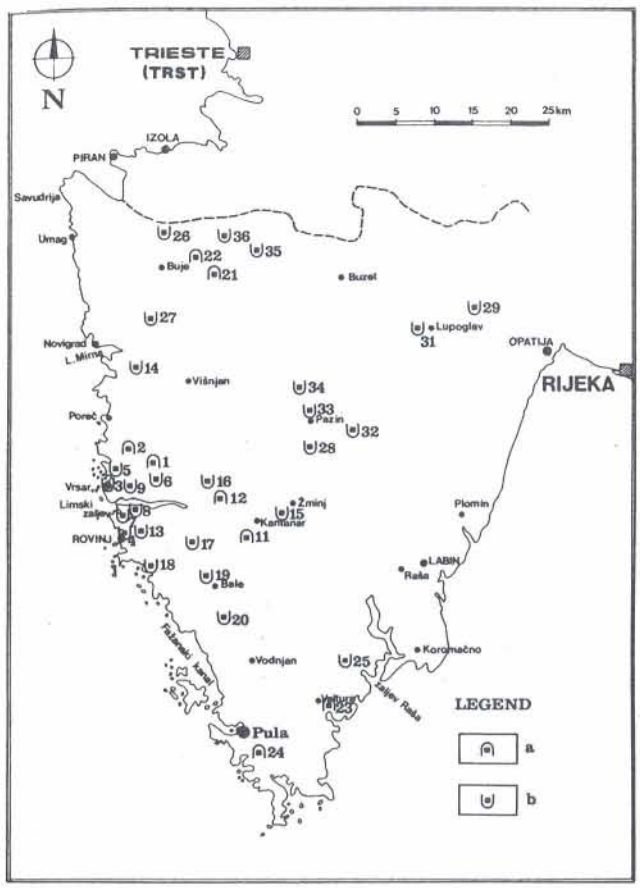


Fig. 15 Dimension stone deposits in Istria

UPPER JURASSIC
a) *quarries on exploitation*
1 Kirmenjak
2 Valkarin
b) *quarries out of exploitation*
3 Vrsar (Orsera)
4 Zlatni rt
5 Funtana and Radmani
6 Gradina and Bralići
7 Mondelaco and Signori
8 Soline and Limski kanal
9 Kloštar and Monteriko

LOWER CRETACEOUS
a) *quarries on exploitation*
11 Kanfanar
12 Selina
b) *quarries out of exploitation*
13 Fantazija
14 Jadran zeleni, Tar
15 Žminj
16 Lakovići, Voštani
17 Šorići, Movica
18 Veštar
19 Bale
20 Negrin

UPPER CRETACEOUS
a) *quarries on exploitation*
21 Saint Lucija
22 Grožnjan–Kornerija
23 Valtura
24 Vinkuran
b) *quarries out of exploitation*
25 Marčana
26 Gaderi
27 Saint Stjepan, Ponte Bracano
28 Bazgalji, Saint Magdalena, Lovrinići
29 Planik

EOCENE
b) *quarries out of exploitation*
31 Lupoglav
32 Gračišće

The exploitable deposits will be shown according to the stratigraphic belongings.

UPPER JURASSIC

The core of the western istrian anticline is built of the sediments of Upper Dogger, Oxfordian, Kimmeridgian and Tithonian. The sediments of Upper Jurassic are elaborated and described in detail (Tišljar, 1976 and 1978, Tišljar et al. 1983, Velić i Tišljar, 1988).

To Kimmeridgian belong perireefal and shallow marine limestones (biosparites, biosparrudites, intrasparites, oosparites and biomicrites), and to Tithonian belong peritidal and lagoonal cyclic deposition of micrites, desiccation breccias, intraformational pebble conglomerates, intrasparites and oncolites (fig. 16).

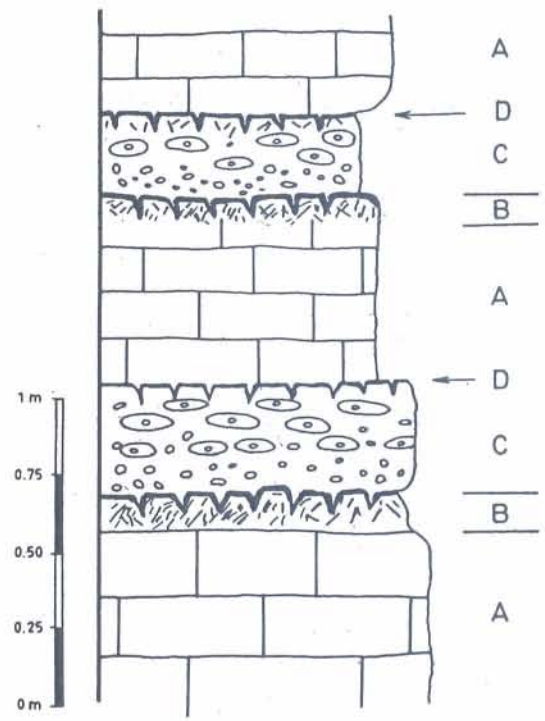


Fig. 16 The Kirmenjak quarry, desiccation cycles in the Tithonian limestones (after Tišljar et al., 1983)

A subtidal-lagunal deposition, stylolitic micrite/clotted micrite, beds are quarried as dimension stone Orsera or Kirmenjak
B desiccation and erosian phase, desiccation breccia, desiccation cracks or erosional surfaces
C inundation and subtidal deposition, intraformational pebble conglomerate/intrasparrudite (bottom) and oncoidal intrasparite (top)
D desiccation and/or vadose features

In the limestones of Upper Jurassic, dimension stone known as **Orsera** or **Vrsarian** or in the past known as »la pietra bianca in strati a Orsera« (Sospisio, 1922) is exploited. The stone is dense, whitish, grayish, ivory, browngrayish and from green to blue tones. It is characterized by stylolites, parallel to bedding. Stylolites are particularly evident in the

33 Pazin
34 Trviž, Ukotići
35 Sorbar
36 Merišće

case of sawing the stone vertical to bedding and stylolites. In respect to colour the following types can be distinguished: white, ivory, gray and green. The stone is polished to the high lustre.

Today is exploited in two quarries:
- Kirmenjak (3 km southwest of Žbandaji), and
- Valkarin (5.5 km southeast of Poreč),

on market known as **Kirmenjak stone.**

In nearer and farther past the exploitation was carried out in these quarries too (fig. 15):
- Zlatni rt, the deposit southwest of Rovinj, not exploited because of tourism and the protection of environment,
- Funtana, northern of Vrsar,
- Radmani, northern of Vrsar,
- Gradine, south of Kirmenjak,
- Bralići, in the vicinity of Gradine,
- Mondelaco, north of Rovinj,
- Signori, NNW of Rovinj,
- Soline, NNW of Rovinj,
- Kloštar, east of Vrsar,
- Monteriko, southeast of Vrsar, and
- Limski kanal.

LOWER CRETACEOUS

To the lowest part of Lower Cretaceous belong dolomites with a few interbedded micrites, pelmicrites and stromatolites (Berriasian). In these sediments, the nonactive quarry Fantazija (east of Rovinj, today geologically protected object), is situated.

After Tišljar et al. (1983) Valangian-Hauterivian sediments are fenestral micrite/biomicrite, biosparite, pelmicrite/pelsparite, intrasparite, stromatolite and oncolite.

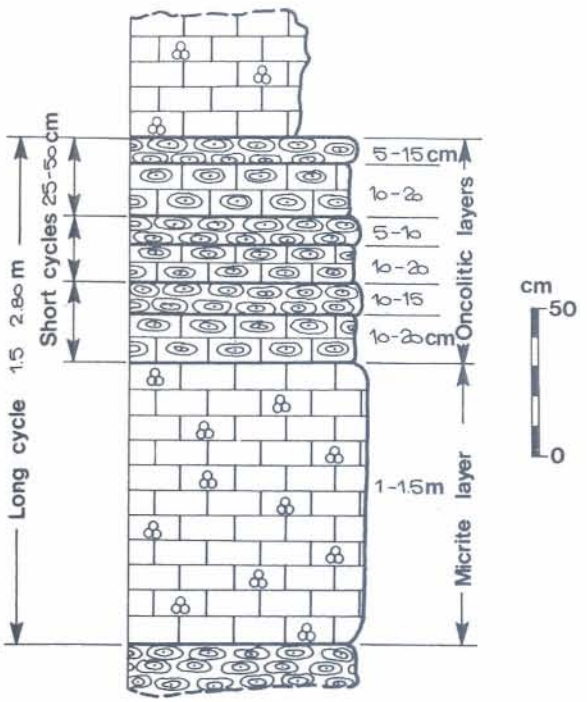
Barremian sediments are white to yellowish biosparites, intrasparites, fenestral micrites, pelsparites/pelmicrites and stromatolites, as well as sporadical peritidal breccias and mud pebble conglomerates.

