

ELLEN HICKMANN – ANNE D. KILMER –  
RICARDO EICHMANN (HRSG.)

## Studien zur Musikarchäologie III

Archäologie früher Klangerzeugung und Tonordnung

The Archaeology of Sound: Origin and Organisation

Vorträge des 2. Symposiums der Internationalen Studiengruppe Musikarchäologie  
im Kloster Michaelstein, 17.-23. September 2000

Papers from the 2<sup>nd</sup> Symposium of the International Study Group on Music Archaeology  
at Monastery Michaelstein, 17-23 September, 2000

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Musikarchäologie in der Ägäis und Anatolien

Music Archaeology in the Aegean and Anatolia

Vorträge des Internationalen Musikarchäologischen Kolloquiums des  
Deutschen Archäologischen Instituts (Istanbul) in Zusammenarbeit mit der  
ICTM-Study Group on Music Archaeology und dem Institut Français d'Archéologie (Istanbul)  
Mimar Sinan Universität, Istanbul, 12.-16. April 1993

Papers from the Colloquium on Music Archaeology organised by the  
Deutsches Archäologisches Institut (Istanbul) in cooperation with the  
ICTM-Study Group on Music Archaeology and the Institut Français d'Archéologie (Istanbul)  
Mimar Sinan University, Istanbul, 12-16 April, 1993

2002



Verlag Marie Leidorf GmbH · Rahden/Westf.

**Die Deutsche Bibliothek - CIP-Einheitsaufnahme**

**Hickmann, Ellen, Kilmer, Anne D. und Eichmann, Ricardo (Hrsg.)**

Studien zur Musikarchäologie III ; Archäologie früher Klangerzeugung und Tonordnung ;  
Musikarchäologie in der Ägäis und Anatolien

[Red.: Orient-Abteilung des Deutschen Archäologischen Instituts].

Rahden/Westf. : Leidorf, 2002

(Orient-Archäologie ; Bd. 10)

ISBN 3-89646-640-2

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Verlag Marie Leidorf GmbH  
*Geschäftsführer:* Dr. Bert Wiegel  
Stellerloh 65 · D-32369 Rahden/Westf.  
Tel: +49/(0)5771/ 9510-74  
Fax: +49/(0)5771/ 9510-75  
E-Mail: [vml-verlag@t-online.de](mailto:vml-verlag@t-online.de)  
Internet: <http://www.leidorf.de>  
Internet: <http://www.vml.de>

ISBN 3-89646-640-2

ISSN 1434-162X

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Umschlagentwurf: Ricardo Eichmann, Berlin

Redaktion: Deutsches Archäologisches Institut, Orient-Abteilung, Podbielskiallee 69-71, D-14195 Berlin

[e-mail: [orient@dainst.de](mailto:orient@dainst.de) — Homepage: <http://www.dainst.de>]

Satzerstellung, Layout und Scans: Fa. Merowarch, Spremberg

Druck und Produktion: DSC-Heinz J. Bevermann KG, Raiffeisenstraße 20, D-49124 Georgsmarienhütte

# Prehistoric Paintings, Sound and Rocks

Igor Reznikoff

## ZUSAMMENFASSUNG

*Basierend auf akustischen Studien in paläolithischen Höhlen mit Malereien, wofür hauptsächlich die menschliche Stimme eingesetzt wurde, wird eine Wechselbeziehung zwischen den Stellen an den Höhlenwänden, wo die beste Resonanz entsteht, und denen, wo die Malereien lokalisiert sind, aufgezeigt. Es scheint so zu sein, dass die Menschen des Paläolithikums, die die Höhlen mit Malereien ausschmückten, die Stellen nach der bestmöglichen klanglichen Entfaltung für bestimmte gemalte Szenen ausgewählt haben. Dies ist ein Hinweis auf einen rituellen Aspekt dieser Malereien und Höhlen, das Singen einbezogen. Das Forschungsproblem, die angewandte Methode und die Resultate werden beschrieben, wobei auch die möglichen verwendeten Instrumente berücksichtigt werden. Eine analoge Studie wurde über bemalte Felsen angestellt.*

## 1. INTRODUCTION TO THE SOUND DIMENSION OF PAINTED CAVES

This is a direct research in prehistoric studies that introduces to the world of sound of the Paleolithic people who painted the caves or marked them; it shows a relationship between these paintings or signs, and the sounds that might have been produced adjacent to them by the members of the tribes. By 'direct' research, we mean that the research is not based on analogies or suppositions resulting from comparative anthropological or ethnomusicological studies, but rather on experimental evidence. More specifically, by approaching the subject from the point of view of acoustics, one studies the sound resonance of a given cave, resonance which those decorating the cave during the upper Paleolithic period could have appreciated and *used*; and then, in a next step, one looks for possible links between the locations chosen for the paintings and the locations with the best e.g. the greatest resonance. Stated briefly, the

hope was that there would be the more paintings or signs in locations with the best resonance or sound quality. This hypothesis and, more generally, the relation between sounds and paintings was actually verified in most of the caves we studied in France; sometimes with strong clear evidence as in the caves of Le Portel and Niaux (Ariège), Isturitz (Pays Basque) and some parts of the main cave of Arcy-sur-Cure (Yonne, Burgundy), and sometimes in a more complex way, as in some parts of Oxocelhaya cave (Pays Basque).

The first study in the caves was done in 1983 and 1985, and in 1987 the study was extended to painted rocks in the open air, where the quality of the resonance is the quality of the echoes; since then, many other caves and painted rock areas have been studied.

Because the subject of the sound dimension of painted caves is not well known in music archaeology we will first reintroduce and explain here some of the basic elements of the approach, concepts, methods and main results, and then give some of the new results obtained recently.

The first papers on the discovery are those of the author,<sup>1</sup> of which some developments were also given in Reznikoff/Dauvois.<sup>2</sup> For other references see the bibliography below.<sup>3</sup> The first paper on the sound dimension of painted rocks in the open air is that of the author.<sup>4</sup>

## SOME GENERAL CONSIDERATIONS

A universally acknowledged rule in anthropology and ethnomusicology can be stated as follows: there are no societies without songs and chants, and more specifically, there is no rite or celebration

<sup>1</sup> Reznikoff 1987a and 1987b.

<sup>2</sup> Reznikoff/Dauvois 1988.

<sup>3</sup> And see the notice at the end of the paper.

<sup>4</sup> Reznikoff 1995.

which does not use sound, and, primarily, recitation and singing (in the broadest meaning of the word), perhaps supported by musical instruments, which perhaps replace the voice. In so-called 'primitive' societies (North American and Amazonian Indians, nomadic African and Australian hunters, Siberian hunters) every rite is recited and sung. To certain extent it can be asserted that *the more 'primitive' the society, the higher the quality of sound perception and intonation* (the 'classic' example being that of the Indian listening to vibrations on the ground). Recognizing this universality,<sup>5</sup> the origins of both the essential function of sound and of language for the human being can be situated in the earliest appearance of man as a social being. (The author's hypothesis is that language and sound belong to the human species like a particular song belongs to a breed of bird.) It is highly probable (besides direct evidence of instruments such as bone whistles, flutes, rhombuses and lithophones)<sup>6</sup> that Paleolithic people played instruments and recited and chanted like their above-mentioned relatives. What is more, we may suppose that the tribes who painted the caves recited and chanted (and most likely, danced) during processions or rites in these caves. This, however, has remained a supposition based on comparative studies which, despite their conclusiveness, leave the matter without direct evidence or concrete proof, since the use of these instruments cannot be considered as definitely related to what happened in the painted caves. Even in the case of the flutes found in the cave of Isturitz, in the main gallery decorated with the famous pillar engraved with reindeer (see below), one can argue that, maybe, these instruments were not played there by the people who decorated the cave nor played in relation to the engravings (or other possible ornaments), and that they just used the space because it is a space with a remarkable sound quality. Our argument is the following: we observe the correlation of a remarkable engraving located in a remarkably resonant space (besides the fact that the flutes are also found in this resonant space). Avoiding general anthropological and ethnomusicological arguments and focusing on archeological and experimental acoustical evidence, we thus put the question as follows: to what extent would it be possible to establish on this factual and experimental evidence the use these people made of sound and voice in relation with the paintings or other signs in caves?

