

KARST IN FRANCE AND UNESCO WORLD HERITAGE

KRAS V FRANCIJI IN SVETOVNA NARAVNA DEDIŠČINA UNESCO

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Abstract

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French Karst covers the third of the territory. Because calcareous deposits date back to the Cambrian and are now located in tabular region as well as in tectonic areas, French karst is famous for its diversity. Large karst landscapes are well known, such as *Les Grands Causses*, the *Gorges du Tarn* and the *Gorges du Verdon*. Resurgences such as the *Vaucluse Fountain* and the spring of the *Lez* are very famous too. Karstic units can show very large dimensions: 400 km for the six hydrological networks of the *Pierre Saint-Martin*, 104 km for the *Arbas Mountain*. Maximum depths can reach high records, at *Pierre Saint Martin*, *Berger Cave*, *Jean Bernard Cave* and recently *Mirolida Cave* was acknowledged to reach 1733-meter depth.

Studies proceeded during the last century have revealed an important cave fauna. Considering the heritage value of French karst, the key point is not only the presence of more than 160 decorated caves from Palaeolithic period but also the number of caves showing concretions. Moreover, a rare phenomenon has to be underlined: in *Ariege*, the *Intermittent Fontestorbes Spring* is the most regularly and completely studied resurgence in the world. This amount of exceptional features for these caves commands to organise studies and programmes to establish conditions of a good conservation of this heritage for the next generations.

Key words: karst, natural heritage, France.

Izvleček

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Patric Cabrol & Alain Mangin: Kras v Franciji in svetovna naravna dediščina UNESCO

Kras pokriva tretjino ozemlja Francije. Ker so karbonatne kamnine, ki so bile odložene od kambrija dalje, danes kot planote ali pa tektonsko razgibana ozemlja, je francoski kras znan po svoji pestrosti. Znane so obsežne kraške pokrajine, kot so *Les Grands Causses* ali soteski rek *Tarn* in *Verdon*. Prav tako so znani kraški izviri, npr. *Fontaine de Vaucluse* ali izvir reke *Lez*. Kraški sistemi so lahko zelo veliki: šest hidroloških sistemov *Pierre Saint-Martin* meri 400 km, v gori *Arbas* pa 104 km. Največje globine, *Pierre Saint-Martin*, *Jami Berger* in *Jean Bernard* dosežajo rekorde, nedavno tega je bila v *Jami Mirolida* dosežena globina 1733 m. Raziskave v zadnjih sto letih so odkrile pomembno jamsko favno. Ni samo več kot 160 jam s paleolitsko jamsko umetnostjo najpomembnejša dediščina francoskega krasa, ampak tudi številne zasigane jame. Poudariti je treba tudi redek pojav: zaganjalka *Fontestorbes* v departmaju *Ariège* je najpopolneje in najbolj zvezno opazovan tak izvir na svetu. Veliko število izrednih pojavov v jamah zahteva pripravo preučevanja in programov za ustrezno ohranjanje te dediščine bodočim rodovom.

Ključne besede: kras, naravna dediščina, Francija.

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INTRODUCTION

In France, 30% of the land is covered with calcareous formations more or less evolved to karst formations. About 100 000 caves are explored by about 20 000 speleologists; 7000 to 8000 of them belong to the *Fédération Française de Spéléologie* and about 800 to the *Club Alpin Français*. The distribution of these caves is very unequal. Some areas are very well supplied like Hérault for example with 4000 caves whereas others like Côtes d'Armor (Brittany) show no cave at all.

It has been a tradition for French scientists to be involved in the field of the underground studies. From the middle of the XIXth century up to now, this research has been very active, and it is strongly organised through many laboratories linked or belonging to the CNRS. The first laboratory in Europe devoted to karst studies was the French *Laboratoire Souterrain de Moulis* created in Ariège.

