Megalithic Quarrying Techniques and Limestone Technology in Eastern Spain

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Evidence in Eastern Spain and in the Balearic Islands indicates that during the building period of the megaliths and thereafter the inhabitants of this region developed a considerable limestone technology. This technology embraced an empirical knowledge of carbonate chemistry and karst geology which enabled them to quarry large limestone blocks to gain a maximum of usable material with a minimum of effort. It appears that one of the quarrying methods used was based on the chemical dissociation by fire of standing stone blocks at their attachment points, a technique hitherto unknown or unreported in the literature. Throughout the interval of megalith occupation there is evidence of the exploitation of limestone for a wide variety of purposes, including the making of objects such as containers, querns, and funereal vessels. Ultimately, their experiments led to a unique burial practice in which the dead were cremated by means of quicklime.

The quarrying methods used by the Iberian megalith builders are described below. Most of the specifics of their methods will be drawn from one well studied site, Son Carla on the island of Menorca, but similar quarries have been identified at numerous sites in the Balearic Islands and at Sisante in La Mancha on the mainland.

Prehistoric Chronology of the Balearic Islands.

Since this study deals mainly with sites in Spain's Balearic Islands, Mallorca and Menorca, a brief review of this area's prehistory will put the investigation in a time and cultural perspective. The only megalithic site investigated on the mainland, Sisante,[1] presented evidence of identical quarrying methods but time has not yet permitted correlation of the limestone technology with other megalithic stations there. Thus, the reader is directed to Savory[2] or Pericot[3] for a review of the peninsular megalithic sequence and its affinities with the Balearic culture.

1. Personal communication from Sr. D. Francisco de Hoyo.

2. Hubert Newman Savory, *Spain and Portugal: The Prehistory of the Iberian Peninsula* (*Ancient Peoples and Places*, vol. 61 [New York 1969]).

3. Luis Pericot-Garcia, *The Balearic Islands* (New York 1972).

Rossello-Bordoy[4] divides the Balearic prehistoric period into an essentially tripartite system, with subdivisions as follows (the term Talayotic refers to the *talayot*, a round or square squat tower that is the characteristic megalithic construction in the Balearics).

Initial Settlement Period: 4000-2000 B.C.; cultural details little known; possibly husbandry was the subsistence base.

Pre-Talayotic: 2000-1300 B.C.; farming and husbandry; dwelling in natural caves or limestone buildings and wood huts in small communities; domestic vessels of ceramic or limestone; burial in natural caves, rock-cut tombs or rockshelters; begin building of megaliths.

Talayotic (I-IV): 1300-123 B.C.; farming; political organization possibly in chiefdoms; dwelling in limestone

4. Guillermo Rossello-Bordoy, *La prehistoria de Mallorca* (*Trabajos del Museo de Mallorca*, vol. 2 [1972]); *La cultura Talayotica en Mallorca* (Palma 1973).