Most of the caves are highly resonant, remarkable as acoustic pipes (that are also vaulted), and can produce quite astonishing echo-effects. If these people chanted or used sound, it would therefore seem quite likely that they would have chosen for their rites accessible locations having the best acoustics. This acoustical aspect of the caves had never

been considered before our study in 1983, yet it is by taking this into account that the above question can be asked more specifically: what can we discover about prehistoric peoples' use of the caves' natural acoustics, or to be more precise and returning naturally to our main purpose, *is there a link between the location of a painting or a sign and the sound value of this location in the cave?* If the two are linked, what possible deduction might be made as to the meaning of a sign or a picture in relation to its location and the location's sound value?

Clearly a positive reply to these questions leads to greater understanding of Paleolithic art and could eventually throw light upon the nature of the rites practiced at that time.

## EXPLANATION OF THE METHOD

The method consists in studying, or rather listening to, the resonance of sounds mostly in terms of their intensity and duration at different points along the cave walls; in 1993, we introduced also the number of echoes. In this way, the places with the greatest resonance can be located, or, more generally, the places where the quality of the resonance changes significantly. A map of resonance in the cave galleries can thus be drawn. In acoustical terms, the changes correspond to the alternation along the wall of nodes and antinodes for those frequencies that are characteristic of particular parts of the cave. The matter can, however, be rather complex, if the pitches that resound in different parts of the cave are also identified. In different parts of the cave, different and, possibly, many pitches (even if only the basic sound is taken into account) can be peculiar to its resonance since its form can be very complex; we are thus faced with two variables: location and pitch. In the best instances there is a dominant basic sound throughout most of the cave (e.g. gallery Jammes in Le Portel), or all sounds resonate well (e.g. Salon Noir in Niaux, Isturitz's main hall, main bottom gallery in Arcy), making the situation relatively easy to tackle with.

In other instances (Horse gallery in Le Portel) there is a complex acoustical network, and the variations in resonance can be very great. For example, in Niaux the duration of the resonance can vary from more than 5 seconds opposite the

<sup>5</sup> See Schneider 1975, for a general study; and, for example, Grimaud 1960; Kirby 1934 and 1936; Marshall (Mission) 1956.

<sup>6</sup> See Bibikov 1981; Fages/Mourer/Chauviré 1983; Dams 1985; Dauvois/Boutillon 1994.

*engraved bison*, to no resonance at all; and from a dull, lifeless resonance, to the superb resonance like that of a Romanesque chapel in the Salon noir, which resounds majestically as does the great hall in Isturitz.

Some caves, however, do not sound clearly, e.g. because of a clay covering on the rock, as in the little Grotte du Cheval at Arcy, which is also very narrow (one has to crawl a long while – it is not clear whether the gallery was so low in Paleolithic times because of possible ground level change), or in the somewhat chalky cave of Rouffignac (in Dordogne, famous for its mammoths) where, however, by progressing to the direction of the best resonance obtained, we happened to come to the main locations of pictures.

The acoustical properties of the cave depend on its shape, which has generally not been altered since the Paleolithic period, except sometimes on the ground level after excavations like, unfortunately, those in Lascaux, or from a natural landslide like that in the cave of Fontanet (Ariège), where after a landslide the acoustics have changed from that of an open-pipe to one of a closed-pipe. No conclusive study seems to be possible in Fontanet. As in some parts of the main Arcy's cave (there are some red points along the wall but almost no resonance, clearly a cave-in has changed it). However, in the main hall (Grande Salle) of Isturitz's cave the landslide of what is supposed to have been the natural entrance to the hall has obviously not caused any change because of the very big dimensions of the sounding part of the hall and the remoteness of the entrance. There may be also puddles whose level can change, but not to an extent that would noticeably change the resonance (this was confirmed in the Horse gallery in Le Portel, from 1983, a dry year, to 1985, a rather wet one: the nodes and antinodes of the sound wave remained apparently unchanged. The same was observed in Oxocelhaya). Of course this point of a possible geological or physical change in the cave, a change in its shape, has always to be taken in consideration since the method is based on the natural physical features of the cave which constitute objective data with respect to the cave when it was decorated.

This acoustical study was carried out *vocally* (in the broadest sense: the sound vibrations of the body) in a register from middle C1, to G3, reinforced with strong harmonics (overtones) and whistles up to G5; and *aurally* (using an ordinary tuning fork, based on A 440, to help to determine pitch). The voice is used quite softly, since in a place of resonance a sound is immediately amplified. In general, the slightest cranial resonance (on a *mm*) is sufficient when ampli-

fied by the cave, thus there is no need for great intensity of sound. It is the cave's natural resonance alone that counts, a resonance created by the slightest vibration of a sound characteristic of the resonance, and amplified by the cave (or a part of the cave) if the frequencies correspond. A sonometer, to measure the intensity of the sound can be used in order to make more precise the notion of sonorous or resonant location in estimating the resonance of it (see below). But apart from the measurement of its duration (with an ordinary chronometer) it is not easy to measure the quality of a resonance, because its intensity comes from a growth in intensity in specific frequencies – proper to the resonance – creating stationary waves that make the measuring device easily saturated, while our perceptions remain clear.

It should be noted that human sound perception, aural or physical (when the body perceives vibrations), is of unequalled precision and, with a trained ear, permits a flexibility of approach that is invaluable for this sort of work, if we bear in mind how complex it can be in practical terms. The vocal work is also indispensable if we consider that the study is *anthropological* and not just geophysical and acoustical; thus, it is essential to understand the correlation between the resonance of the body and the resonance of the cave. Moreover, once the relationship between the location of the pictures and the acoustics of the caves has been established, it can be demonstrated a posteriori that the people who painted the caves were also using their voices (see Conclusions); moreover, in some locations, the cave, because of the resonance, imposes certain kinds of vocal production.

This use of voice provides a more subtle approach which makes possible a profound study from an anthropological point of view. For example, the use of the voice, and even just of breath or the body's vibrations when exhaling, can, in a recess, create a cranial vibration. The choice of vowels is relatively unimportant; the sound *o* can be used, but in general, as we have seen above, the sound *mm* with the mouth closed (or the accentuated *hm*) is sufficient in the right place to make up to 100 m of the cave resound.

These arguments about the precision of a trained ear and perception, the necessity of an anthropological approach as well as the simplicity of the procedure and practice, have convinced acousticians – and of course musicians – of the soundness of this method. However, M. Dauvois with some acousticians has tried to work with a machine making a noise of a dense set of frequencies produced at the same time and then to compare the intensity of the answers in all

these emitted frequencies<sup>7</sup>. But the inconvenience is that, in the case of strong resonance, the easily occurring saturation effects may leave the answer completely inconclusive. In some cases, when the resonance is absolutely obvious because of its intensity, the machine didn't show anything at all. Moreover the conditions of emission are too far from natural and even more from subtle ones (e.g. given by cranial resonance) to be sufficiently reliable at all. When the resonance is clear, it is ridiculous, from our point of view, to substitute the eye that sees a pointer, or a number on a gauge, for the ear that hears the resonance, unless if it is to measure intensity. Of course in the oral method one needs an elementary training in music and emission of voice. We are looking, nonetheless, for a sonometer that indicates the intensity in given frequencies and harmonic sounds; in our experience this would improve the natural oral method and make it almost perfect. The comparison of results obtained with the machine and by natural perception is certainly interesting, but a trained perception must prevail. It is only because of our training (first in Romanesque churches) in fine sound perception that the first discoveries were made; M. Dauvois and so many others have been for years in prehistoric caves and did not notice anything at all concerning the resonance in relation with the paintings.

In practice the work was done as follows. One walks through the cave, in the middle or next to the wall, testing different sounds at different pitches; possibly, at some location for a certain pitch the cave will respond. One must then ascertain: (1) the exact pitch that produces resonance, (2) whether there are other sounds (the fifth for example) which respond, (3) the situation and orientation for the best resonance (in terms of intensity and duration), and (4) finally, of course, the precise location from which the resonance is created.

In a first approach point (2) can be left aside. Point (3) can show where one could go to make sounds: to the direction from where the resonance seems to come. We can formulate the hypothesis that in some cases, in the darkness, *the Paleolithic people progressed in the cave by using the voice and resonance's response as a sonar*, thus progressing to the direction of the best resonance (as if they were naturally attracted by it, since it gives an idea of the extension of the cave where to go). This hypothesis has been verified in several cases (in Rouffignac as seen above, also in Isturitz, Arcy, Le Portel). From the results of the point (4) we get the map of resonance of the cave or of parts of the cave.