Aptian sediments in lower part are mainly composed of subtidal to lagoonal limestones. Higher part of Aptian is characterized by sporadical and short emersions with formations of intraformational breccias and mud pebble conglomerates. Occasionally, there are thin layers of oncolites which contain algal ball oncoides, intraclasts, as well as gastropodes and micritized foraminifera.

Albian is characterized with deposition of large quantities of detritic limestones. Biomicrites, rudist coquinas, microcoquinas and biostromes appear sporadically.

In the limestones of Lower Cretaceous of numerous quarries **»Giallo d'Istria«** or »Istrian yellow« was exploited.

From, in the past numerous quarries, today is **Istrian yellow** exploited in the quarries of **Kanfanar** and **Seline.** After Tišljar (1976) in the Kanfanar quarry is visible the rythmical alternation of micrite and oncolite (fig. 17). The two cycles may be distinguished:
- long cycle represented by a micritic layers and several oncolite layers, and
- short cycles contain micritic layers with macroids and strata built up of macroid dominantly.



LEGEND

1 2 3

Fig. 17 The Kanfanar quarry, of Istrian yellow rhytmical alternation of micrite and oncolite (after Tišljar et al., 1983)

1 micrite
2 macroidal oncolite
3 micrite with macroids

Due to higher organic matter content in macroids, their colour is darker than light-brown and yellowish colour of micrites and thus they are easily seen on the polished slabs. Polished surface of slab has nutty appearance. It is probable that after its appearance in the past the stone was named **»karst rose«**. Decorativity of the particular lower beds is evident in the cuts of skeleton Requienia ammonia.

Except in the active quarries of Kanfanar (SSW of the railway station in Kanfanar) and Seline (SE of Lovreč), dimension stone was in past exploited in the following quarries (fig. 15):
- Žminj, SW of Žminj,
- Jadran zeleni, SE of Tar,
- Lakovići, SE of Lovreč,
- Voštani, east of Lovreč,
- Movica, SE of Rovinjsko selo,
- Šorići, ESE of Rovinjsko selo,
- Veštar, SE of Rovinj,
- Bale, near Townlet Bale, and
- Negrin, south of Bale.

The large spreading of Istrian yellow in detail is introduced in present time successful explorations (fig. 18). Clearly are visible horizontal displacements of Istrian yellow beds along faults. This is excelent »sing-post« for farther searching the new dimension stone deposits of Istrian yellow. Authors are grateful to Mr. I. Velić, Mr. B. Sokač and Mr. J. Tišljar, for the permission of first publishing represented data, and map. After Velić et al. (1987) the thickness of Istrian Yellow varies in the broadly limits.

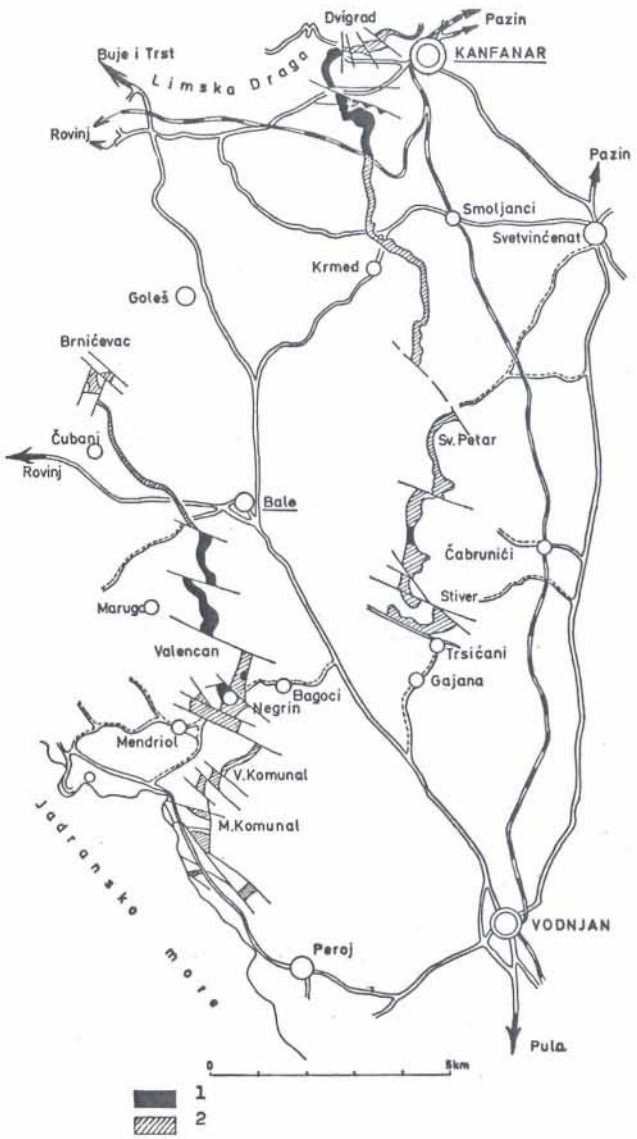


Fig. 18 The spreading of Istrian yellow

1 the spreading of Istrian yellow known before 1982
2 the spreading of Istrian yellow after geological explorations 1982/84
(Published by permission of Director of Institute of geology in Zagreb Mr. Gj. Benček, and of the authors Mr. I. Velić, Mr. B. Sokač and Mr. J. Tišljar)

It is lacking on north in the Heraki area, and their total thickness is about 14 m in the Dvigrad area (fig. 19). This is result of different paleoenvironmental conditions and frequent changes of some lithostratigraphic units.

UPPER CRETACEOUS

Upper Cretaceous sediments are represented by perireefal and reefal limestones.

After Tišljar et al. (1983) lithological composition of the Cenomanian limestones in souther Istria is quite uniform. Thick biostromal layers with local bioherms built up of large rudist shells, and large masses of rudist fragments of different size and roudness, forming coquinas, coquinites and microcoquinites. Textural difference among these rudist limestones are particle size, roundness, sortness and quantity of matrix and cement.

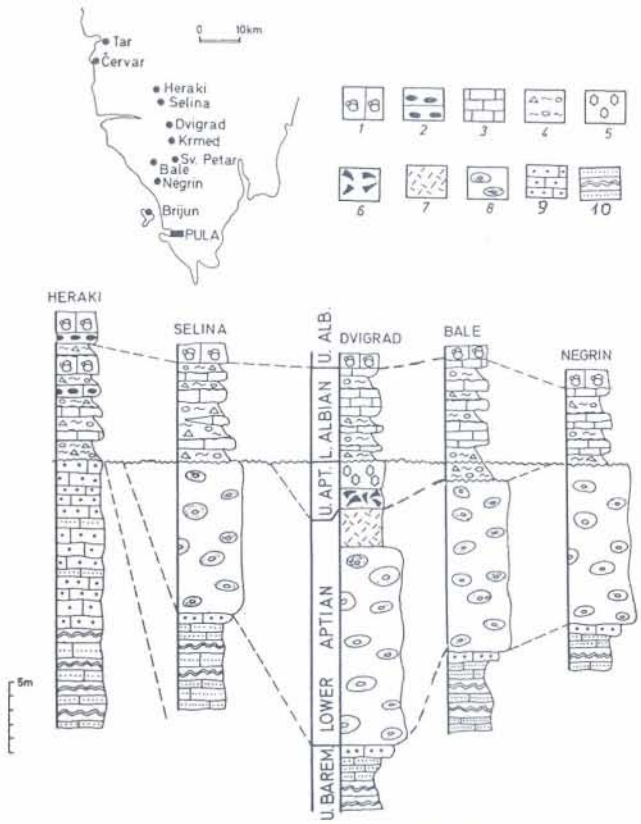


Fig. 19 Condensed correlation scheme of the detailed geological columns (simplified) of the area of West Istria (after Velić et al., 1987)

1 foraminiferal biomicrite/biosparite
2 black-pebble breccia
3 micrite and fenestral micrite
4 emersion breccia and/or mud-pebble conglomerate (clayey matrix)
5 algal biomicrite/biosparite
6 coquina
7 well sorted biointrasparite
8 massive micrite/oncolite (Istrian Yellow)
9 intrasparite
10 thin-bedded stromatolite/pelmicrite

The mechanism of genesis of the described types of limestones is explained and ilustrated by Tišljar (1976) at the example of dimension stone deposit Valtura (fig. 20).

Senonian limestones are represented by thin micrite layers which alternate with biostromes or bioherms of rather small size, and thin bedded micrites in alternation with foraminiferal biocalcarenites and intraclastic limestones.