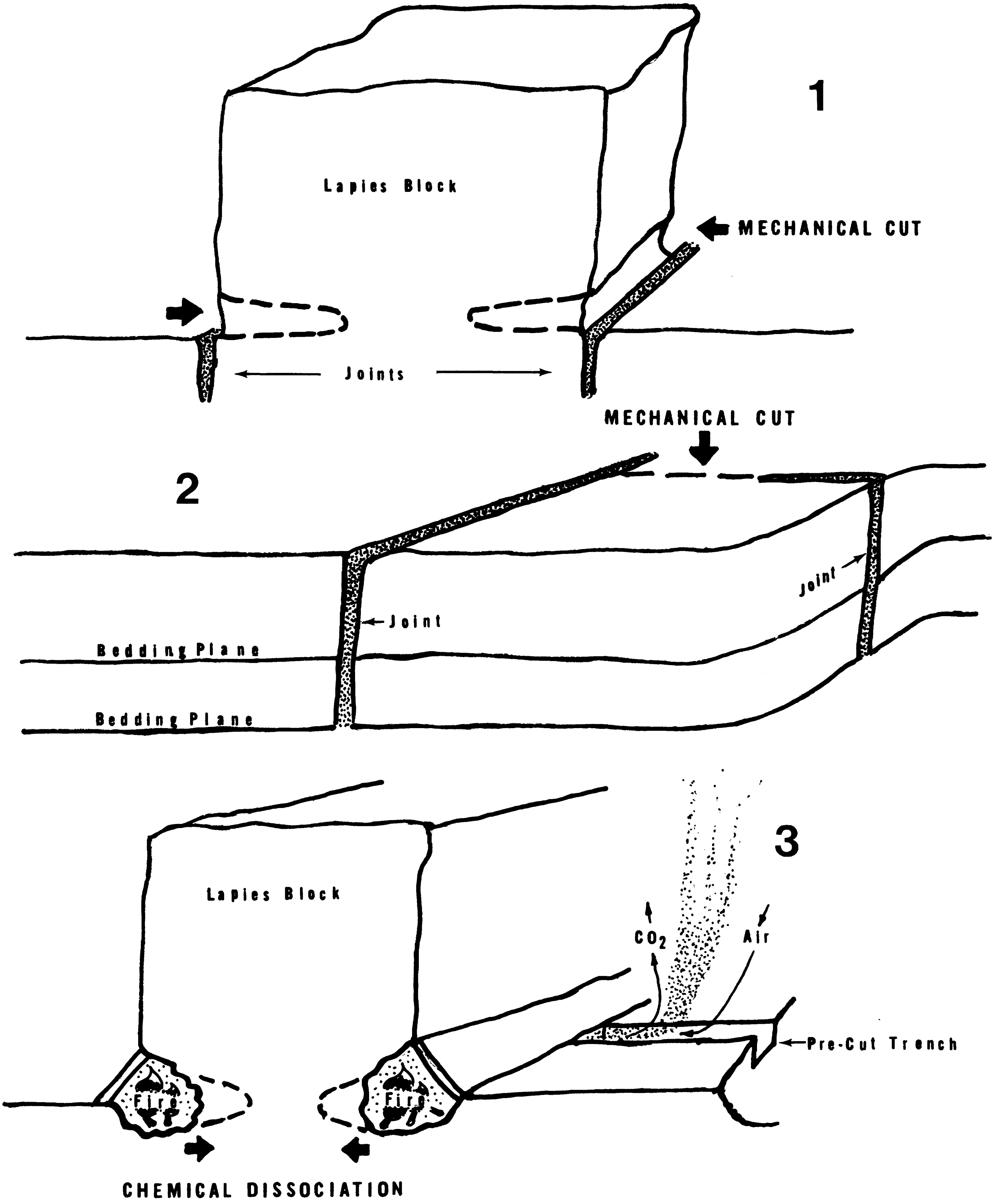

Figure 1. The three methods of quarrying dimension stone utilized in the construction of the megaliths of Eastern Spain and the Balearic Islands.

megaliths and ancillary huts; domestic ceramic vessels; burial in collective tombs, with quicklime during the final phases; extensive use of limestone for all building purposes. Degradation of indigenous culture after beginning of Roman influence about 500 B.C..
Roman Conquest 123 B.C.

The reader's attention is drawn to recent work by Frierman[5] on a corresponding accomodation to locally available materials in the Eastern Mediterranean area. He proposes that lime burning and the subsequent recombination of its end product, quicklime, with water into calcite vessels was the precursor to fired clay ceramics during the Pre-Pottery Neolithic period in Anatolia and the Levant. These containers, called by Frierman *vessaille blanche,* seem to be an earlier, parallel development of a limestone technology at the other end of the Mediterranean.

Limestone Technology.

Evidence for a continuing tradition of a limestone and lime technology in the Balearics rests on two major points: 1) the unique quarrying methods utilized by the megalith builders there and 2) the equally unique burial practices of the Talayotic culture itself. There is considerable evidence for evolutionary development of this tradition in the form of wide use of carbonate rock for many purposes between the building of the megaliths and the quicklime burials which seem to have begun about a millennium later. That a cultural continuum existed during this period has been firmly established by Rossello-Bordoy on the basis of artifact typologies.[6]

It is believed that the builders of the *talayots* developed a quarrying technique based on lime burning. It has been noted that their descendents used quicklime, a natural product of lime burning, in connection with the interment of their dead in collective burial areas. From Rossello-Bordoy's chronology the main quarrying phase probably took place 1500-1300 B.C.; representative dates for the quicklime burials are: Cueva dels Morts de Son Gallard, Mallorca (280 ± 100 yrs. B.C.) and Abrigo Bocosco de Son Matge, Mallorca (250 ± 100 yrs. B.C.). The quarries at Son Carla, Menorca, will be described as representative of megalithic quarrying methods. Burials at the Cueva de Son Net and Cueva dels Morts de Son Gallard, Mallorca will serve as examples of the funereal use of quicklime.