When walking along the path, the response might increase or decrease, might disappear or

appear at a different pitch (there may be several pitches resounding at neighbouring points), and special features of the cave must be taken into account (recesses, niches and so on). Those points where a new pitch is discovered, or where it reaches maximum intensity or duration, or where the number of echoes increases, are of course particularly notable. More generally, one looks at points of maximum resonance, modified resonance, resonance related to another resonance (for example by harmonic relation).

We have thus to introduce the notion of *sonorous* or *resonant* location. As we have seen in the discussion above on the method, this notion is naturally obvious: one hears and feels immediately a resonance and strong resonance of course even more. But to make it precise, a location with a *strong* resonance is one where the intensity of sound increases in the mean more than 10 decibels (we used the sonometer Aclan SDN 80 F; the increase is often up to 15 decibels, and can reach much more in the precise frequency) or where the resonance lasts for more than 3 seconds or where the vibrations of the cave extend for more than, say, 25 m. As mentioned above, we have recently taken into account the number of echoes: turned to the bottom of the main cave of Arcy, where most of the pictures of this cave are actually found, the number of echoes can reach 7, as in the main hall of Isturitz, a most resonant one: there stands the famous pillar with engraved deer. In Oxocelhaya, in the Larribau gallery we had to consider as sonorous the locations where sounds can be obtained from stalactites or limestone draperies (see Example 3 in the next section).

Obviously, some pitches recur most frequently; the caves may resound in one tone: the large Jammes gallery in Le Portel, for example, sounds at the pitch D; the Horse gallery, on the other hand, has several resounding pitches.<sup>8</sup> The work may appear confusing initially, but one soon becomes familiar with the cave as one might with a musical instrument. To carry out or even to witness this sort of work is most impressive, and it is quite an exceptional experience to hear the cave respond to a sound made in front of an animal on the cave wall.

Once the map of resonance has been established it is superimposed on the map of the cave drawings. The question of possible correlations between sounds and pictures arises, and, through sound, between the pictures themselves. Dauvois has suggested that sounds could have been emit-

<sup>7</sup> See Dauvois/Boutillon 1994.

<sup>8</sup> See Reznikoff/Dauvois 1988.

ted from different locations alternatively – especially from locations related by resonance phenomena. This suggestion has proved to be quite relevant e.g. in the Portel. In Oxocelhaya sounds could have been produced simultaneously on stalactites and from a recess near by (see Example 3).

## FIRST RESULTS

These results are based on studies in the caves mentioned above. The cave at Le Portel (studied in 1983 and 1985) is particularly remarkable in that it is made up of three major independent galleries. The Niaux gallery (studied in 1983) is, on account of its size, exceptional. In the cave of Isturitz (studied since 1993), in the main hall which is like a concert hall for the beauty and strength of its resonance, as mentioned before, flutes were found of the Paleolithic period. The main cave of Arcy (studied since 1993) – where the discovery of the paintings is recent – has proved to confirm the results we expected. The study of the cave of Oxocelhaya (studied since 1993), however, needed new concepts. We studied also la Grotte du cheval (in 1993) at Arcy and the cave of Rouffignac (in 1994) – in both caves the results are somehow verified but not so clearly as in the other caves. As explained above, we could not draw any conclusion from the study of the cave of Fontanet (studied in 1983). The following points can be drawn directly from these studies, although more work will be necessary to both confirm and extend them. As far as the relationship between the location of pictures (painting, carvings, signs) and the acoustics of locations is concerned, the following general principles have emerged:

Principle 1 – *Most pictures are located in, or in immediate proximity to, resonant places.*

It must of course be borne in mind that a painting requires a suitable wall (this is not necessary for a mere sign) and that a resonant location is not always suitable from a pictorial angle. This means the possibility of a gap between a point of resonance and a painting; hence the use of the expression ‘in immediate proximity to’, which would generally never be further away than 2 m (even in a cave 120 m long). In Arcy and Oxocelhaya we had to extend this notion of proximity to include the possibility of being, in a gallery, *exactly in front of (opposite to)* a very resonant place: in Arcy (see Example 5, H) there are paintings on a wall, particularly a bovine-like animal, and on the opposite wall, exactly in front of the bovine, there is a niche, with red spots close by, a niche in which remarkable sound effects are easily obtained

giving bovine or bison like growls (by cranial resonance with the consonant *bm*; see below what we call the Camarin effect). The same was observed in Oxocelhaya, in the Laplace gallery (Example 3, 1), where the *falling bison* is located just in front of a narrow and long recess (in French we say *boyau*, a gut) marked with a very remarkable red spot at the most resonant place in the recess (see Principle 3 below), from where one can make the whole Laplace gallery resonate, also in a ‘bison like’ way.

Principle 1 proved to be true in all the caves we mentioned (for Oxocelhaya’s Larribau gallery considering also sounds that can be produced from draperies), sometimes up to a very high proportion of paintings (signs, carvings, castings). Sometimes in an astonishing way: in the large Niaux cave, the isolated engraved bison is located in a very resonant place.

Conversely, it is unreasonable to expect every point with good resonance to be painted; there are too many (at Niaux, for example) and they are often in unsuitable or inaccessible places. Hence we introduce the notion of an ideal place of resonance, one providing strong resonant qualities in the sense defined above, and one which is also accessible and suitable for pictures either in itself or in the immediately neighbouring area. This leads directly to the next point:

Principle 2 – *Most ideal resonance places are locations for pictures (there is a picture in the nearest suitable place). Among the ideal resonant places, the best are always decorated or at least marked.*

Principle 2 was also verified, as in Le Portel where most of the sounding locations are used; in Niaux, the ideal resonant Salon Noir contains most of the pictures. By contrast, an analogous large ‘room’ in Le Portel, the centre of the main gallery, is not resonant and contains only a few pictures. In Arcy also, most of the pictures are in the most resonant part of the cave (or appear at the end of a quite resonant one as is the case in the *Dance hall*, where we venture to predict more discoveries because of its sound value; but it is possible, however, that this hall was not yet reached by the people progressing in the cave). The second Principle, which focuses on the extent to which the resonant places were used, proved true to a high percentage if we insist on the quality of the ideal resonant places as defined above.

These principles give a general outline of *the relationship between the location of the drawings and the resonant places*. It is also possible to formulate the following hypothesis, of which we found many examples:

Principle 3 – *Certain signs are explicable only in relation to sound.*

Moreover, certain points have quite exceptional acoustics and produce the most extraordinary phenomena with vocal emissions. In the double *Camarin* recess or niche of the Breuil gallery in Le Portel, a single expiration or a simple sound vibration *mm* quickly brings you to stand within the resonance of the recess – it seems inconceivable that the painter would not have noticed it – and it produces low sounds that resemble a growl or the lowing of a bison, resounding down the whole gallery. This appears comparable to the Incas' acoustic caves, where a jaguar's roar is imitated by amplifying sound through stone channels as described by Lumbreras.<sup>9</sup> We call this the *Camarin* effect. The recess is predictably decorated in a most exceptional way.<sup>10</sup> Such effects in recesses were found elsewhere: one in Arcy, e.g., in front of a bovine like animal (as seen above, also in Example 5), and three in Oxocelhaya. In the last cave, the first location is in front of the *bison tombant* (gallery Laplace), another in relation to stalactites; both recesses with red spots clearly marking the precise location of the maximum of resonance – these spots illustrate Principle 3. In the third location, attracted by its sound value, I found two previously unknown red dots (see below).

Since these principles are verified with a high percentage, it is possible to say that, in the caves we studied, the choice of locations for paintings was made mostly for the sound-value of these locations. Paleolithic people chose good resonant places; this is the meaning of the first principle: *a picture requires sound*; whereas the second principle, which concerns the extent to which resonant places were used, indicates the importance of sound in itself: *sound calls for a picture*.