Many national and international working groups have been active in various fields related to karst studies: cave formation, characteristics of karstic landscapes, hydrology in calcareous regions, cave sediments' studies,

concretions studies, biospeleology, geochemistry, and so on...

Famous scientists who left strong marks on modern knowledge of karst evolution made this long history. Among them, Delarouzee is famous for he initiated biospeleology in the XIXth century. Consecutive progress were made during the same century and the beginning of the XXth, with Lucante, A. Viré, E Racovitza, Jeannel and essentially E.A. Martel whose name is undoubtedly linked to modern knowledge of karst. Among explorers we first have to mention Martel but also Fournier, G. de Lavour, R. de Joly, F Trombe and Norbert Casteret.

Even if the list is not exhaustive, we have to mention A Cavaillé, J Corbel, B. Gèze, J. Nicod, P. Renault, A. Vandell, F. Trombe, as scientists, but it is essentially after the Second World War that the French research was the most efficient, due to the results produced in the *Laboratoire Souterrain de Moulis* and the team of geographers from Aix en Provence.

Today, various research programs are in progress through many teams from the CNRS and universities.

THE ECONOMIC IMPORTANCE AND THE VARIETY OF THE FRENCH KARST.

French karst is highly important regarding economic, patrimonial, educative and sportive aspects.

ECONOMIC INTEREST OF THE FRENCH KARST
107 caves are open for tourism and 4.000.000 of visitors are registered every year. (Padirac, Bétharam, Orgnac, Clamouse, Armand, Demoiselles, Choranche...).

Many large cities only use water provided by karst: Montpellier with the Spring in Lez, the *Fontaine de Nîmes*, Besançon and so on...

Some ores such as lead or zinc are trapped in karst: see for instance the Malines Mine (Gard).

THE VARIETY OF THE FRENCH KARST

The French karst is extremely varied depending on the nature of the calcareous formations where it has devel-

oped: pure lime stones but also dolomites and dolomitic formations, argillaceous lime stones and marls, and so on. They appear as thin layers or as massive beds. Somewhere, they can be tabular but somewhere else, they can be strongly tectonised. Some of them are enriched with various metals such as lead, zinc, copper, barium and nickel, as for the southern edge of the *Montagne Noire*.

The French karst also develops under different climatic conditions. It varies from Mediterranean to Atlantic climate, and from humid Atlantic to Continental and even up to semi-arid Mediterranean climate. Most of the French karst developed during the Quaternary Period but in some areas such as Quercy phosphates, the karst formation dates back to the Tertiary Period. A beautiful tertiary fossil fauna is very well preserved in this Quercy formation.

A LARGE PATTERN OF POTENTIAL VARIETIES

Because of the extreme diversity of its environment, the French karst shows a large pattern of potential varieties.

1) Large karstic landscapes:

These large karstic landscapes made this country

very famous. First, we have to mention the Grands Causses (Causse du Larzac, Causse Noir, Causse Méjean), the *Gorges du Tarn* and *la Jonte*, the *Gorges du Verdon*, the *Gorges de l'Ardèche*, the *Désert du Platé*, *les Arres d'Annie*, *la Pierre Saint Martin*, the *Massif du Vercors*, the Jura Mountains with famous *reculées* such as *la Loue*, *le Massif de la Chartreuse* and so on...

2) Important resurgences:

The most famous in the world is probably the *Fontaine de Vaucluse* but other ones show very high flows too such as the *Lez Spring* in Montpellier, *la Fontaine de Nîmes*, the *Loue Spring* (Doubs), the *Girardes in Dévoluy Area*, the *Touvre* in Angoulême, the *Chartreux* in Cahors, the *Buège* in the *Séranne*, *Port-Miou* which flows down into the Mediterranean Sea in the *Calanques de Cassis* near Marseille...