Son Carla: Geology and Geography.

Son Carla is located on a low hill on the southern plain of Menorca about 8 km. SSE of the town of Ciudadela, inland from the sea about 5 km. It is one of the largest megalithic *poblados* (towns) in the Balearics and is very large and well preserved by any European standard. Lying on a nearly horizontally bedded, heavily weathered Miocene limestone, the site, before building began, must have presented what is known as *lapies* surface. This is a fairly common feature of karst areas, and Menorca, like the rest of the Balearics, is heavily karstified. Known also as *karren* in German or "clints" and "grikes" in some British karst literature, these surfaces were heavily corroded by rain water carrying carbon dioxide in solution. The CO_2, a product of organic decay, is picked up by rain water in the atmosphere and in the soil zone to form carbonic acid.

This mildly acidic combination attacks the drainage channels on the surface of the limestone and enlarges them. These channels, formed along joints (vertical fractures) in the rock, occur on both bare and on soil covered soluble rocks. With time, as weathering continues, these channels deepen leaving pointed or flat-topped blocks, like paving stones, standing in rows.[7] Eventually, the blocks stand truly isolated and at Son Carla measured (as evidenced by the remaining *lapies* blocks in the quarries) 1-3 m. in length, 1-2 m. in height and 0.50-1.50 m. in width. These were the blocks quarried by methods 1 and 3 in Figure 1 for the Talayotic site.

As the ground slopes away to the south and west at Son Carla, the surface drainage network has cut through the rock in places leaving erosional exposures up to 3 m. in height. Here, thin beds of limestone, 0.50-1 m. thick, appear naturally separated by their bedding planes like a stack of dominoes. To make this source of building stone even more attractive to the Talayotic quarrymen, joints, the right angle system of cracks in limestone that are probably produced by earth tides, have sliced through the beds. Thus, as shown in method 2, Figure 1, only a minimum of cutting would be necessary to remove a slab completely. There is evidence at Son Carla that these erosional exposures were trimmed back evenly in places, like sanding the jagged edge of a piece of plywood, to better evaluate the quality and ease of quarrying the beds.

There is nothing particularly noteworthy or especially desirable about the limestone itself at Son Carla. Since the same formations are exposed throughout the southern part of the island, employment of the material there must be due to another factor. This factor was probably the existence of the *lapies*. The occurrence of

5. J.D. Frierman, "Lime Burning as a Precursor of Fired Ceramics," *IEJ* 21 (1971) 212-216.
6. Rossello-Bordoy, op. cit. (in note 4, 1973).
7. L.D. Fellows, "Cutters and Pinnacles in Greene County, Missouri," *Bulletin of the National Speleological Society* 27 (1965) 141-153.

Figure 2. Fortified wall surrounding megalithic station at Son Carla, Menorca.

Figure 3. Block partially separated by Method 1, Figure 1, in Son Carla quarry. Jacknife, indicated by arrow, gives scale and lies in the mechanically cut trench.

Figure 4. *Lapies* block at Son Carla quarry is 1 ½ m. long and has been trenched in two planes preparatory to removal. Many such partially quarried stones remain at this site and were abandoned for reasons unknown.

large blocks of easily quarried stone simultaneously determined both the material and the site.

Megalithic Quarrying Techniques.

The quarries at Son Carla can be assigned to the Talayotic period with certainty.[8] Extensive quarrying by the Romans, who conquered the Balearics in 123 B.C., cut through the earlier workings in a number of places, as still later Moorish and modern work has done to the periods preceding them. The different techniques and tools used in successive periods are unmistakable, making chronological interpretation easy.[9]

Given the availability of large limestone blocks the Talayotic builders employed three distinct methods to obtain their dimension stone, the major building material that served to face, frame, and support their constructions. Shown in Figure 1, these three methods include two mechanical separation techniques (Methods 1 and 2) and a third which involved the use of fire (Method 3). In Method 1 quarrying was accomplished by removing free-standing *lapies* blocks, a common feature of karst areas, from bedrock by means of stone mawls (FIGS. 3, 4). Method 2, also a mechanical separation technique, was more sophisticated and took advantage of thin-bedded limestone slabs already partly separated from bedrock by enlarged joints. These flat-lying slabs were removed by cutting along two right angle joints until they intersected and simply lifting the resulting slab away at its bedding plane juncture with the lower beds. Method 3 utilized fire to chemically detach *lapies* blocks from bedrock and will be described in detail below.