In the limestones of Upper Cretaceous there are numerous dimension stone deposits, of which are today active the following:

- **Saint Lucia**, in the anticline of Buje, with varieties of »unito« and »fiorito«, depending, whether the stone contains fine skeleton debris of rudist, or larger rudist skeleton in fine grained matrix, of different nuances of gray colour, often banded structure from the thin layers of the bituminous matter,
- **Grožnjan-Kornerija**, in the anticline of Buje, in the vicinity of Marušići, whitish to yellowgrayish colour, skeleton debris gives to the stone grained

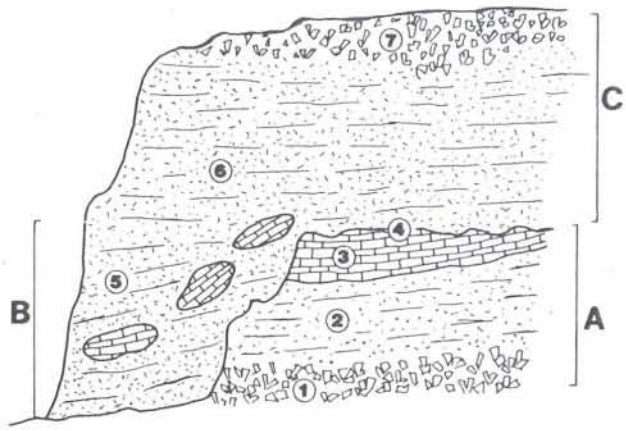


Fig. 20 The Valtura quarry, depositional environments of rudist limestones Turonian age (after Tišljar, 1976)

A cycle
1 rudist biostrome
2 break of biostrome development and deposition of rudist coquinite
3 deposition of fine-grained rudist debris, rudist microcoquinite
4 break of deposition, intensive horizontal and vertical erosion and removed of rudist debris

B cycle
5 deposition of rudist debris, rudist coquinite and fragments of rudist microcoquinite

C cycle
6 break of erosion A cycle sediments and deposition of rudist coquinite
7 repeated development of rudist biostrome

appearance, therefore very much alike to matherials known on the market as »Granitello«,
- **Valtura**, northeast of Pula, different nuances of yellowgrayish colour, with the difference of varieties »unito« (microcoquinite) and »fiorito« (coquina), depending on dimensions of skeleton debris,
- **Vinkuran**, old »Cava Romana«, southeast of Pula, the stone of whitish colour, with the varieties of **»unito«** or **»statuario«**(microcoquinite) and **»fiorito«** or **»travertino«** (coquina), belonging to soft and porous varieties of limestone.

In nearer and further past the exploitation was carried out in these quarries too:

- Marcana, northeast of Pula, soft and porous limestone of white colour, for which Kieslinger (1932) describing instability of certain limestones wrote: »Ganz besonders gut haben sich die Kalke von Marzan in Istrien als Bausteine bewährt . . .«,
- Gaderi, north of Buje,
- Ponte Bracano, in the valley of the River Mirna,
- Saint Stjepan, in the valley of the River Mirna, the only quarry with the underground exploitation in the past, for which Marić (1951) wrote, that this big quarry in Istria takes the significant place in civil engineering,
- Mirna-Bazgalji, south of Pazin,
- Saint Magdalena-Čulen brdo, south of Pazin,
- Lovrinići, south of Pazin, redish, pinkish, grayish and brownish limestone and limestone breccia,
- Planik, not far from Lanišće, shelly limestone,
- Goli otok (island), breccia of orange colour with calcite-hematite and limonite cement, and limestone, and
- Krk (island), limestone breccia.

EOCENE

At the present moment, dimension stone is not exploited in the sediments of Eocene. In the further and nearer past limestone conglomerates, breccias and limestones were exploited in numerous deposits, some of them here mentioned:

- **Istranka**, in the past exploited in the vicinity of Lupoglav, nummulitic limestone of dark brown colour with numerous light skeletons of large nummulites, and others large benthic foraminiferas, pigmented with bituminous matter, the stone of great decorativity and remarkable appearance,
- Granitello-Gračišće, in the past exploited near Gračišće, nummulitic breccia, lower units of Turbidite sequence, of grayish and brownish colour, with greenish nuances,
- Mandorlato, nummulitic breccia, lower units of Turbidite sequence, of yellow-grayish and grayish colour, the quarry situated in the town of Pazin,
- Mandorlato and Unito, nummulitic breccia, lower units of Turbidite sequence, of yellow-grayish colour and bluish nuances, in the past exploited near Trviž (locations: Brtoška, Stenice, Čize),
- Ukotići, near far from Trviž, nummulitic breccia,
- Sorbar, northeast of Marušići, limestone conglomerate of brownich colour, and
- Merišće, northeast of Jeličići, marmorizated limestone breccia of whitish and pinkish colour, intersected with yellow calcite-limonite veins.

The region of Dalmatia

The greatest spreading in this region enclose sedimentary rocks, rudistic limestones of the Upper Cretaceous age. As far as dispersion is concerned,

Table 1 Mechanical and physical properties of dimension stone, Istria (data: Institute of Civil Engineering of Croatia, Zagreb)

Properties	1	2	3	4	5	6
Compressive strength dry samples, MPa	138,5	149,0	223,0	136,0	101,0	72,0
Compressive strength water-saturated samples MPa	113,5	124,5	162,0	110,5	66,5	63,0
Compressive strenght after 25 cycles of freezing and thawing MPa	103,0	104,0	149,5	106,5	42,5	68,0
Resistance to grinding (Boehme method) $cm^3/50\ cm^2$	16,1	19,3	19,1	23,7	45,1	44,3
Density, kg/m^3	2700	2714	2713	2630	2712	2700
Bulk density, kg/m^3	2677	2615	2688	2557	2294	2380
Porosity, %	0,85	3,65	0,92	2,78	15,42	11,85
Water absorption, %	0,77	0,94	0,20	1,30	5,78	4,00

1 Orsera, Kirmenjak; 2 Istrian Yellow, Kanfanar; 3 Istrian Yellow, Selina; 4 Saint Lucija; 5 Valtura Unito; 6 Vinkuran Statuario

the carbonate clastic rocks of Paleogene follow to the greater extent. The other lithostratigraphic units are represented to the lesser degree. Therefore is logical that greatest number of dimension stone deposits are placed in various varieties of rudistic limestones.

TRIASSIC

There are no dimension stone quarries in the sediments of triassic age. In them of some interest can only be the smaller part of limestones of the Middle Triassic age, what mentious Kieslinger (1932) when describes »Bunte Alpenmarmore« and refers location »Muc bei Spalato (Trias)«. North of Muć is situated the narrow zone of unbedded limestone (Ladinian) of the east-west striking.

JURASSIC

In sediments of the Lower Jurassic near **Trilj**, occasionally was exploited Lithiotis limestone, on market known as **Negris fiorito**. Geological conditions of the deposit are unfavourable, with vertical layers.

As dimension stone, apart from Lithiotis limestone, the surrounding limestones of completely black colour could be exploited, but without significant decorativity.

Southeast of Drniš, in the sediments of Lower Jurassic, the limestone **Crna Krička** was exploited. After Tišljar (1980a) in the tectonic block of smaller area, the thickbedded, dark-gray to black limestone dappled with redish and yellowish veins and stylolites used to be exploited. Because of tectonic framework and density of discontinuities, only tombolones and smaller blocks can be taken out. The use of this stone is strictly limited to covering of interiors. Not far from this quarry Lithiotis limestones are spreading.

On the southwest slopes of the Mt. Dinara, east of the Cetina River, are situated thickly bedded, dense limestones of white colour with stylolites, alike to the stone on market known as »biancone« and »Hoch Jura«, as well as limestones of gray and brown-gray colour, investigated on several locations. In the area of **Česma**, the explorational drilling was carried out. The thickness of layers vary from 0.75 to 2.5 m. Petrographically are determined as pelmicrites and micrites.

CRETACEOUS

The slightly dispersed sediments of the Lower Cretaceous age in continental part and the islands of Hvar and Korčula are not significant from the point of view of dimension stone exploitation. All the deposits are placed in different varieties of the Upper Cretaceous limestones.

One of the varieties is yellowish-whitish and brownish-grayish dense limestone, massive or thick bedded, on the market known as **Dolit**. This limestone is exploited in the deposit Donji Dolac east of Dugopolje. Petrographically is determined as micrite and brecciated micrite. Because of the tiny and space restricted cracks, it is recommended to use them primarily for production of thicker slabs and elements. Limestone of same quality is **Dicmit**, in the past was exploited in Dicmo on the northern part of Krušvarsko polje.