To illustrate the last two principles, it should be noted that some signs were (re)discovered aurally: by advancing in total darkness through the cave and presuming that a sign would be found in a particularly resonant place, locating the latter, then switching on a light, and indeed finding such a sign, even in a place unsuited for paintings. This was done first in Le Portel, in the Horse gallery.<sup>11</sup> The same experience was done in Oxocelhaya with J. D. Larribau, in the narrow recess in front of the *bison tombant* (see Example 3, A). But even more: some pictures or signs have been discovered (for the first time) by using sounds. In Le Portel after my discovery of some locations interesting for their sound value (in Jeannel gallery, see Example 1 below) Dauvois discovered some new paintings in these locations.<sup>12</sup> More recently I have discovered, as mentioned above, two red dots in a sounding niche (with a *Camarin* effect that lasts for 4 se-

conds), related also to sounding stalactites in a part of the Oxocelhaya cave where no signs or pictures have been discovered before (see Example 3, C). This has been the case also with painted rocks in the open air (see below). To return to Principle 2 let us repeat that in Niaux, where there is a multitude of possible locations, pictures, as a general rule, are found in the places with the most remarkable acoustics: the bison on the ground, arrows, and lastly the Salon Noir, where the great quantity of pictures can be explained acoustically (compare this to the center of the main gallery in Le Portel which is not resonant and contains very few pictures, especially considering how large it is). Seven detailed examples will illustrate the significance of these results as we can discover them in the caves. Examples 1 and 2 have been already published.<sup>13</sup> We repeat them because of their clarity and pedagogical aspects. More detailed studies of Examples 3 to 7 are yet to appear, so we give here only a summary.

## SOME EXAMPLES

Example 1. Le Portel (Ariège), gallery 1 (Jeannel). This example is not very remarkable in practice since the variations in sound intensity are relatively slight, as indeed are traces of pictures. It has been chosen for its simplicity (see Fig. 1).

One enters the cave in Le Portel by gallery 1 and follows the low rectilinear passage along the north right-hand wall towards the centre of the cave. The initial dull resonance gives way to a clear resonance on the pitch A1 at the very point where the picture of the first *bison* appears. This resonance changes to G1 at the *black signs* and changes back to A at the picture of the *owl* (probably a Harfang owl, or snow owl, extant now only in circumboreal countries; this owl is a significant sign, as will be seen in Example 2); at the horse it changes back to G, and again back to A at the second *bison*; the resonant qualities then die away rapidly, as do the pictures. There is thus an oscillation A – G – A – G – A (the A is slightly sharp) which follows the succession of pictures: bison, black signs, owl, horse, bison (see Fig. 1).

<sup>9</sup> Lumbreras 1972.

<sup>10</sup> Dauvois/Vezian 1984.

<sup>11</sup> Reznikoff/Dauvois 1988, Example 2; and using machines, Dauvois et al. 1998, p. 57.

<sup>12</sup> See Dauvois et al. 1998.

<sup>13</sup> Reznikoff 1987 a and b.



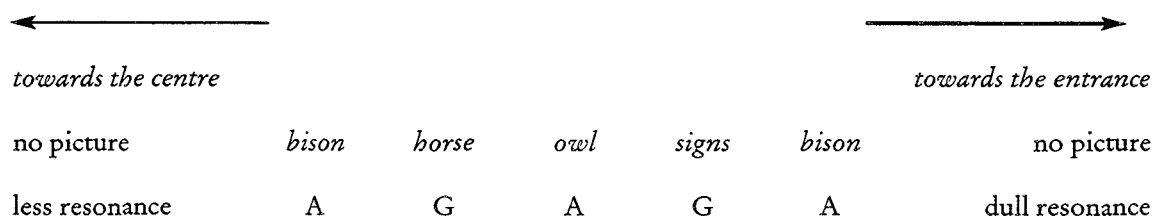


Fig. 1

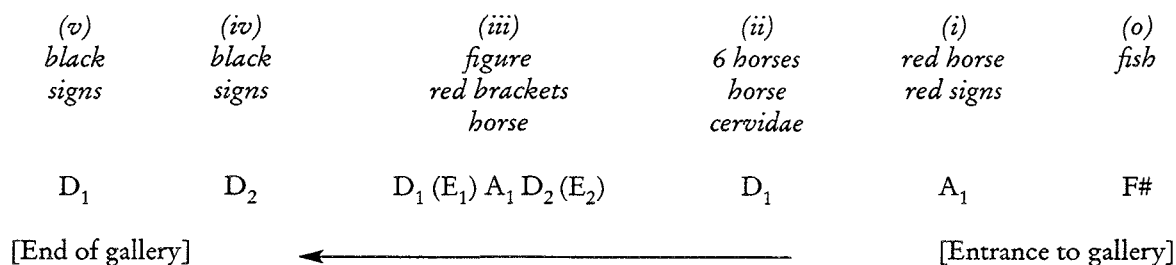


Fig. 2

It is in this part of the gallery, in front of the owl, that M. Dauvois found, because of the sound value that I discovered, some new pictures.

The next example is remarkable for the clarity of the resonance and also for the complete correlation between resonant locations and pictures.

Example 2. Le Portel, gallery 2 (Jammes).

(See Fig. 2) One enters this gallery, goes past the Horse gallery, and on the left on the south wall a red mark (i) corresponds exactly to the appearance of a resonance in A<sub>1</sub>, a perfect fifth above D<sub>1</sub>, the dominant tonic of this gallery; on the right a small red horse also marks this location: this illustrates Principle 3. As one continues towards the end of the gallery, on the left the sound A is replaced by G at the location of several painted figures (ii) (horse, deer, etc.); on the right, the large painting of six horses corresponds to the first large pictorial space after the red mark (i). Continuing further, one reaches a central place of resonance, an essential sound node (iii) marked by the red bird (or curved brackets sign) and the figure with the gnarled abdomen (ithyphallic). This location (iii) has the resonance at D<sub>1</sub>-D<sub>2</sub> typical of this gallery; to be more precise, resonances are found at D<sub>1</sub>, A<sub>1</sub>, D<sub>2</sub>, E<sub>2</sub>, but mostly at D<sub>2</sub> which, with D<sub>1</sub> and A<sub>1</sub>, resounds (with normal voice intensity) to the end (v) of the gallery (35 m away) and as far as the owl at the entrance (gallery 1; see Example 1), which also resounds at A on the other side (65 m away). Moreover this point (iii) resounds in relation to the Horse gallery (even though it is 70 m away and at a sharp angle).

Here, therefore, we may imagine sounds made from different parts of the cave simultaneously or alternatively: from gallery Jammes, from the owl at gallery Jeannel and from the Horse gallery. One then moves further along, where the resonance D<sub>2</sub> is dominant until it moves to D<sub>1</sub> at the location of the black signs (iv) on the left; this resonance reaches its maximum at the end of the gallery (v), marked with a cluster of black marks. From this end of the gallery one can be heard in the whole gallery by using the resonance (without it the sound is quickly dampened); this resonance is particularly strong at points (iii) and (i), and as far away as at the location of the owl at the entrance: it indicates precisely the end of the resonance more than 100 m away. The locations (i)-(v) correspond to the essential places of resonance in gallery 2 and are the exact locations where collections of pictures are found. The resonances in D<sub>2</sub> at (iii), A<sub>1</sub> at (i) are harmonically related, as octave and fifth, to the basic tonic, D<sub>1</sub> in (v); the E in (iii) corresponds to the interval of a second, but how surprising it is to find a fish (o) at the very point where the third F# resounds at the entrance to this gallery, while the red sign (i) appears, as we have seen, as a sign of purely acoustic significance.

This second example is typical of findings in various galleries, although the complete coincidence between places of resonance and locations of paintings is exceptional here in comparison to the situation elsewhere. The next example is new and opens a new chapter in these studies.

### Example 3. Oxocelhaya (Pays Basque).

In the cave of Oxocelhaya we can distinguish four parts. Three of them were already considered above:

(A) The Laplace gallery with its *bison tombant*, and other pictures among which is a gracious *doe* (see Fig. 3); they are located in front of (opposite to) a very resonant narrow and long recess (*boyau*) marked with the large red spot we have spoken of, corresponding to the maximum of the 'Camarin effect' in this recess. There are also on the same wall as the bison and the doe, but much before them, *horses*, in front of which the resonance changes a little (it is analogous to the case of Example 1, above). However there was in this section of the gallery, where the horses are, a cave-in that might have changed the resonance; it was probably stronger before.