The large, thin slabs obtained by Method 2 seem to have been used largely for facing such things as the *temenos* wall surrounding Son Carla (FIG. 2). Over a kilometer long, this wall is of ashlar construction, up to 3 m. thick and 3 m. high and contains corbelled rooms large enough to stand up in. Figure 2 shows the intricate fitting of the facing slabs the largest of which is 2.8 m. high, 3.2 m. wide and 0.50 m. thick.

Blocks obtained by Methods 1 and 3 appear to have been used for similar purposes. Being generally thicker than the slabs acquired by Method 2, these blocks were used in the building of cyclopean constructions. This construction technique utilizes dry-laid stones set in courses like bricks. In quarrying the *lapies* blocks for this purpose by Method 1, a trench was cut partly into bedrock and partly into the block. The block was then separated from bedrock by deepening the groove with stone mawls until the cut extended completely through the attachment plane. Figure 3 shows such a block partly undercut, exactly as it was left when "the whistle blew" 3500 years ago and the workers left it. This method is more laborious than the other systems used and does not seem to have been very popular, judging from the few block scars that attest to its use at the Son Carla quarries. It is hypothesized that it was only used when the block was so thick it could not be separated by the method about to be described. By way of preface, the key to whether Method 1 or Method 3 was employed seems to have been based on the minimum dimension in the attachment plane: if the block was over about 75 cm. thick it could not be calcined successfully at the attachment plane and had to be removed by mechanical cutting.

Use of Fire at Son Carla for Quarrying.

When quarrying the narrower individual blocks in the *lapies* field, the Talayotic builders cut a trench around the base of the standing stone that extended about 10 cm. into the bedrock. This groove also undercut the block itself, probably to the same extent. Usually two lateral trenches were cut into the groove at right angles, one on the long axis and one on the short axis of the block, both narrower and shallower than the perimeter groove itself (FIGS. 5, 6). In a number of socket scars there are more than two lateral trenches and, occasionally, only one but never fewer. In no case was evidence seen of cutting extensively in three planes and a high regard for minimum expenditure of energy for maximum yield of stone volume is everywhere apparent.

The actual method by which the block was then detached from the bedrock is not known but two possibilities suggest themselves. Eliminating known contemporary methods usually used for separating blocks of limestone or much harder, tougher metamorphic and igneous rock is easy from the evidence present at Son Carla. Water soaked or mechanically driven wooden wedges, the usual "bench method" quarrying technique of the period,[10] could not have been employed to remove the blocks, because: 1) The bottoms of the socket scars bear no grooves which could have been used for such purposes; 2) the perimeter grooves might have accepted wedges, but excessive, inappropriate work would have been expended on a task more easily done in another way. 3) The relatively elaborate perimeter and lateral

8. Both Rossello-Bordoy and Serra-Belabre have described other Talayotic quarries although they did not detail the techniques described here. See G. Rossello-Bordoy, "Cantera de Sa Punta de Dent," *Boletin de Socieded Luliana* 31 (1959) 578-580; M.L. Serra-Belabre, "Canteras megaliticas en Manorca, *Pyrenae* 2 (1964) 134-137.

9. The authors are indebted to Julian Whittlesey who first identified the quarries at Son Carla and their chronological positions.