3) Large hydrological systems:

Exceptional developments of galleries can be seen at the *Pierre Martin*, where six hydrological systems have a total of 400-km long gallery, the *Massif d'Arbas* with 104 km of galleries and wells, 45 entrances and 1004 m of difference in level, the *Alpe system* with 60 km, the *Granier system* (Isère) with 55 km, the *Dent de Crolles* with 50 km, the *Verneau system* with more than 33 km of galleries, *Saint Marcel d'Ardèche* with 27 km, the *André Lachambre system* in the *Pyrénées Atlantiques* shows 25 km of galleries with very beautiful mineralization of calcite, aragonite and hydromagnesite. The *Cabrespine Cave* covers 18 km and so on. To give a comparison, the most developed system in the world is the *Mammoth Cave System* (Kentucky, USA), which shows about 557 km of galleries.

4) Large Depths:

In France, large calcareous formations exist at very deep levels. This has initiated the research of a world record of depth: *Mirolida Cave* (Haute Savoie) is 1733 metre-deep, *Jean Bernard System* (Haute Savoie) is 1602 m, *Pierre Saint Martin* (Pyrénées Atlantiques) is 1342 m, and *Berger Cave* (Isère) is 1271m.

5) Important fauna:

The long history of the French karstic fauna has interested a lot of biologists. They discovered and identified 639 invertebrate species. Some caves located around the *Laboratoire Souterrain de Moulis* have been intensively investigated (*Sainte Catherine Cave*, *Liqué Cave*, etc...). *Hautecourt Cave* (Ain) may also be mentioned for the study of underground fauna and its relation with environment. For about twenty years, the studies for hydrological system fauna has been developing: we can men-

tion the *Baget System* in *Ariège* (Raymond Rouch from the *laboratoire de Moulis*), the *Lez Resurgence* in *Hérault* (Florian Malard from the university of Lyon), the *Sauve Spring* in *Gard* (C. Juberthie et R Rouch), the *Anglars System* in *Lot* (C. Bou, Danielopol and R Rouch), the *Torcien System* in *Ain* (G. Gibert), the *Arbas System* in *Haute Garonne* (F Lescher-Moutone and N Gourbault). Because of the size of the systems still to observe, these studies are just beginning.

6) The French karst particularities: Palaeolithic age artefacts, concretions and Quercy phosphate ores. An exceptional phenomenon: Fontestorbes, an intermittent spring

Large karstic formations can be found everywhere in the world (China, Europe, Madagascar, USA). In some countries, karst is particularly developed as it is in Slovenia for instance. Extreme depths are also reached in Caucasus Karst, but the feature that makes the French karst exceptional, is the abundance and value of mixed archaeological, mineralogical and paleontological remains, and last but not least, the exceptional natural phenomenon of the *Fontestorbes disturbed spring* (literal translation of the name of this intermittent spring) in *Ariege*.

6.1 Archaeological heritage:

More than 160 caves are ornamented with engravings, paintings or drawings from the Palaeolithic period. From this point of view, France is in possession of an exceptional heritage, contemporaneous of the origins of Art, with fabulous caves such as: *Chauvet*, *Lascaux*, *Cosquer*, *Niaux*, *Pech Merle*...

6.2 Mineralogical heritage:

French caves show magnificent concretions of great interest. Large caves opened for tourism like *Clamouse Cave*, *Choranche Cave*, *Demoiselles Cave*, *Esparrons Abyss*, *Aven Armand* and *Aven d'Orgnac* show a great diversity of colours and shapes that make them very attractive to tourists. Some caves closed to visitors contain rare if not unique concretions, such as "mushrooms" from *Lauzinas Cave*, "pastis distributor" of *Cabrespine Cave*, "blue needles" of aragonite of *Asperge Cave*, "cymbals" of *TM 71 Cave*. In some cases, the abundance of monotype concretions is quite exceptional such as aragonite and hydromagnesite from the *Réseau Lachambre*, "soda straws" of *Amélineau Cave*, and the "aragonite chandelier" of *Limosis Cave*. Some concretions are exceptional for their size: it is the case at *Aven d'Orgnac*, at *Demoiselles Cave*, at *Clamouse Cave*.