From the Ancient times, through the Middle Age, till present days in exploitation is whitish limestone, on spots of bluish nuances, well known as **Seget**. The deposit is on the hill of Saint Ilija near Trogir. This is one of the rare quarries in our region, where the exploitation was carried out by English company in 1920/30 (Marić, 1930 a). Petrographically is determined as biosparite, but the skeleton debris is not macroscopicaly observed.

In continental part of this region important are fosiliferous rudist limestones which consist of the abundance skeleton debris, in the first place, rudists of different dimensions, roundness and sorting. The fragments of skeleton are regularly of darker yellowish and brownish nuances, differing from the calcite matrix, that visually emphasize their decorativity. Petrographically are determined as biosparite.

The limestones of that sort are nowdays exploited in the quarries:
- **Vrsine**, NNE of Vrsine, west of Trogir (figs. 21 and 22), and
- **Plano**, NE of Trogir,

while the following quarries were exploited in the past:
- Voluja, in the bay of Voluja south of Marina, petrographically determined as biosparite and fossiliferous dismicrite,
- Okrug, western part of island Čiovo, petrographically determined as dismicrite, while people of that time called it »glassy«, because the surfaces of calcite cleavage reflect the beams of light, and therefore glaze, the quarry is placed in the touristic zone,
- Mosor, on the northern slopes of the Mt. Mosor, south of Donji Dolac,
- Dubrava, north of Šibenik,
- Kremenovo, near Dubrava, and
- Krševine and Krtoline, east of Dubrava.

The deposit of fossiliferous and partly rudist coquina limestones Vrdovo on the southern slopes of the Mt. Dinara, north of Sinj, was in the phase of investigation.

The **Fantazija** stone exploited southeast of Donji Dolac differs from the enumerated dimension stones. The stone is of brecciated and marbleized appearance, wax lustre, yellowish-gray and brownish colour, with greenish nuances.

After Jovičić et al. (1989) the dimension stone deposit **Boriština** on the island of **Dugi otok** is placed in rudiste limestones of Upper Turonian-Lower Senonian age. Three types of limestones can be visually separated in the deposit:
- graybrownish limestone, stylolitic biomicrite, lower bed,
- white rudiste limestone, petrographically determined as biomicrite/biosparite and biosparrudite, exploitable layer of 20-odd m thickness,
- white plate limestone, biosparite and biosparrudite, hanging bed.

In the region of Dalmatia, regarding the dimension stone exploitation, the island of **Brač** takes a significant place, being famous of **»the marble of Brač«**.

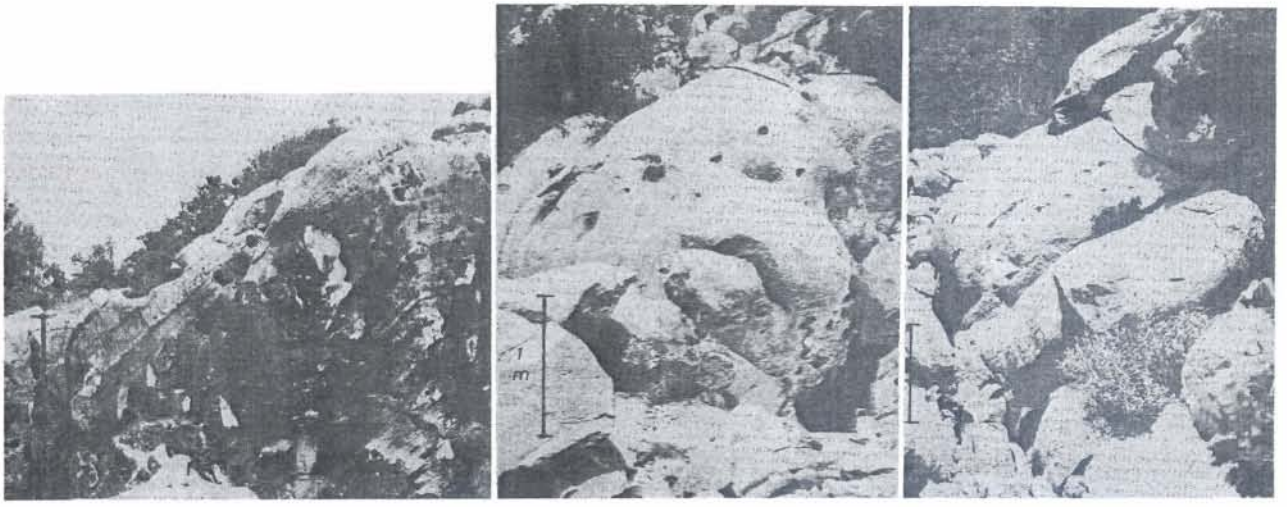


Fig. 21 Dimension stone deposit Vrsine, outcrops of fossiliferous rudiste limestone, the phase of geological investigation 1970 (photo: B. Crnković)

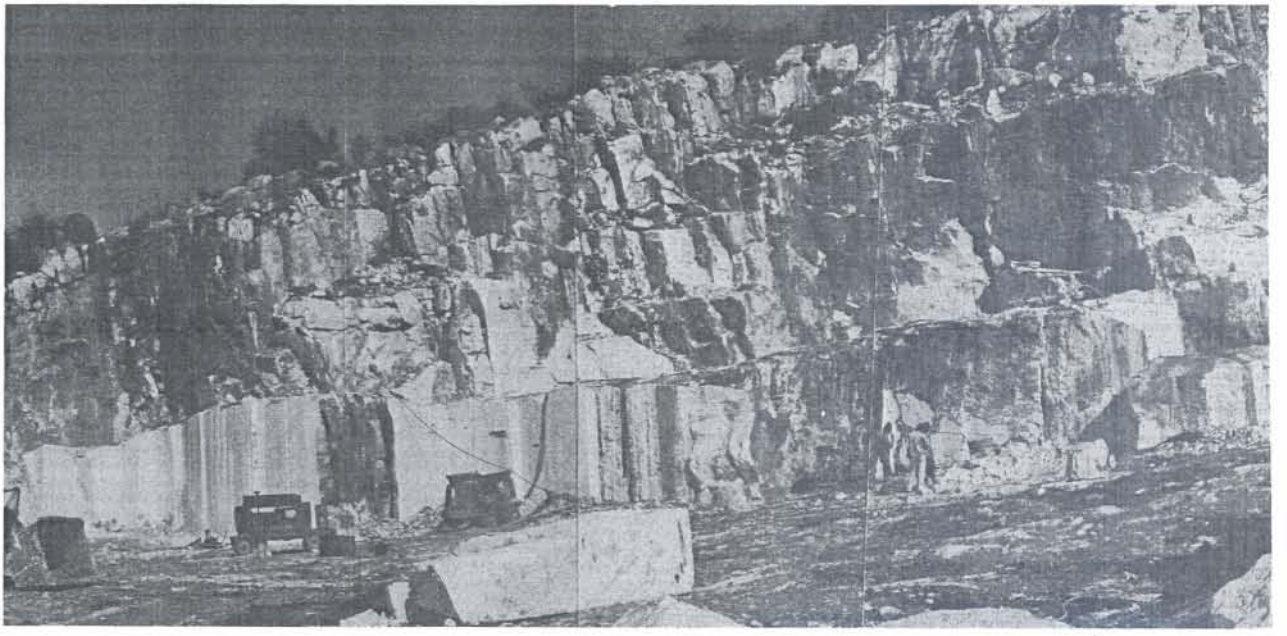


Fig. 22 The Vrsine quarry, same place as photo fig. 20, but 1993, successful quarried the fossiliferous rudiste limestone (photo: B. Crnković)

The island is almost completely built of the carbonate sediments of Upper Cretaceous age (Turonian-Senonian), and than slightly dispersed foraminiferal limestones and clastites of Eocene.

In the tectonically-structural sense the island is asymetric anticline, where layers along the northern limb slightly plung the north. Because of that structure all dimension stone deposits, from the ancient times till nowdays, are dispersed on the northern and eastern side of the island. Therefore exploitation covers the wide zone of the east-west striking (fig. 23).

From the point of view of dimension stone exploitation of the forementioned zone, from Splitska on west to Povlja on east, after Tomašić (1979), we can distinguish lower beds and hanging beds (fig. 24).

Lower bed is exploited not far from Pučišća in the open-pit quarry, beneath the sea level. This is dolomitic limestone **Sivac** (Gray stone), petrographically determined as dolomitic micrite/biomicrite. On the market are known two varieties of stone: **Adria Grigio Macchiato** (Adria gray spotty) and **Adria Grigio Venato** (Adria gray veined). The first is of homogenous structure, uniform gray colour, and the other is intersected with darker-gray veins and oval stains.