10. E.g., R.J. Forbes, *Mining and Quarrying* (*Studies in Ancient Technology*, vol. 7 [London 1963]).

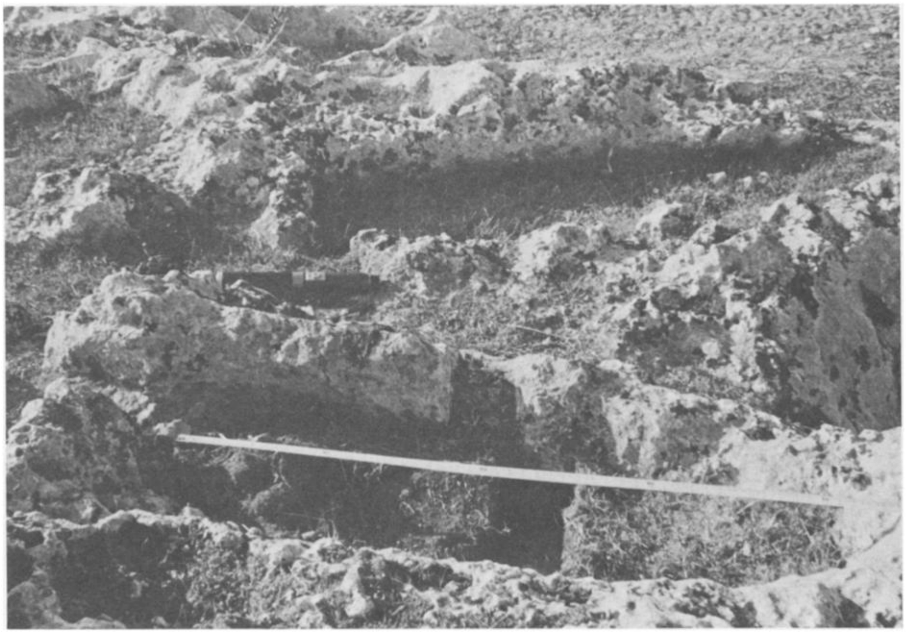

Figure 5. Scars left by quarrying using Method 3, Figure 1, are now indicated by soil-filled depressions.

trench system imply a more sophisticated method. Undercutting the block alone, not the bedrock too, would indicate another, heretofore unpublished, approach had been used: weakening the attachment area and simply "whacking" the block off with a log ram.

Briefly considering the last possibility, a calculation using the sum of moments method shows that two men wielding a log ram do not produce nearly enough force to remove even a small *lapies* block. Given a tensile strength of between 25.5 and 63 kg./sq. cm.,[11] assume two men heft a log ram weighing 50 kg. over a 1 m. distance at a small, free-standing block. If the block measures 130 cm. long by 30 cm. wide by 160 cm. high and has been undercut in the attachment plane 10 cm. on all sides, a solution by the sum of moments shows that these men can produce less than 1/10th the force necessary to remove the block if they strike it at a point 130 cm. above the ground. In addition, common sense militates against the use of the whacking method by Talayotic quarrymen simply because of the unpredictable way in which limestone fractures when struck in this way.

Much more reasonable, but again without published precedent, are two alternatives involving the use of fire in either of two ways, or in a combination of the two: Fire might be employed 1) to chemically decompose the limestone along the attachment area or 2) to expand the stone in the same area after which it was doused with water to contract the stone, thereby setting up a mechanical stress that fractured the block at its junction with the bedrock.

Separation by purely fire induced expansion-contraction is the least likely, but can not be ruled out as a method from what is known of the Son Carla quarries. It enjoys the plausibility advantage of world-wide use at that time and later was the accepted method of removing rock in mines until the adoption of explosives for that purpose only a few hundred years ago.[12] The case against it at Son Carla involves the elaborate trenching system, since the trenching serves no useful function in the "hot-cold-bash" method. There is, in fact, no reason to trench at all with this method. This argument would be negated, of course, if the trenches were used for purposes other than the detachment of the blocks.

O. Davies[13] remarks the use of the "hot-cold-bash" technique in antiquity for the quarrying of siliceous rock, noting that a favorable molecular change takes place when heat is used that, in effect, softens the stone. He does not elaborate on the consequences of fracture through thermal expansion-contraction and believes that fire-setting was not used for quarrying calcareous rock.[14]

The writers feel he is incorrect in the latter judgment and have compared the coefficients of linear expansion to assess the effects of thermal expansion-contraction in limestone quarrying.[15] It was found that limestone, sandstone, and marble, all have coefficients of linear expansion of the order of 7 to 12 in the temperature

11. Physical constants from *Industrial Minerals and Rocks* (New York: American Institute of Mining and Metallurgical Engineers 1960).