Quality, diversity and abundance of these concretions in French caves have justified studies on their origins and also on the way we can protect them (Patrick

Cabrol and Alain Mangin essentially). These studies have shown that beyond their esthetical aspect, concretions are pure scientific objects, which allow to study the mechanism of infiltrating zone in karst areas. Moreover, concretions are paleoenvironmental archives of great precision for the past half million years. Concretions are better archives than polar ice, because of the chronology precision allowed by Th/U disequilibria dating method.

6.3 Paleontological heritage:

Bones from animals of Quaternary period are very abundant in France, sometimes exceptionally numerous as in Aldène Cave (Hérault) where more than 200 000 cave bears are fossilised and make an important phosphate bed which was exploited 50 years ago. Elsewhere, we have to mention the variety of species, such as in Châtillon-Saint-Jean (Isère) for instance.

We especially have to mention the phosphate ores from Quercy. The whole evolution of vertebrate fauna during the 30 millions of years of the Tertiary Period is gathered there on a pretty small area (20 x 50 km).

60 million years ago, calcareous formations were present in these regions of Lot and Tarn-et-Garonne. Karstification produced many caves where animals fell down (Avens, Abysses). Their remains are fossilised in very thin grain sediments caused by dissolution of soils formed under tropical climate of this period. During 30 million years caves played this function of reservoir for these fossils with very good preservation conditions.

Scientific results obtained on this fauna deal with various research fields. More than 250 papers and 15 PhD were published since 1960.

Beyond the geological interest, Quercy phosphate ores show a great interest for mine exploitation techniques and are a witness of human activity from 1870 to 1905.

Quercy phosphate ores show a scientific and heritage interest that is unique in the world for this period.

A question can be asked: Must karstic sites known for prehistorical archives be always excluded or not? (Archaeological relics, ornamented caves etc...)?

6.4 - An exceptional phenomenon: intermittent Fontestorbes Spring in Ariège

Fontestorbes intermittent resurgence is located near Belesta (Ariège). It shows a rare cyclic variation of flow during low water periods. Only thirty cases are described in the whole world but this one is truly exceptional because of the large flow variation with a minima of 20 litres per second up to a maxima of 1800 litres per second following a very regular periodicity of about an hour.

Located near a road it makes an attractive site for tourism in the area. Speleological expeditions have led to discover on the upstream, the sub ground river that provides water to the intermittent phenomenon. Two places in the cave show the cyclic ascending and decreasing movements of water, with amplitude of 4.5 meters and 5.5 meters. This resurgence is already protected by registration in the national site book (october the 10th 1921) and is included in the project of a protected area for Ariège.