In hanging beds alternate vertically and lateraly fossiliferous rudiste limestones of the »unito« and »fiorito« type (fig. 25). The limestone of »unito« (monotonous) type contains fine-grained skeleton debris of the uniform dimensions. Limestone of the »fiorito« (blooming) type in fine-grained skeleton debris contains large skeletons of rudiste and other fossils. Limestones are of different yellowish-gray nuances. It's decorativity is marked with skeleton debris which is of regularly darker nuances than the

Fig. 23 The island of Brač, Hvar and Korčula, dimension stone deposits

The island of Brač
UPPER CRETACEOUS
a) *quarries on exploitation*
1 Punta and Barbakan (Veselje unito, Veselje fiorito), and Sivac (Adria Grigio)
2 Kupinovo (Kupinovo unito, Kupinovo fiorito, Diokles), and Kupinovo novo
3 Zečevo and Glave (San Giorgio)
4 Žaganj Dolac (Rasotica)
5 Dragonjik
6 Dračevica
7 Pražnica
b) *quarries out of exploitation*
8 Splitska and Škrip
9 Postire and Rasohe
10 Lozna
11 Saint Nikola
UNINDENTIFIED AGE
(younger from the Upper Cretaceous)
a) *quarry on exploitation*
12 Oklad

The island of Hvar
UPPER CRETACEOUS
b) *quarries out of exploitation*
1 Pokonji Do and Križna Luka
2 Bogomolje
3 Saint Nedjelja
4 Vranković

The island of Korčula
UPPER CRETACEOUS
a) *quarry on exploitation*
1 Humac
b) *Quarries out of exploitation*
2 Krkmača
3 Oskorušica
4 vrbovica
5 Vaja
6 the small islands of Vrnik Kamenjak, Badija and Sutvara

matrix. Petrographically are determined as biomicrite/biosparite and biomicrudite/biosparrudite.

Numerous quarries are placed from the western to the eastern part of the island:
- Splitska, Škrip, Postire and Rasohe, out of exploitation,
- **Punta** and **Barbakan** near Pučišća, on market known as **Veselje unito** and **Veselje fiorito**,

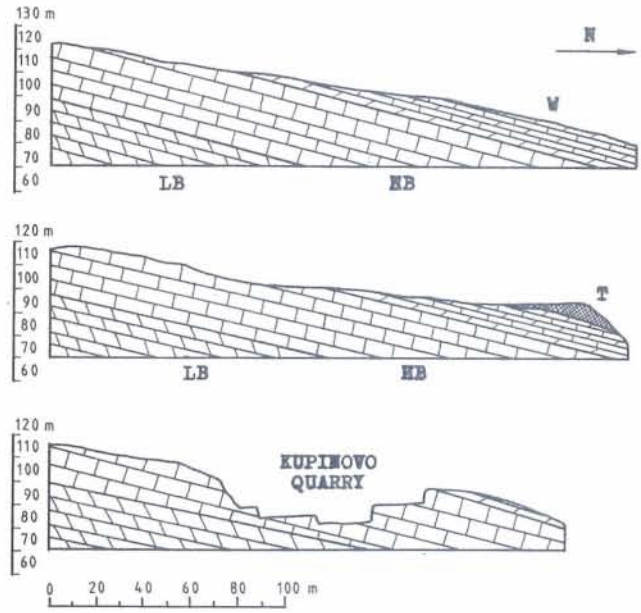


Fig. 24 The Kupinovo quarry, vertical section (after Tomašić, 1979)

LB lower bed, dolomitic micrite/biomicrite, Sivac
HB hanging beds, fossiliferous rudist limestone unito and fiorito type, Veselje, Kupinovo
W waste hanging wall
T waste talus

- **Kupinovo**, and **Kupinovo novo**, east of Pučišća, on market known as Kupinovo unito, Kupinovo fiorito and **Diokles**,
- Lozna, east of Kupinovo, out of exploitation.

Fossiliferous rudiste limestones in the eastern part of the island are of yellowish, yellow-whitish and yellowish-grayish colour. Sometimes, on surface, because of intraclasts and fine-grained skeleton debris are of the spawnly appearance. They contain skeleton debris of rudistes and foraminiferas, as well as intraclasts in micrite and sparite matrix. Petrographically are determined as biomicrite/biosparite, biointramicrite/biointrasparite and dolomitic biomicrite/biosparite. The varieties of »unito« and »venato« are differed. The variety of venato contains dark brown bituminous and dolomitic enriched veins. On market the stone is known as **San Giorgio Unito** and **San Giorgio Venato**, and exploited in the quarries **Zečevo** and **Glava**.

In the vicinity of Selce, in the past period, the stone of same quality was exploited in the quarries Saint Nikola and Glavice.

On the eastern part of the island, in **Žaganj Dolac** near Sumartin, there is the rudiste limestone deposit of remarkable decorativity, known on marked as **Rasotica**. In darker brown matrix, the lighter fine-grained and larg skeletons of rudiste, and banded accumulations of bituminous matter accentuate the decorativity. Sporadically, near fractures, limestone is of lighter nuances, most probable because of bituminous matter oxidation, under the influence of rain circulations. The stone of Rasotica is petrographically determined as bituminous biomicrite/biosparite, and biomicrudite/biosparrudite. The use strictly restricted to covering of interiors, because of fading, under activity of exogene, oxidating factors.

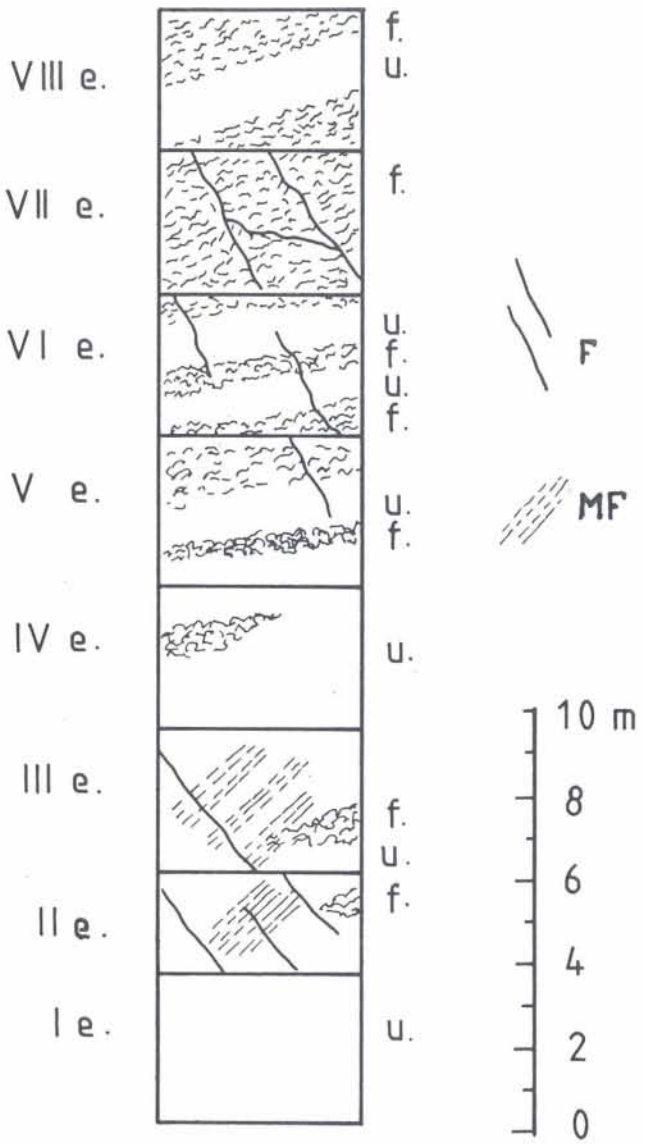


Fig. 25 The Punta quarry, vertical section of hanging beds (after Tomašić, 1979)

Ie – VIIe multi-benches
u stone unito type
f stone fiorito type
F fracture
MF dense micro-fracture so-called »books«

Not far from Nerežišća, fossiliferous rudiste limestone is exploited in the **Dragonjik** quarry. The stone is of yellowish whitish and yellowish-grayish colour, with clearly marked grained skeleton debris, and therefore alike to the stone varieties called »Granitello« (grained). Petrographically is determined as dolomitic biointramicrite/biointrasparite and biomicrite/biosparite.

North of the Dragonjik quarry in the wider surroundings of **Dračevica**, there are several quarries in which private stone-masons exploit the stone. The small quarry of nicely brownish and the colour »of coffe with milk« is placed near **Pražnica**.