12. C. Singer, E.J. Holmyard, and A.R. Hall eds., *A History of Technology* (Oxford 1956) 565-566.

13. O.Davies, *Roman Mines in Europe* (Oxford 1935).

14. Ibid., p. 190.

15. N.L. Lange, ed., *Handbook of Chemistry* (New York 1949) 1642.

Figure 6. Block scar shown in Figure 5 was cleared of soil and soft, partly calcined bottom was easily penetrated by knife. Such a surface could be expected in this otherwise hard limestone if the block were quarried by fire setting.

range from 25 to 100 degrees centigrade. Quartz, a representative siliceous material, has a coefficient of linear expansion of 8 to 13 in the temperature range 0 to 80 degrees centigrade. It is obvious that the calcareous rocks compare favorably with the siliceous material so there is no reason to exclude them from the types of rock available to the "hot-cold-bash" method on this account, before even considering a favorable molecular change like that of the SiO_2 rocks.

It is the favorable molecular change that takes place during the heating of limestone that makes fire a prime choice as a quarrying technique prior to the invention of explosives. Limestone, by definition, must be composed of over 50 per cent calcium carbonate. The thermal reactions of $CaCO_3$ are indicated below. The various reactions follow from the original, called calcination, dissociation or lime burning. These reactions are the basis of the manufacture of portland cements, mortars and other industrial products.

$CaCO_3$	+	heat ↓	$\rightleftharpoons$	CaO	+	CO_2	Dissociation
(limestone)		(1368 BTU/lb.)		(quicklime)		(gas)	
CaO	+	H_2O	$\rightleftharpoons$	$Ca(OH)_2$	+	heat ↑	
				(slaked lime)		(490 BTU/lb.)	Quicklime reaction
$Ca(OH)_2$	+	CO_2	$\rightleftharpoons$	$CaCO_3$	+	H_2O	Slaked lime reaction
		(from atmos.)		(set mortar, calcite)			

If the calcium oxide (quicklime) is produced by firesetting against limestone and water is not intentionally added in definite proportions, water from the atmosphere slakes the lime over time and carbon dioxide (again from the atmosphere) reacts with the now slaked lime to produce a soft, friable form of calcite.[16] The point is that quicklime is unstable and will revert to the calcite form naturally.

It is obvious that the temperature and heat requirements are modest for the initial reaction to take place[17] and are well within the capability of a well-made wood fire. Wood stacked around the base of the limestone block would produce a temperature of around 960°C.,[18] well above the optimum dissociation temperature of above 898°C., provided the carbon dioxide produced is carried off.[19]

The amount of heat required is also within the capacity of a wood fire. Pine, (evergreens are locally available at Son Carla) has a Heat of Combustion of around 6,640 kilocalories per kilogram, while heat consumed during limestone dissociation is calculated to be about 254.5 calories per degree centigrade per kilogram. Using the block from the earlier example it can be quickly calculated that less than 100 kg. of pine would be required to calcine the entire block (assuming 100 per cent heat transfer to the stone). If only dissociation of the attachment area is considered the wood required is considerably reduced, to around 10 kg., again assuming 100 per cent heat transfer from the fire and no heat transfer within the block. The latter assumption is not strictly valid but limestone is a poor conductor of heat having about the same thermal conductivity as basalt or only 3 times that of asbestos board at 100°C.

We list here other aspects of the dissociation process which should be mentioned as germane.[20]

1) Reaction time decreases with increased temperature above the dissociation temperature of 898°C.
2) Limestone pieces the size of railroad ballast are usually used for calcining, but blocks up to 8 in. thick are frequently converted — minimum dimension is the critical element, not the total size of the piece.
3) Dissociation is usually accompanied by linearly increasing amounts of carbon dioxide (44/100 of the weight of limestone is converted to CO_2) as temperature increases; reaction ceases if the gas accumulates at the conversion face.
4) Reaction proceeds from outside surface inward — meaning that even small amounts of calcination would reduce the attachment area of the block.
5) Despite the simple chemical reactions involved, lime burning is considered an art.

We suggest that deliberate dissociation with wood fires was regularly practiced by the Talayotic quarrymen at Son Carla, alone or in combination with the "hot-cold-bash" method. Reconstructing, we can say that wood fires were set in a perimeter trench and covered by mud, stone or other material to cut down infra-red radiation and convection losses and, thus, concentrate heat at the limestone-air interface. Such closed wood fires regularly permit ceramic firing temperatures of 1000-1200°C.[21] and would hasten the dissociation process. Lateral trenches were provided to carry off carbon monoxide and dioxide and to supply air for the oxidation reaction, providing a "draft" and chimney for this closed "hearth."