7 Hydrological systems and caves very much studied:

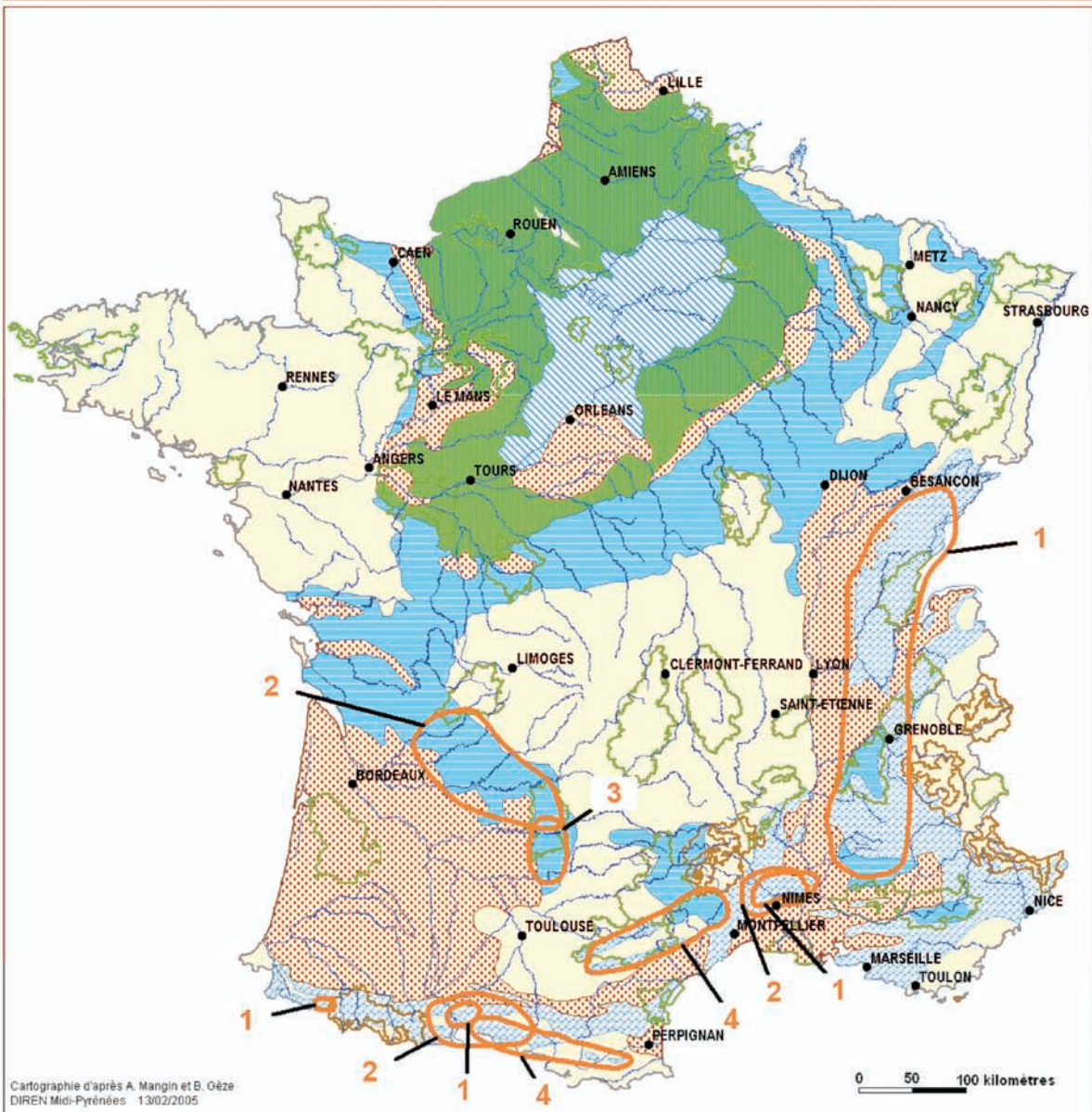
French karst is so rich and various that it has justified numerous fundamental researches and it is now difficult to present an exhaustive list of these studies. Among recent studies, we can mention experimental studies of karstic Baget System and the one of the *Fontaine de Fontestorbes* in Ariège, the Lez Spring in Montpellier, the *Fontaine de Vaucluse* in Vaucluse, the *Causse du Larzac* and *Causse de Sauveterre* in Aveyron and Hérault, the Champlive Basin in the Jura Mountains, the Touvre in Charente.

Regarding formation and dating of concretions and sediments in the caves, we have to talk about the studies made in Clamouse Cave, the Devèze, Pont de Ratz (Hérault), Choranche (Isère), Orgnac Aven (Ardèche), Niaux Cave (Ariège), Villars Cave (Dordogne) and Chauvet Cave (Ardèche).