After the short elaboration of the main characteristics of dimension stone deposits, we should take a look at the incorrect interpretation of the part of these deposits in the monograph of Gušić and Jelaska (1990). The mentioned authors described carbonate sedimentary rocks of the island according to formations. In the Dol Formation they described the stone Sivac, commercially called Adria Grigio, which they identify with the stone Zečevo and Glava, commercially called San Giorgio. They literally write »... in the quarries of Glava and Zečevo quarrymen pick stone (home term for stone extraction) similar to Sivac. The similarity includes some differencies, which wouldn't necessarly be sufficient for the different commercial name of dimension stone. ... Therefore, it would be extremely unusual that the quarrymen froma Selca also pick the Sivac, because of that this kind of stone is there for the need of world market named San Giorgio.«

But it is not correct! There are important and essential differencies between the types of stone commercially called Adria Grigio and San Giorgio:

- in stone appearance and decorativity of the polished surface, Adria Grigio or Adria Gray, as its name tells itself, is of gray colour and in the same time »macciato«, which means spotty, with clearly marked oval and longish darkgray spots, and venato with clearly marked darker gray veins; San Giorgio is of yellowish-whitish and yellowish-grayish colour, not spotty, but of spawnly appearance, with fine-grained but evident skeleton debris, while venato has darker brown veins pigmented with bituminous matter;
- in genesis and the environmental conditions of the sedimentation, both sediments could be of the same age, and deposited in the same time, but in different conditions, that resulted in the described visual differencies; Adria Grigio is exclusively micrite limestone, deposited calcite mud, while darker gray oval and longish spots are remnants of the worm boring in that mud; such bio-activity is not evident in the stone San Giorgio, its main components are fine-grained skeleton debris and intraclasts;
- therefore it is logical that two in its essence and visually different limestones represent two different facies and have different commercial names.

On the island of **Hvar**, after Majer and Crnković (1977), in the quarries of Križna Luka, Pokonji Do and Bogomolje, whitish limestones were exploited. Coloured limestones are also dispersed and were exploited in the past:

- Saint Nedjelja, red-yellowish and greenish-gray limestone breccia, and
- Vranković and the bay of Jagodna, pinkish striped limestone.

On the island of **Vis**, in Labotovo, was exploited greenish limestone of pinkish and greenish nuances, on market known as Roza Val.

The island of **Korčula** is also known of its dimension stone exploitation.

In the present time the only active quarry on the island is **Humac**, southeast of the town Korčula. After Jovičić et al. (1991) three types of limestone can be separated in the deposit:

- dense gray limestone, lower bed,
- fossiliferous rudiste limestone of orange colour, exploitable layers thickness from 0.8 to 1.7 m,
- thick bedded rudiste limestone, hanging bed.

Exploitable layers petrographically are determined as biomicrite/biosparite and biomicrudite/biosparrudite.

In nearer and further past exploitation was carried out in these quarries too (fig. 23):

- Krkmača, not far off the quarry Humac; where two types of exploitable fossiliferous limestones can be separated in the deposit of olive-gray and gray colour, petrographically determined as biomicrite, biopelmicrite and biointramicrite,
- Oskorušica, west of the town Korčula, fossiliferous limestone of light gray and rosy-gray colour, petrographically is determined as biomicrite/biosparite, biopelmicrite and biorudite,
- Vrbovica, on the north part of the island, with two types of fossiliferous limestones, of whitish rosy and brownish colour so called Pigavac, petrographically are determined as biosparite and biosparrudite
- Vaja, in the bay of Vaja west of Ročišće, white limestone.

The exploitation was carried out in the quarries of the small islands of Vrnik, Kamenjak, Badija, Sestrice and Sutvara, east and northeast of Korčula.

From the enumerated most significant is the island of **Vrnik** (fig. 26). The height of old multi-benches quarry is 50 m. The fossiliferous rudiste limestone of unito and fiorito types, of whitish-rosy and grayish-rosy colour, petrographically are determined as biomicrite/biosparite and biomicrudite/biosparrudite.

Of the deposits in continental part of the region, we should mention **Visočani**, northwest of Dubrovnik. In the deposit fossiliferous rudiste limestone was exploited, visually alike to the stone from the quarries near Pučišća on the island of Brač. During the aggression and violence of chetniks 1991/92 all the plants are partly looted, and partly destroyed, while the quarry is demolished, therefore we fear that it would be out of use for the longer time.

PALEOGENE

The sediments of Paleogene cover the remarkable area in the northwestern part of the region, that would in another parts stretch in a form of narrow zones, mostly in overlap faults. In the northwestern part the general striking of Paleogene is NW-SE with the change in striking WNW-ESE and partly to W-E in central part, that would in the southern part take the same striking NW-SE. In the Paleogene mostly are represented carbonate clastic sediments, to the lesser degree limestones, with flysh as important lithostratigraphic member.

Dimension stone deposits are primarly situated in differently coloured limestone conglomerates of the »Promina formation«. The colour of conglomerate depends on the colour of pebbles and cement. Conglomerates are thickly bedded with the conspicuous layer's discontinuities. Sporadically in deposits alternate thiner and thicker layers of limestone.

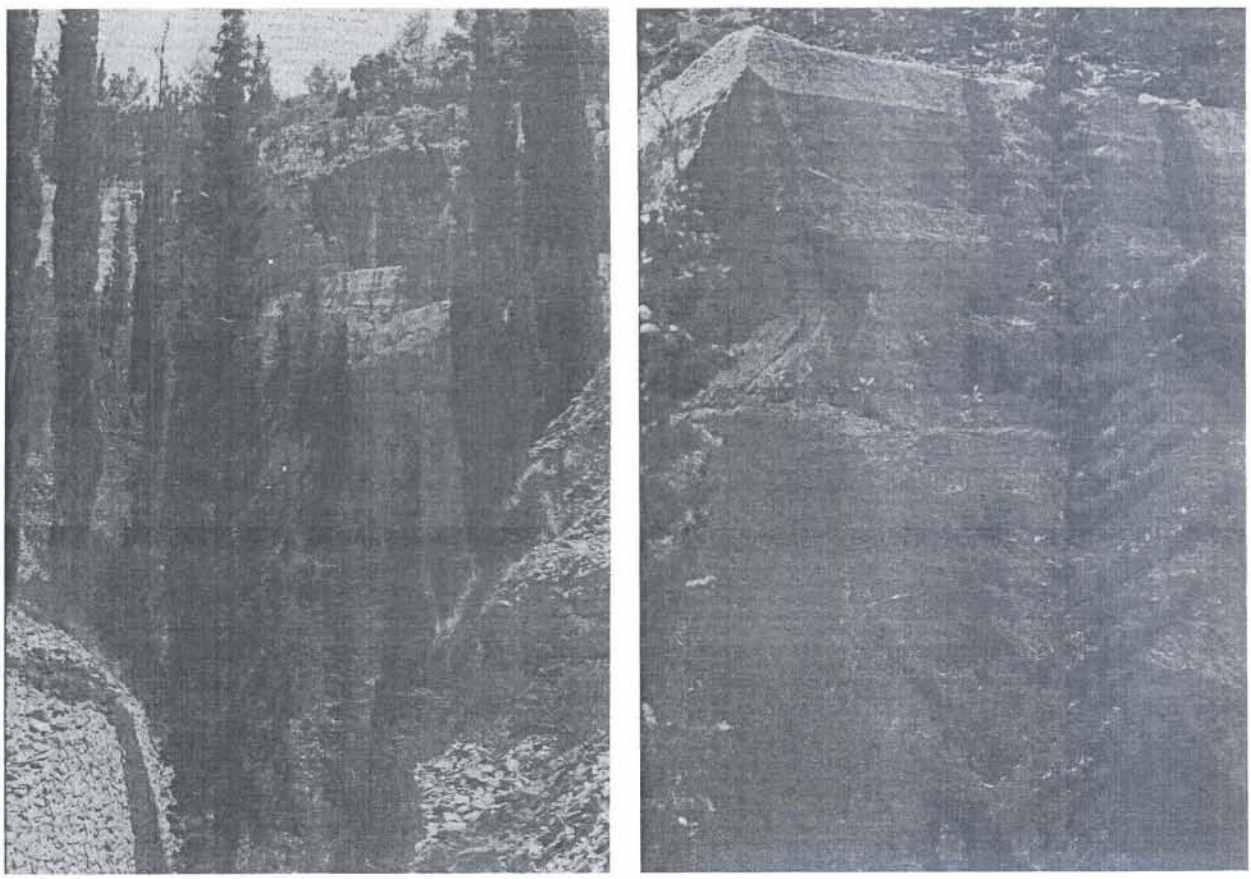


Fig. 26 The island of Vrnik, old quarry in the fossiliferous rudist limestone unito and fiorito types, height 50 m, with the large waste in front of view; and remains of the old quarrying of blocks (photo: D. Jovičić)

The following dimension stone deposits are in the clastic sediments of Paleogene:

- **Marići**, east of Obrovac, thickly bedded, conglomerate of grayish and pinkish colour,
- Gradina, east of Obrovac, out of exploitation,
- **Rozalit**, near **Pakovo Selo**, SSW of Drniš, conglomerate of pinkish colour, after which got the name; the deposit of exchangable layers of conglomerates from 0.5 to 6 m thickness, and layers of redish limestones from 0.3 to 1 m of thickness (fig. 27).