Comparison of Early Quarrying Methods.

Without exception, all accounts of early limestone quarrying in the Old World show that extraction was accomplished by the bench method; quarry sites being either open pits or underground mines. This method, the worldwide preferred system up to the present, leaves its mark at the site as a series of steps that resemble the bleacher seats in a stadium. In order to remove blocks in antiquity usually three mechanical cuts were made in two planes, at both ends and at the rear. The bottom attachment area was then separated by drilling holes at intervals, inserting wooden wedges and either driving them with hammers or soaking them with water so that they swelled and broke the block loose. An alternative method was to cut the block completely loose on all sides without resorting to wedges.

Before contrasting the efficiency of the Egyptian, Greek, and Roman systems[22] with those of the Talayotic stone workers it is necessary to consider tool availability. There is no evidence for the use of metal quarrying tools in the Balearics during this period, either by discovery of the tools themselves or by marks left on the rock at quarry sites.

Except for the Early Dynastic Period in Egypt, when monumental stone construction in the eastern Mediterranean began and quarrying was carried out with

16. Alfred White, *Engineering Materials* (New York 1939) 367-377.

17. It alone is endothermic, requires energy input.

18. Anna O. Shepard, *Ceramics for the Archaeologist* (*Carnegie Institution of Washington Publication* 609 [Washington 1965]) 78-80.

19. White, op. cit. (in note 16) 368.

20. Cf. Robert Boynton, *Chemistry and Technology of Lime and Limestone* (New York 1966).

21. Shepard, op. cit. (in note 18) 79.

22. Forbes, op. cit. (in note 10); Singer, et. al., op. cit. (note 12); M.E. Blake, *Ancient Roman Construction in Italy from the Prehistoric Period to Augustus* (*Carnegie Institution Publication* 570 [Washington 1947]).

stone tools, other early historic extraction was aided by the availability of metal tools. By Roman times bronze chisels, punches, drills, and saws were abundant and must have greatly reduced the labor of limestone removal.

Nevertheless, it is believed the Talayotic quarrymen approached their task with a superior knowledge of limestone geology and lithology, even if their extraction equipment may have been inferior. The evidence of this superiority is as follows:

1) They avoided massive limestones and deliberately chose either *lapies* blocks or thin, flat bedded deposits that offered stone already partly separated by natural agencies. In addition to eliminating laborious cutting in several planes, this choice obviated dependence on the notoriously unpredictable manner in which massive limestone splits.

2) The use of naturally cut blocks and beds presupposes a knowledge of the existence of cutters and joints in the rock, knowledge that frequently is lacking in modern farmers when drilling water wells, putting in sewage disposal facilities, draining fields, etc.

3) They possessed the knowledge that fire makes a good limestone quarrying tool.

From the foregoing it should not be assumed that all the dimension stone at Son Carla was quarried. It was not. All pieces smaller than ca. 0.75 cu.m. seem to have been obtained from another source — very likely simply from the surface in the vicinity.

Burials in Quicklime.

Many lime interment sites have been excavated in the Balearics and published descriptions are available for several of them.[23] In major details they are quite similar and include individual burials in a communal pit located in a rockshelter or shallow cave. The pits themselves vary greatly in size: from less than 20 individuals at Barranc, Biniaraix, Mallorca, to several hundred at Cueva dels Morts de Son Gallard, Mallorca and most show considerable disturbance of earlier interments by later intrusive burials. The idea that the bodies were cremated *en masse* because of plague or other collective catastrophe is not tenable, because of the non-synchronous disturbance of bones throughout the deposit. By the same token original disposition of the dead is being dealt with, not secondary burial, since jewelry and other accoutrements are often found encircling long bones and skulls. The exact method of burial has not yet been reconstructed but it seems likely that pits were simply dug in the collective burial pit, the body laid out and covered with quicklime and then water poured over it to start the slaking process. In some cases the heat thus generated was sufficient to char the bone and in other cases not, so there seems to have been no deliberate effort made to completely consume the corpse. As could be expected, where high concentrations of quicklime occurred the remaining bones have been completely fossilized.