(B) A second part, with also a sounding recess marked with red spots at the location of the maximum of resonance, is next to a remarkable set of sounding stalactites ('lithophones').

(C) A third part, where no signs or paintings were known before, and where as we mentioned above, in a little niche, also in relation with sets of sounding stalactites, two red dots were found, because of the sound richness of this niche.

And finally we distinguish a very important part (D), known as the Larribau gallery, where among various pictures is the famous *cheval au licol* – horse with what seems to be a halter or a bridle.

The problem was, that in this important part of the cave, in a first study done in 1993 there was no interesting resonance found in relation with the pictures. This gallery was therefore, apparently, refuting the main Principle 1. Apparently but not really, because in a second study, the same year, we noticed that next to the *cheval au licol*, on the opposite wall there is a sounding drapery (that resounds to a tap as some stalactites and stalagmites do). Beside this drapery, to the right, two fragile *little clay horses* are in immediate connection, at their right, with another drapery. Finally we discovered that in the Larribau gallery there is a sound network of draperies, stalactites (and some stalagmites) related to the pictures: *Principle 1 is verified if we include among resonant locations those with sounding draperies or stalactites.*

But in the above-mentioned parts (B) and (C) of the cave, there are also connections with stalactites, and, surprisingly enough, in front of the *doe* (see Fig. 3) of Laplace gallery (part [A] of the cave) there is also a large drapery that sounds, and also one at the entrance of the sounding recess in front of *bison tombant*. The Oxocelhaya cave is therefore characterized by pictures related to a network of draperies, stalactites and narrow recesses with strong 'Camarin effects'.

The question remained, however, to know whether these draperies and stalactites were there in late Paleolithic times – and could have been used then for sounds as they can be nowadays.

Fortunately the question has been studied from a geophysical perspective, and in the case of Oxocelhaya the answer is positive. Indeed, contrary to a common opinion, it is only in some very particular conditions, geological, chemical but also climatic and probably biological that limestone concretions can grow. In particular rather warm climatic conditions are necessary.<sup>14</sup> The argument then is the following: in Oxocelhaya the important draperies and stalactites can be either older than 80 000 B.P. or more recent than 10 000 B.P., but the later could not be the case because we have discovered traces of prehistoric bear's claw marks on some of them, while it is known that the prehistoric bear – because of climatic change – disappeared in this area certainly before 10 000 B.P. It is reasonable to assume that similar stalactites belong to the same period.

Of course this doesn't prove that the Paleolithic people who painted the cave made sounds with these draperies or stalactites. There is no absolute proof even in caves where stalactites are painted or marked with dots or show ancient traces of being struck: maybe they were not played by the same people who painted them or painted these caves! But we can ascertain that in Oxocelhaya in almost all painted or decorated locations there is a straightforward relation to sound: Principle 1 is verified with a high percentage. Principle 3 is remarkably illustrated by the red dots in the sounding narrow recesses. As to Principle 2, it is verified in Laplace gallery, in Larribau's (sounding draperies are related to pictures), and in the part (B) of the cave, where the set of sounding stalactites is related directly, by proximity, to the recess painted with red spots. It is only in part (C) – which resonates with a duration of 4 seconds – that the Principle 2 is very weakly verified: only two small dots in a low niche were found in this part of the cave.

A detailed study of the sound dimension of the Oxocelhaya cave is forthcoming. An art study in Laplace gallery is given by G. Laplace and J. D. Larribau.<sup>15</sup> No accessible study of the Larribau gallery (where the paintings were discovered by J. D. Larribau) has appeared yet. J. D. Larribau discovered also the painted cave of Erberua;<sup>16</sup> together with Isturitz's and Oxocelhaya's caves, the three are neighbouring and there is a modern direct access from Isturitz to Oxocelhaya.

<sup>14</sup> See Quinif 1989 and 1992; Dubois et al. 1991.

<sup>15</sup> Laplace/Larribau 1984.

<sup>16</sup> See Larribau/Prudhomme 1984 a and b.

<sup>17</sup> Buisson 1990. See also the paper by Lawson and d'Errico (this volume).

<sup>18</sup> Laplace 1984.

Example 4. Isturitz.

The Isturitz main hall, in which Paleolithic flutes were found,<sup>17</sup> is an exceptional space from the point of view of sound and resonance. As mentioned earlier, the landslide that modified the entrance is too far away from the main part of the space to have seriously modified the resonance. This resonance lasts for more than 5 seconds. All tones, low or high, sound equally, with a clear resonance, a beautiful harmonic fifth. At the central pillar with a group of carved *reindeer* (see Fig. 4) the resonance is a little shorter, but very large, with a beautiful harmonic third. It is easy to get 5 echoes and with higher sounds, even 7. It is a space that naturally invites singing or playing sounds in or *with* the resonance. It is really remarkable that flutes were found there. It certainly proves that the sound quality of this space was just felt as in the Paleolithic period as it is now. We conjecture that there are more pictures – engravings on the rock or paintings – still to be found: the famous pillar with engraved reindeer was found, by chance, under a thick stalagmitical covering that fell down. This cave is studied by G. Laplace.<sup>18</sup>

Example 5. Arcy-sur-Cure (Yonne).

We studied two caves at Arcy:<sup>19</sup>

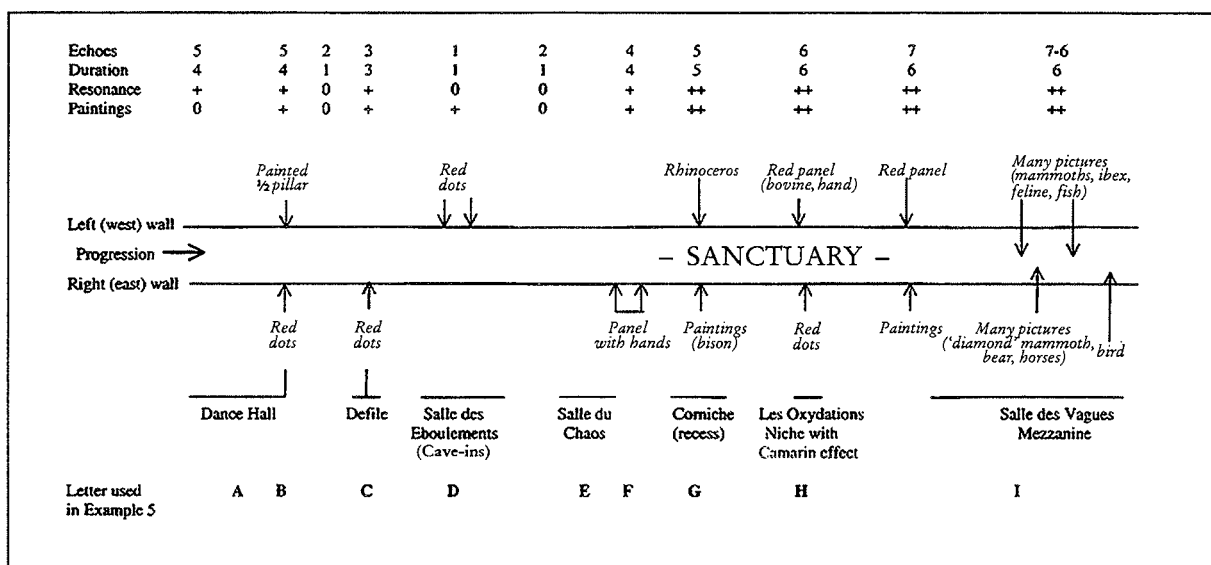
1) The little Grotte du Cheval – but known for its mammoths – has a very long (60 m) and narrow access where one has to crawl. This access doesn't sound at all and has no signs or pictures, contrary to many narrow recesses where there are locations with strong maxima of resonance (as seen often above). A little resonance appears, however, at the entrance of the first room (before the 'female signs' on the ceiling). Sounding stalactites (sounds F, A, C) are related to one of the main sets of pictures. It is not clear, however, whether these stalactites were there when the pictures were traced. At the peculiar *mammoth*

*with a long trunk* one finds what is probably the (relatively) strongest resonance. Other correlations can be shown, but the resonance is rather weak, probably because of the thin covering of clay that covers the rock and on which the pictures are traced; because of the weakness of the resonance its differences in intensity are also weak and the study becomes very delicate – perhaps a finer perception and approach are needed. Also, according to P. Dubois, specialist in the geology of caves, the level of the ground in the Grotte du Cheval has changed; probably not much, but because of the small dimensions of the cave (there are only a few place where it's possible to stand) even a small change of level of the ground can modify the resonance. In this very special cave we consider the results as inconclusive compared with results in other caves, for instance in the next one.