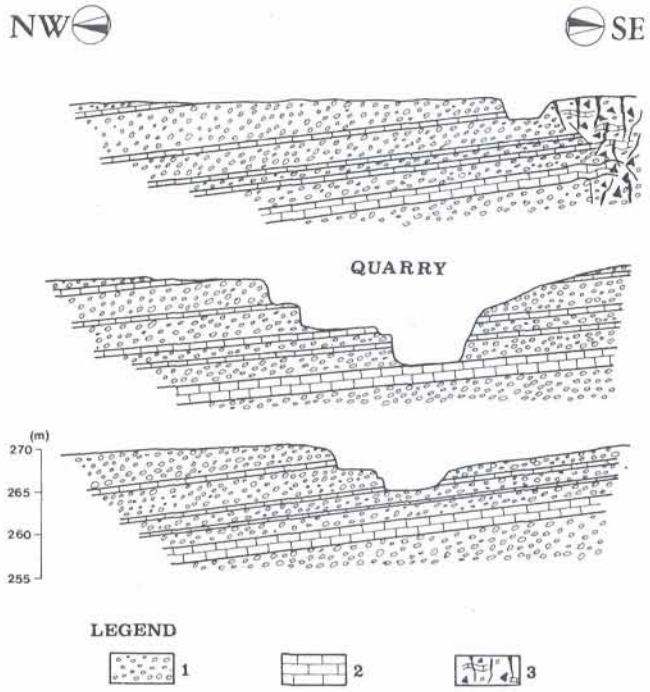


Fig. 27 The Rozalit quarry, cross section through the deposit (after Tišljar, 1980b)

1 conglomerate, dimension stone Rozalit
2 limestone
3 tectonic breccia

- **Multikolor**, near **Radošići**, west of Sinj, with different nuances of gray colour, and diversly coloured pebbles, after which got the name, and thickly bedded structure.

In Poljička Zagora, not far from Donji Dolac in **Putišići,** biocalcarenite on marke known as **Jadran zeleni** (Adria Verde or Adria Green) is exploited. The main components represent the abundance of densly packed small foraminiferal skeletons and intraclasts, some detrital minerals, therefore the stone according to its appearance is called Granitello. The colour is green-grayish, and sporadically, along the fractures yellow-grayish. The layers are nearly of 1 m thickness.

The limestones of Paleogene age are regularly of pastel colours, very decorative, but of limited stretching.

The extremely decorative dense limestone **Alkasin** is from time to time exploited in the deposit **near Radošići**, west of Sinj. The limestone is interbedded in limestone conglomerates. The colour is redish, redish-brownish and rosy-yellowish. Sporadically are noticed yellowish stylolites. Petrographically is determined as micrite.

Of the potentially prospective areas built of decorative foraminiferal limestones should be noticed Čvrljevo and Vinovo, SW of Drniš. Limestone are pinkish, yellowish and redish. Petrographically are determined as biomicrite/biosparite.

The numerous small deposits, which mentions Marić (1930 b) on the occasion of visiting the areas such as Žitnić, Sedramić and Planjane, are out of exploitation, and represent the small deposits of decoratively coloured limestones, limestone breccias and conglomerates. There are some that were formerly exploited, such as Finor, Karneol, Salamin and Belgris.

And finally, **Benkovac platy stone,** fine-bedded, dense limestone of yellowish and grayish colour, is exploited northwest of Benkovac, in Kukolj-Kave quarry. Petrographically is determined as micrite.

We should mention here the limestone-dolomitic breccia **Oklad**, south of Novo Selo on the island of Brač, of unidentified age. The breccia lie discordant on the Senonian limestones and it is evident younger than the limestones of the Senonian age (fig. 28). It is of different nuances of gray and brown-gray colour and contains angular fragments of limestones and dolomites of the Upper Cretaceous base. The pigment of breccia is of bituminous matter, therefore its application is restricted to covering of interiors.

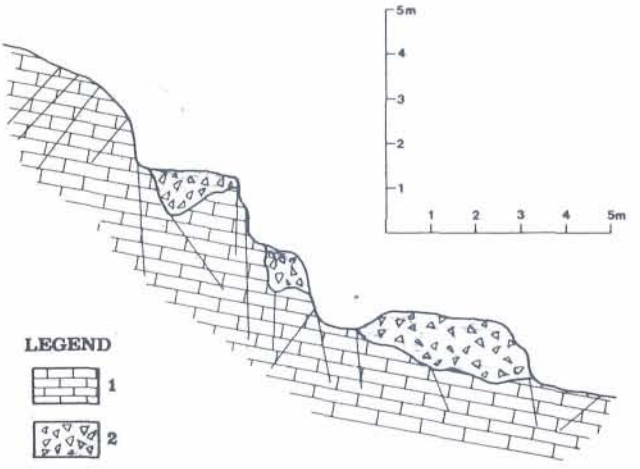


Fig. 28 The Oklad quarry, cross section through the deposit (after Crnković, 1979)

1 limestones of Upper Cretaceous age, biomicrite and bintramicrite/biointrasparite, with the erosion surface
2 breccia, the transgressive overlap, dimension stone Oklad

Final considerations

After Crnković and Bilbija (1984) dimension stone and its deposit are evaluated by means of:

- geological criteria (size of deposit, the possibility to extract blocks, uniformity of appearance of the stone mass in its deposit, and the quantity of the stone mass),
- technological and economical criteria (quality of blocks and possibility of economical industrial processing),

Table 2 Mechanical and physical properties of dimension stone, Dalmatia (data: Institute of Civil Engineering of Croatia, Zagreb)

Properties	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Compressive strength dry samples, MPa	115,7	140,5	125,2	106,4	119,0	112,0	116,7	243,4	111,1	140,0	192,0	95,0	166,0	159,0
Compressive strength water-saturated samples MPa	103,8	142,3	112,7	90,4	109,0	119,5	120,8	229,1	143,3	159,6	181,5	98,0	138,0	132,2
Compressive strenght after 25 cycles of freezing and thawing, MPa	112,3	124,5	120,4	102,2	83,0	90,0	90,4	220,1	102,0	144,8	131,1	114,0	147,0	133,5
Resistance to grinding (Boehme method) $cm^3/50\ cm^2$	30,1	29,0	29,3	32,2	29,7	27,9	22,6	16,3	13,4	14,6	22,9	16,6	15,8	17,0
Density, kg/m^3	2700	2700	2680	2703	2720	2760	2708	2700	2730	2710	2850	2720	2730	2730
Bulk density, kg/m^3	2520	2610	2600	2495	2490	2560	2554	2660	2690	2680	2490	2690	2690	2700
Porosity, %	6,67	3,33	2,99	7,70	8,46	7,25	5,69	1,48	1,47	1,11	12,63	1,12	1,47	1,10
Water absorption, %	1,22	1,00	0,63	2,02	2,05	2,36	1,72	0,72	0,19	0,16	4,09	0,17	0,16	0,15

1 Seget; 2 Plano; 3 Vrsine; 4 Veselje Unito; 5 Kupinovo Diokles; 6 Sivac-Adria Grigio; 7 San Giorgio; 8 Rasotica; 9 Dolit; 10 Adria Verde; 11 Oklad; 12 Rozalit; 13 Multikolor; 14 Alkasin

- technical criteria (applications of the stone, depending on its physical and mechanical properties, and its durability), and
- criteria of decorativity (the general appearance of the stone, it is very important for the stone's marketability).

The sume of all these values of a deposit leads to its assessment and ranking as:

- of international importance,
- of restricted international importance,
- of national importance, and
- of local importance.

On the basis of these criteria after Ivković and Crnković (1987) the active quarries of dimension stone are evaluated on Table 3.