Investigations at the Cueva de Son Net reveal how the quicklime was prepared and utilized ca. 300 B.C. to consume the flesh of cadavers buried there. Various sized pieces of limestone were fired in a corner of this shallow cave, as shown in Figures 7 and 8, and the resulting end products, powdered calcium oxide and incompletely converted larger limestone cobbles, were utilized directly in the burials. The fires for this purpose have partially calcined the roof of the cave (FIG. 7).

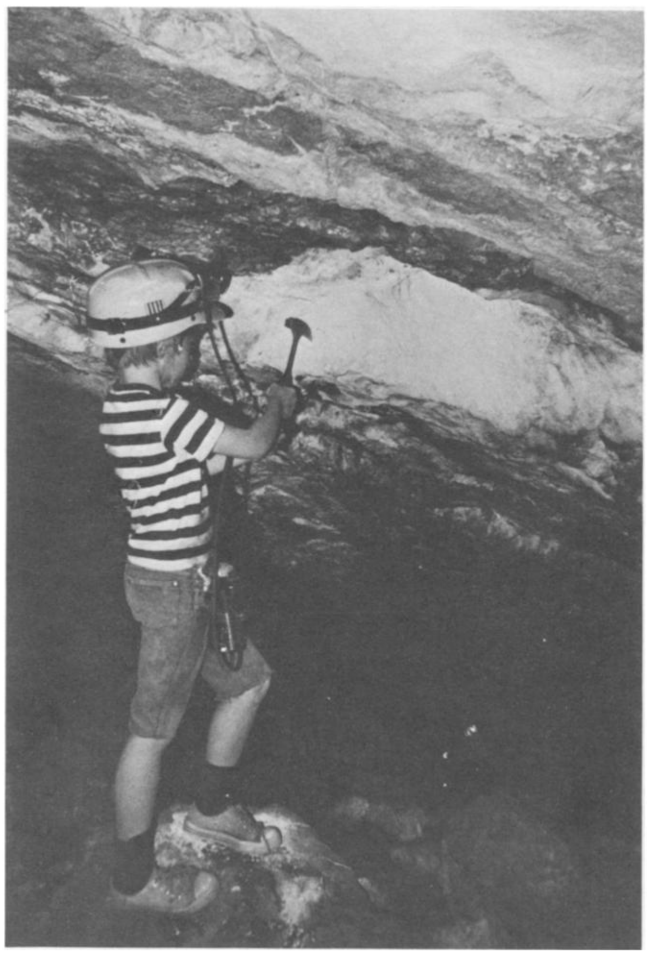

Figure 7. Soft, partly calcined roof of the Cave of Son Net, Mallorca, where late megalithic burials were made in quicklime.

23. Rossello-Bordoy, op. cit. (in note 4, 1973); and Miguel Terradell, "La necropolis de 'Son Real' y la 'Illa dels Porros,' " *Excavaciones Arqueologicas en España* 24 (1964).

Figure 8. Pieces of imperfectly burned limestone removed from burials in the Cave of Son Net.

Residual pieces of "dead burnt" limestone, unsuitable for the slaking process, mixed with ashes and charcoal underlie the floor of the cave at this point showing that the calcining of the cave ceiling was not the accidental result of an occasional cooking fire. Obviously in command of their lime technology, the people who interred the dead at this site utilized both powdered quicklime and partially converted, larger limestone pieces to generate enough heat, through the addition of water, to effect combustion of the corpse.

The fact that the Talayotic people used both sources of calcium oxide, the powdered product and the partly converted material, shows that they were not fussy in this matter and probably appreciated the fact that relatively small quantities of quicklime were sufficient to cremate a body. It cannot be determined whether these people utilized raw quicklime, which is very caustic, or used a partially slaked product in their burial rites. In view of their technological mastery of lime burning, it seems likely they were capable of discerning the difference between these two products and opted for the latter.

It is interesting to note that the lime technology tradition in this area continues to the present. Lime burning pits are abundant, dating from all points in the historic period and much evidence is available to show that the production of lime was a major industry during the Moorish occupation 1000 years ago. Today a local construction material, Cal Mallorquina, is widely used as a mixture of lime and calcareous soil that makes an effective, very inexpensive cement. Its composition is approximately that of Roman *pazzolano,* a true cement that was used in Italy in the 1st century B.C. about the time of the Roman occupation of the Balearic Islands.

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