2) The main cave (Grande grotte)

This cave (only 200 km from Paris) has been continuously visited since the 16<sup>th</sup> c. (the famous botanist Georges Buffon visited it for example) and because of this the cave has become black from the smoke and soot of torches and candles. From the 19<sup>th</sup> c. on, it was forgotten until recently that the cave was decorated. In the late 1970's the owner of the cave decided to 'clean' it with water under high pressure and hydrochloric products; this was, of course, what appeared to be a disaster when a first painting was discovered by P. Guilloché in 1990.<sup>20</sup>

We consider here only the half of the cave where paintings have been found. In the other half (the first when coming from the actual entrance) the resonance is not so remarkable – except for some isolated locations – but it is not clear whether the Paleolithic people visited this first half of the cave at all. We proceed in the direction of the bottom part of the cave (see figure below).



<sup>19</sup> For a general study of both caves: Baffier/Girard 1998.

<sup>20</sup> Liger 1990 and 1992; Girard 1991.

A) Just before the decorated part is the large *Dance Hall* (*Salle de Dance*, where indeed balls were held in the past!); it resonates well, with a duration of 4 sec. and five echoes and reminds one a little of Isturitz's main hall (but Isturitz has up to seven echoes). No paintings have been found there (except at the end of the cave, see below) but the 'cleaning' of the walls was very intense up to a height of 2.50 m: all the concretions have been washed away and the rock appears white and naked. We conjecture, however, that if the Paleolithic people did visit this hall some findings will be excavated from the ground, perhaps bone flutes (as in Isturitz).

B) At the far end of the *Dance Hall* – towards the painted sanctuary – at the place called *Le Calvaire*, on the left, is a stalagmitic *half pillar coloured with red ochre*; the resonance is still very impressive in both directions (towards the *Dance Hall* or towards the sanctuary).

C) The resonance quickly diminishes, no paintings have been discovered; we then come to the low and narrow *Defile* creating an increase of resonance (on G–F# up to 10 dB, measured with J. C. Liger in 1994), and as expected, *red spots* of ochre appear on the ceiling, typical of sounding narrow recesses, spots that escaped the 'cleaning' process.

D) In the next part, *Salle des Eboulements (cave-ins)*, some *red dots* are found, on a low level of the left wall, however the resonance is weak because of an important cave-in and thus no conclusion can be drawn.

E) Then we come to the *Salle des Chaos* at the beginning of which there is no sound, no pictures. But soon we come to

F) The main painted space; a greater resonance occurs with a duration of 5 sec. and 4 and, a little further on, 5 echoes (easily obtained with a high-pitched voice), while in no resonant places it is about 1 sec. and 2 echoes. At the right are important *red hands*.

G) A little further, at the left is a red panel with a *rhinoceros*; exactly opposite to it is a recess parallel to the red panel, which in this resonant space sounds even more, and is itself decorated (in particular with a bison).

H) We now have a still better resonance, up to 6 echoes. A second red panel, also at the left, with a bison (or related species) corresponds to a little niche, *opposite to it and above a location called 'les coulées d'oxydations'*. In this niche a remarkable deep resonance occurs in low F, with what we call the *Camarin effect* (see above under Principle 3). This niche is surrounded by stalactites, now broken, some marked with red dots. While in the middle of the cave, at this level of progression, the resonance increases up to 6 sec. and 7 echoes, further paintings are found on both sides.

I) We come now to the bottom part of the cave, the *Salle des Vagues (Hall of Waves)*, because of the

ground) where the resonance is still very good. On the low ceiling many paintings appear preserved from the 'cleaning' by a thin covering of calcite. A new technique can locally and delicately rub out this covering: beautiful animals appear (mammoth, a feline, a salmon, and the gracious *ibex* that was the first picture to be found, by P. Guilloiré; see Fig. 5–7). At the right is a long narrow open recess (called the *Mezzanine*) fully decorated (bear, horse and the so called *diamond-incrusted mammoth*, see Fig. 8). This *Mezzanine* has an even stronger resonance, the ceiling is painted with animals and at its bottom is painted a *bird*.

J) After a very narrow passage (*Fox's Hole*) one comes to the *Salle des Cascades* with a large red panel, but landslides and cave-ins have hidden it and deadened the resonance.

From B) (the painted half pillar) to H) and I) the resonance increases almost regularly – it can be measured simply by the duration of the resonance and the number of echoes – and the richness of the ornaments increases as well. Of course one can argue that some paintings have disappeared because of the 'cleaning' we spoke of. There is nevertheless a clear result: in the most resonant locations many pictures are found; in the main cave of Arcy, Principle 2 is illustrated in a remarkable way.

Example 6. Rouffignac (Dordogne).

This very big cave has been known also since the 16<sup>th</sup> c. We studied only the main decorated part. The rock is chalky and the resonance is often quickly damped (as in the *Grotte du Cheval*, see above). Therefore the results are not so clear. However, differences in the quality of the resonance are noticeable.

We started in the *Two Mammoths* gallery where, in front of the two *mammoths affrontés* (mammoth facing each other), the resonance, in B<sup>b</sup>, increases. Then, making short sounds with the voice, we proceeded as explained above (see Explanation of the method), *to the direction of the best resonance* (answering our sounds): we happened 'naturally' (aurally) to come to the panel with *three rhinoceroses* and then to the famous *procession of ten mammoths*, in the Breuil gallery. From this experience it appeared clearly – in other caves as well – that sound was certainly used by Paleolithic people also as a sonar to progress in the dark cave. By the 'sonar' method we came to the engraved *five mammoths*, where a slight increase of resonance appears.

At the famous *Grand plafond* where, painted on the ceiling, are about forty animals, there is no particular resonance. This painted ceiling is low but the level of the ground at this location has changed – it was probably much higher, and there may have been a *Camarin effect*. However, the wall in this space doesn't sound either, except in its curve open to paintings. A study of other locations and particularly of some recesses ought to be done.

### Example 7. Niaux (Ariège).

This was one of the first caves that we studied. It is very big, but our studies in front of the pictures was clear and easy.

At the well known panel with its many red dots and linear signs the cave doesn't sound much, just as in other places with similar signs in the cave. *It seems that the location of such signs was not chosen for acoustical reasons.* In front of animals, on the contrary, the resonance is remarkable: (i) in front of the *bull engraved in the ground*, and even more (ii) at the famous *engraved bison* (in the clay) where the resonance lasts for more than 5 sec. as well as in front of the *arrows* next to the *bison*. Finally (iii) at the first panel (on the left) of the *Salon noir* and in all parts of it, as we have already seen, the resonance is exceptional (we have not studied the part beyond the lake).

The Niaux cave is a perfect illustration of Principle 1 concerning the representations of animals. It is also very interesting that, from the sound point of view, some signs (e.g. more 'geometrical' ones) are treated differently from others (animals).

## CONCLUSIONS ON THE CAVES

Since the places with good acoustics and the pictorial locations coincide to such a high degree and sometimes completely (as in Portel's Jammes gallery studied in Example 2 and in Arcy's sanctuary studied in Example 5, for instance), also in places that would seem hardly suited to painting, we can conclude that in most of the caves studied, *the location for a rock painting was chosen to a large extent because of its sound value.* This acoustical quality must have been discovered mostly vocally since, for example, the tapping of feet is too dull a sound to make the galleries vibrate; moreover, since resonance is variable, a drum (which has a fixed pitch) would not suffice to determine so well the points of resonance (but could still serve as a support), whereas flutes and whistles are too shrill to cause the rock walls to resound – but of course they could be used otherwise in sounding spaces (Isturitz). Likewise, because of the relatively low frequency resonance it would have been men's voices that were used and would guide the other participants (this in no way excludes the possible participation of women).