Table 3 The evaluation of dimension stone

	geological criteria: size of deposit			geological criteria: distribution compared to possibility of block extraction				technological criteria			technical criteria: application distribution					criteria of decorativity				whole evaluation		
	deposit of large development	deposit of middle development	deposit of limited development	deposit of extraordinary possibility	deposit of large possibility	deposit of limited possibility	deposit of tombolones	block utilizability 85–95%	block utilizability 75–85%	block utilizability under 75%	universal application	vertical limitless and horizontal limited application	only vertical application	only interior application	stone of exceptional and unique appearance	stone of specific apperance	stone typical for this type	stone of common appearance	world important	limited world important	national important	local important
Orsera – Kirmenjak	+				+				+		+					+				+		
Istrian Yellow – Kanfanar	+				+				+			+				+				+		
Saint Lucija			+			+		+						+		+					+	
Vinkuran		+		+				+					+				+			+		
Veselje – Punta	+				+			+				+					+			+		
Adria Grigio	+			+				+				+					+			+		
Dragonjik		+			+				+			+					+				+	
Rasotica			+			+		+						+	+					+		
San Giorgio		+			+			+				+					+				+	
Dolit			+			+				+	+						+				+	
Adria Verde			+			+		+			+					+					+	
Rozalit	+				+			+			+						+				+	
Seget		+			+			+				+					+			+		
Plano		+			+			+				+					+				+	
Vrsine		+			+			+				+					+				+	
Romanovac			+			+			+					+		+				+		
Marići		+			+				+		+						+				+	
Alkasin			+				+		+					+	+						+	
Multikolor		+			+			+			+						+				+	

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Ležišta arhitektonskog kamena u Hrvatskoj

B. Crnković i D. Jovičić

Prema kraćim ili opširnijim definicijama (Bates and Jackson, 1980 i Dineley et al., 1976) arhitektonskim kamenom smatramo onu prirodnu tvorevinu koju vadimo iz stijenske mase u pravilno oblikovanim blokovima i koja se odlikuje odgovarajućim svojstvima. O širokom rasponu genetskih i postgenetskih procesa i čimbenika ovise dekorativnost kamena, njegova fizička i mehanička svojstva i cjelovitost stijenske mase u ležištu.

Hrvatska je okarakterizirana raznolikošću petrografskog sastava i geološke građe. Različitosti građe pojedinih njenih područja uočavaju se na geološkoj karti (sl. 1). Na temelju mobilističke koncepcije geneze i građe Dinarida (Herak, 1991) a sa stanovišta postojanja ležišta arhitektonskog kamena, Hrvatsku možemo podijeliti u šest regija (sl. 2). Ležišta arhitektonskog kamena opisana su po tim regijama i litostratigrafskim jedinicama.

Regija Hrvatsko Zagorje

Prema Heraku (1991) regija pripada strukturnom kompleksu Unutarnjih Dinarida ili Supradinaridiku. Iz opisa građe toga kompleksa i provedenih istraživanja, kao potencijalno produktivne naslage izdvajamo karbonatne sedimente miocena (Crnković et al., 1974/75). U toj su se regiji u daljoj ili bližoj prošlosti kao arhitektonski kamen eksploatirali porozni i mekani vapnenci te litotamnijski vapnenci u ležištima Vinica, Pisana Pečina, Ruopanec, Bizek i Vrapče potok (sl. 3).

Regija Slavonija

Ta regija pripada Panonskim strukturama Pre-Alpskog strukturnog kompleksa. Na temelju opisanih serija orogeneza i građe (Jamičić, 1988), kao i diferencijalnih kretanja pojedinih njenih dijelova (Herak, 1991), u toj regiji možemo očekivati očuvanije »oaze« u kristalinu, što su potvrdila istraživanja ležišta granita Zebrato na Ravnoj Gori (Jovičić, et al, 1992) i u području Jankovac-Radetina.

Regija Banija i Kordun

Regija pripada Supradinaridiku. S obzirom na geološku građu i intenzivne deformacije stijena (Majer, 1984 i Majer i Lugović, 1985) u toj regiji nema mogućnosti nalaženja ležišta rhitektonskog kamena.

Regija Gorski Kotar, Lika i Primorje

Regija pripada strukturnom kompleksu Dinarske karbonatne platforme, Dinarikumu. Intenzivna tektonika i navlačne strukture (Herak, 1991) su ograničavajući čimbenici nalaženja većih ležišta arhitektonskog kamena.

Klastični sedimenti karbona kod Brušana eksploatirani su i kao klesanci lokalno korišteni u gradnji stambenih objekata.

Karbonatni konglomerati kod Sv. Roka eksploatirani su kao arhitektonski kamen u prošlosti.

U juri je značajan kao arhitektonski kamen litiotis vapnenac, eksploatiran u Cvituši kraj Lovinca i Gradini kraj Ričica. Gusti vapnenac smeđosive, tamnosive i smeđocrne boje prošaran bjeličastim, žućkastim, smeđastim i crvenkastim žilicama, komercijalno nazvan Velebit portoro, eksploatirao se nedaleko Gospića. Nedaleko Donjeg Lapca eksploatirao se crveni do crvenkastosmeđasti vepnenac, mjestimice konglomeratičnog izgleda, komercijalno nazvan Unarot.

Kredne starosti je brečoliki vapnenac kraj Prozora jugoistočno od Otočca u kojemu je otkriven antički kamenolom (Šarić, 1980). Sjeverno od Obrovca eksploatiraju se crvenkasti i smeđastosivi brečasti vapnenci i vapnenačke breče Romanovac i Tulovac ili Kastanija.

Regija Istra

Područje Istre pripada Jadranskoj karbonatnoj platformi ili Adrijatiku, koja ima mnogo zajedničkih elemenata s Dinarikumom (Herak, 1991), a prema Olujiću et al. (1972) predstavlja autohton. Osim eocenskog fliša, sa stanovišta eksploatacije arhitektonskog kamena, sve su stratigrafske jedinice potencijalno produktivne. Zbog toga je Istra okarakterizirana brojnim ležištima arhitektonskog kamena i danas aktivnim kamenolomima (sl. 15). Sedimente gornje jure te donje i gornje krede detaljno je obradio Tišljar (1976).

U vapnencima gornje jure eksploatira se kamen na tržištu poznat kao Orsera ili Vrsarski, u kamenolomima Kirmenjak i Valkarin.

U vapnencima donje krede eksploatira se Istarski žuti u kamenolomima Kanfanar i Seline. Protezanje Istarskog žutog utvrđeno je detaljnim istraživanjima ekipe Instituta za geološka istraživanja 1982/84. godine (sl. 18). Autori zahvaljuju članovima ekipe gospodi I. Veliću, B. Sokaču i J. Tišljaru, što su dozvolili da se u ovom članku po prvi puta objave podaci i karta iz njihovog izvještaja prezentiranog poduzeću »Kamen« u Pazinu.

U naslagama gornje krede eksploatiraju se rudistni vapnenci Sveta Lucija, Grožnjan-Kornerija, Valtura i Vinkuran.

Tamnosmeđi i posebno dekorativni numulitni vapnenci, poznati na tržištu kao Istranka, eksploatirali su se u bližoj prošlosti kraj Lupoglava.

Regija Dalmacija

U ovoj regiji koja također pripada Adrijatiku danas su u naslagama gornje krede eksploatacijom obuhvaćeni rudistni vapnenci, u kojima se nalaze aktivni kamenolomi u kontinentalnom dijelu i na otocima.

U kontinentalnom dijelu u okolici Trogira nalaze se kamenolomi Seget, Plano i Vrsine.

Na otoku Braču, od brojnih poznatih ležišta u prošlosti, eksploatacija je danas uglavnom koncentrirana u okolici Pučišća (kamenolomi Sivac, Punta, Barbakan, Kupinovo i Kupinovo novo, poznati arhitektonski kamenovi Adria Machiato, Veselje unito i fiorito, Diokles), kao i Selca (kamenolomi Zečevo, Glave i Žaganj dolac, poznati arhitektonski kamenovi San Giorgio i Rasotica), a aktivni su još kamenolomi Dragonjik kraj Nerežišća i Pražnica.

Na otoku Korčuli aktivan je kamenolom Humac, a po brojnim neaktivnim kamenolomima poznat je otok Vrnik.

U sedimentima paleogena u kontinentalnom dijelu regije eksploatira se Jadran zeleni u Putišićima, konglomerat Rozalit u Pakovom selu te povremeno konglomerat Multikolor i dekorativni vapnenac Alkasin nedaleko Sinja.

Arhitektonski kamen koji se danas eksploatira i nalazi na tržištu vrednovan je prema kriterijima: geološkom, tehnološkom, tehničkom i dekorativnom (Crnković i Bilbija, 1984). Na temelju obavljenog vrednovanja (Ivekovići Crnković, 1987) dio arhitektonskog kamena je ograničenog svjetskog, a dio nacionalnog značenja (tablica 3).