Given this use of sound, it is certain that these people sang (in the broadest sense of the word) and listened for the eventual response of the cave, which was doubtless considered alive in terms of sound. (In total darkness, with only a few torches, this effect must have been striking and still is today; it is indeed very impressive to hear the cave reply from its very depths to an animal on the rock wall.) The

Paleolithic certainly preferred places with the best acoustics; thus the ritualistic or even magical aspect by incantations of these paintings seems to be confirmed: why would sounds and chants be used otherwise? For us there should be also a dimension of praise related with some paintings (e.g. in Salon Noir or Arcy's main cave in the bottom part). Some places could have an initiatory sound character (the *Camarin effect*); in any case, the importance of sound for 'primitive' civilisations is well known.<sup>21</sup> Voices used consonant intervals (unison, octaves, fourths and fifths), which is not surprising, since these intervals have been used universally and are strongly favoured by resonance (octave and fifth are clearly heard as harmonics). We might have supposed that primitive melodies were only of the most limited range, but this is rather not the case here; the fifth is so apparent, sometimes with a little delay, that one is invited indeed to imitate it. As far as the use of instruments is concerned, the low resonance would tend to suggest the use of the drum and the rhombus; but the musical bow, as both an excellent support to the voice and giving the possibility of varying pitch, would seem to be most likely. This reminds us of the famous *horned sorcerer* at *Trois Frères* cave (Ariège) where what seems to be a musical bow is represented. In specially sounding locations, flutes or other instruments could be used, as in Salon Noir or Isturitz (where flutes were actually found; see above). This suggests also that real ritual concerts could have been performed, using voices, instruments, stalactites, ...

These results occasion many more considerations and questions. A question one often asks is whether there are possible correlations between sounds and represented animals or, to be more precise, between the intonation in the resonance of a location and the represented animal(s) in this location. Although we have confirmed some correlations ('bison-like' sounds and bison or related species representations as in Isturitz or Arcy, for instance), the evidence must be very intricate: there are often different animals represented in very close location or even in the same place.

## PAINTED ROCKS

After the first studies in the caves, the idea came naturally to study in a similar way the sound value of the locations of prehistoric paintings on rocks in the open air. For such paintings, e.g. around lakes in Northern Europe or in the mountains of Provence, the problem of an explanation for the choice of their location is even more difficult than the same problem for painted caves. There is also,

<sup>21</sup> See footnote 2 on p. 39.

of course, a need for a good rock surface for painting, but this doesn't really limit the possibilities, since, in open air there are usually many (apparently) good locations from this point of view.

The relationship of the locations to their orientation and, e.g., to the rising or setting sun is rather doubtful since paintings are often orientated quite differently; however, a possible relationship to the celestial system has to be investigated carefully.

Of course it is still possible that there were no special reasons for (most of) these choices, or rather no unity in the reasons or any real rationale in these choices, and that they were made arbitrarily. But this is not a very satisfactory explanation, and the idea that there could be a sound or, here in the open air, an echo consideration in the choice of the locations thus appears quite interesting.

The method was elaborated in the field. The voice was used from D2 to D3, actually with an open air powerful singing technique (about 100 dB at the source), in order to obtain at a given point, in front of a picture, a good echo effect. It would also be possible to use a horn. The criterion for a good sound location was the existence of at least a triple echo: a double echo is not a rare phenomenon, and four echoes would be too restrictive a condition to start with. Of course this echo property of a location depends on the weather and especially on the wind. The echoes often move in space, depending on the wind and landscape; the effect can be astonishing and sometimes even seems magical.

We have studied four examples of rock paintings in Finland: at three lakes in the Helsinki area and one in the area of Mikkeli (in June and July 1987). Three of these studies have been quite positive. The paintings have been dated to approximately 3000–2000 B.C. depending on the specific painting (but these chronological limits are still under debate). Then we studied several areas in the mountains of Provence, in France, at the Massif de la Sainte-Baume (in 1993) and recently (1999) in the Vallée des Merveilles. We shall also give an account of a study done in South Morocco (in 1995).

For the study of the Finish lake paintings, with their specific water level problems, see Reznikoff<sup>22</sup> the other studies are given here for the first time.

## PIN DE SIMON (SAINTE-BAUME)

The study at Sainte-Baume was remarkable especially at the cliff called *Pin de Simon* (Gemenos, Bouches-du-Rhône), where paintings were discovered in 1989 by B. Grasset and studied mainly by Ph. Hameau.<sup>23</sup> Reflected from the opposite cliff there are indeed quite noticeable echo effects. There are seven cavities in this area of the cliff: two of them

are painted, the first and main one called, following Ph. Hameau, *Pin de Simon I* and the last, *Pin de Simon II*; only the two that are painted give good echo effects coming from the opposite cliff. In the first cavity the best effects (4–5 echoes) are obtained where five of the eight major paintings are concentrated, in particular in front of a picture of a *human with open hands and fingers* facing the sky and the opposite cliff. At this picture one gets 5 echoes, the echo effect lasting up to 5 sec. From the last cavity, *Pin de Simon II*, up to 8 echoes (at night, in complete silence and no wind) can be obtained during 6 sec., eventually producing melodies, the last echo appearing after a little while in a very surprising manner. The guide and prehistorian R. Palun and I knew of only one picture there, but because of the remarkable sound value of the place I was sure that there should be more paintings. Indeed, by looking carefully once more, we discovered a new ochre painting, situated on the rock outside the cave, at the left of the entrance, facing the sun (wind and sometimes rain). This picture was actually known to Ph. Hameau, he identifies it as a *hart* but with a “hypertrophied” number of horns, while we venture it to be a rowing boat, the horns being viewed rather as oars (the Mediterranean Sea can be seen from there). In this case it would be the oldest representation of a boat in Europe since the paintings in this area are dated from Chalcolithic age, 2500–2000 B.C. (A comparative study on this painting and its interpretation is to appear).

## VAL SAINT-CLAIR (GEMENOS)

In the same part of Provence, at Vallon Saint-Clair (Quartier des Mines, Gemenos), at a location of ancient roman baths, there are two sets of pictures painted in dark red on rocks separated by what is now a usually dry river.<sup>24</sup> In front of a sun-like painting there are up to 4 echo effects during 3 sec. (when the wind Mistral is not blowing!). But curiously enough, from one side of the rocks, in front of the pictures, by simply whispering one can be heard on the other side of the rocks in front of the second set of pictures, even if there is some noise (possibly from the river) in between. It is however too peculiar an effect to draw any wider conclusions. Also it seems that the landscape (and waters) have changed since ancient times. We discovered near the sun-like painting what seemed to be an ancient stalactite; it might have been resonant.

<sup>22</sup> Reznikoff 1995.

<sup>23</sup> Hameau 1995.

<sup>24</sup> See Hameau 1989.

## MONT BEGO (VALLÉE DES MERVEILLES)

Finally, in Provence, we made a preliminary study at Mont Bego, in the Vallée des Merveilles whose pictures have been exhaustively presented and studied by H. de Lumley.<sup>25</sup> Our study was quite promising. There are several areas where we discovered a conjunction of rich sound values and pictures. Two areas are really remarkable. First the *Lac des Merveilles*, with, next to it, a very large flat rock (sometimes called the *Altar stone*) covered with more than a thousand pictures. There, by the lake, the echo answers whole melodies and it is a pleasure to sing or play; one can easily imagine a 'concert' or rather a celebration using voice and horns. Very remarkable also is the upper area with once again very large flat rocks and, facing the sky, many pictures including a famous one of a *human figure* (or 'god') with *zigzag* (or 'lightening') hands. There, because of the dominant position of the rocks, the echoes come from mountains all around, some at a distance, creating an unreal magical impression. At the Vallée des Merveilles therefore, we have again the conjunction of (i) large flat rocks covered with many pictures and (ii) very rich resonance expressed through echoes, easily suitable for ritual or celebration using voice and sounds. A more systematic study, however, remains to be completed.

## SOUTH MOROCCO

To end this section on painted rocks, we mention here a study we have done in the desert of South Morocco, in the district of Zagora, near Tazzarine at a place called Aït Ouazik. The paintings were discovered by a young shepherd, Mohammed Ouahman and G. Lafuente.<sup>26</sup> This study is worth mentioning because it provides a counter-example to our findings. The engravings on little rocks and stones (mostly of animals) are situated on a hill in the middle of a flat desert plateau. There are mountains in the very far distance, too far away to expect any return of an echo. The value of the location is therefore only visual: it can be seen from far away. A study in other areas of the Moroccan desert where pictures have been found must be done.

This last example reminds us of what is obvious: one can draw, paint or engrave, and celebrate and sing anywhere. But in the case where a choice of a location is possible, for celebrations or rituals that are usually performed with songs and sounds, one would choose a location appropriate for this; moreover, such a location, by its echoing answers, would unite the landscape, the rocks, the lakes or mountains, the sound and the Invisible in this performed celebration and praise, just as mother-earth does, keeping sound and her secrets in the caves.

## CONCLUSION ON PAINTED ROCKS

The ideas, the method and the positive results (at Pin de Simon, Mont Bego and around Northern lakes) obtained with painted rocks must be related to what we know of lithophones in the open air. Since, while there was nothing known on sounds in the prehistoric caves before our discovery, there are some studies on sounding rocks or rock gongs that were used as such in ancient times, by Fagg and others.<sup>27</sup> By Fagg mostly in Africa but also in Brittany, where, according to him, some megaliths seem to be ringing stones. The evidence of a sound dimension of painted rocks is supported also by the study made in the painted caves. In the caves also lithophones seem to have been used.<sup>28</sup> The sounding stones thus create a link between the open air and the ornamented caves. As far as we know, the painted rocks around the Northern lakes and in Provence – rock walls or big flat rocks – cannot be used as gongs but we now have a knowledge of how rich, for the prehistoric tribes, were the relations between sound, caves, space, lakes, rocks, mountains and paintings and how deep and alive the sounds were for them.

## ACKNOWLEDGMENTS

I am deeply grateful to Mr. and Mrs. Gabriel de la Varende allowing me to work in the caves of Arcy-sur-Cure, and I wish to thank D. Baffier and M. Girard for their help in discovering the pictures in the main cave, and J.-C. Liger for assisting me in my work there and in the Grotte du Cheval.

For the study in Isturitz and Oxocelhaya I am grateful to Mrs. J. Darricau for allowing me to work in those caves, and I wish to thank warmly G. Laplace and J. D. Larribau for their help in discovering the paintings there, and P. Dubois for geological explanations and references in the dating of stalactites.

For the study in Rouffignac I am grateful to Mr. J. Plassard for allowing me to work there and for his help in discovering the paintings.

For the studies in Provence, I am grateful to Mr. J. C. Sarles for allowing me to work at Vallon Saint-Clair, and I wish to thank warmly R. Palun for his assistance in the discovery of painted rocks at the Massif de la Sainte-Baume and finally to

<sup>25</sup> Lumley 1995.

<sup>26</sup> Simoneau 1971 and 1976.

<sup>27</sup> Fagg 1956; Conant 1960; Alvarez/Siemens 1988. See also Kirby 1934.

<sup>28</sup> See Dams 1985; Dauvois/Boutillon 1994; and the present paper (Example 3, D).

thank H. de Lumley who marvellously introduced me to the Vallée des Merveilles.

(For the caves of Le Portel, Fontanet and Niaux, we renew here the thanks we have already given elsewhere.)

### Notice

Unfortunately as far as the papers and work of M. Dauvois are concerned – to whom we refer in the present paper – it must be said that in all his publications on the subject, since 1990, M. Dauvois curiously forgets to mention to whom the ideas, the method and the main results actually belong: he never mentions my name, nor my paper of 1987

– to the publication of which he agreed – nor even our joint paper of 1988 (!) trying tacitly to attribute to himself the discovery. M. Dauvois who introduced me to the caves of Portel and Niaux and assisted to my work and discoveries there in 1983 and 1985, has attended my course at the University and my practical courses in resonance and singing – before we met he knew nothing about sound – but in a recent paper (*La Recherche*, Hors série 4, Paris, November 2000) it is written that no one except him has ever worked on the subject of the relation between prehistoric paintings and resonance in the caves! This is one more example of falsification in sciences. Clearly the importance of the discovery has affected his scientific responsibilities and has gone to his head.

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Fig. 3 Doe (Laplace Gallery, Oxocelhaya). This doe is in front of a sounding drapery nearby a sounding recess (see Example 3). Collection J. Darricau.

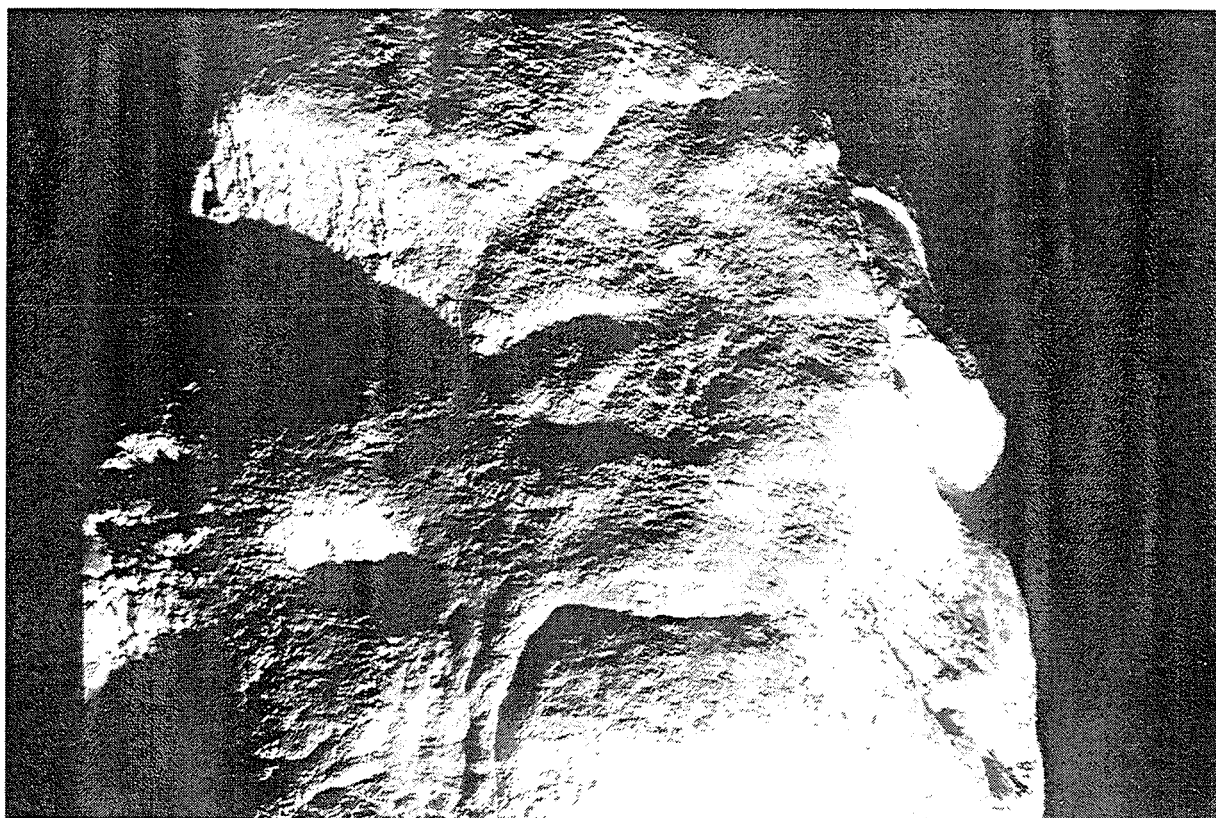


Fig. 4 Pillar engraved with reindeer (Main hall, Isturitz) (see Example 4). Collection J. Darricau.



Fig. 5 Head of a feline (Salle des vagues, Arcy). It is situated in one of the most resonant locations (Example 5, Main Cave, I). Collection La Varende. Photo D. Baffier.



Fig. 6 Salmon (Salle des vagues, Arcy). It is situated in one of the most resonant locations (Example 5, Main Cave, I). Collection La Varende. Photo D. Baffier.



Fig. 7 Ibex (bouquetin) (Salle des vagues, Arcy). This was the first picture found in the Main cave of Arcy (Example 5, Main Cave, I). Collection La Varende. Photo M. Girard.



Fig. 8 'Diamond-incrusted' mammoth (mammoth 'diamante') (Mezzanine, Arcy). This brilliant mammoth appears in one of the most resonant locations of the Salle des vagues (Example 5, Main cave, I). Collection La Varende. Photo M. Girard.