The first environmental study before opening a cave for tourism was performed in 1987 at Esparros Cave in Hautes-Pyrénées and this operation shows how necessary it would be to extend this kind of study. The sad experience of Lascaux Cave reminds us that heavy mistakes can happen. This is the reason why we have made copies of this cave (Lascaux) that the public can visit and we are about to do so with the Chauvet cave and other ones in the future.

Some environmental studies were carried out on caves that are now used as examples to follow: it is the case of the famous Chauvet Cave, Esparros Cave where studies have been going on for ten years. Others cases to be mentioned are Niaux Cave, Cabrespine Cave, Gargas Cave, Pech Merle Cave, Orgnac Aven, Proumeyssac Cave, Bedeilhac Cave and so on. These works have led to build a database, considered as a key for the understanding of natural phenomenon and the preservation of the heritage in these caves.

Heritage of carbonate formations in France



Types of Carbonate Rocks

-  Folded and strongly tectonically changed formations
-  Plateau shaped, tectonically unchanged
-  Deposit with a strong primary porosity (chalk...)
-  Partly carbonate soil
-  Covered formations
-  No substantial carbonate rocks

-  National nature park
-  Regional nature park

- 1 geomorphological [point of] interest**
- 2 archaeological point of interest**
- 3 paleontological point of interest**
- 4 mineralogical point of interest**

THE FIRST INVENTORY OF THE IMPORTANT KARSTIC SITES IN FRANCE.

Regarding the importance of karst in France, for the surface concerned as well as for the heritage value, it is necessary to establish and publish for public community an inventory of major karstic sites in France.

Pierre Chauve organised the work of a team with different specialists of the French karst. They produced a first inventory and a collective book is scheduled for 2005.

SELECTION CRITERIA FOR SITES WITH A HIGH PATRIMONIAL VALUE:

After this first inventory, it is necessary to think about criteria that could select sites that offer the best heritage value in order to register them on the World Heritage list of the UNESCO, on the Ramsar Sites list, MAB, or other records that provide sites with an international acknowledgement.

Among the criteria we can have:

Geology. The meaning of the word has to include karstic feature but also geomorphology, hydrology, mineralogy ...

Inventory of knowledge. Sites have to be well known through scientific studies. If the knowledge of a site is limited, then it is difficult to select it because it is impossible to argue in favour of its scientific interest. This important criterion, of course does not imply, that a well-known site has to be selected as an international valuable site.

Environmental state. If polluted or degraded by heavy use, a site cannot be selected.

Attractiveness for tourism. If accessibility is difficult or limited to specialists, and then prevents access to children, students and people, there is a problem. If so, it would be necessary to find a way to make the site accessible with a reinforced protection that allows its use by a large public.

Interest of selected sites. selected sites have to show a remarkable interest and gather a full knowledge of a karst feature. The number of aspects presented can be limited. The selection of a few sites that show a particular aspect of karst features can be of a great interest if various sites complete each other.

Management of selected sites. If the sites are registered on an international reference list, then their management control will be under the National or the local authorities, that can offer important means of conservation, which is precisely one of the main targets of the UNESCO World Heritage.

MANAGEMENT AND PROTECTION OF GEOLOGICAL KARSTIC HERITAGE WITH AN INTERNATIONAL INTEREST.

Several texts of an international level are used for the protection of the geological heritage.

– The International Recommendations on Karst Preservation.

– The International Union for Nature Preservation has published in 1997 the « Guidelines for Cave and

Karst Protection », which proposes 31 recommendations to protect and manage this heritage.

– The European Community has produced on May, 5, 2004 a text that indicates how to protect and manage geological sites.

MANAGEMENT AND PROTECTION OF GEOLOGICAL KARSTIC HERITAGE IN FRENCH LEGISLATION– LAWS OF 1913, 1930 AND 1976

In France, Natural and cultural heritage is protected with laws according to the kind of heritage interest the sites have.

1) The law of 1913 deals with historical monuments and allows to take in consideration prehistoric, historic and artistic remains.

2) The law of 1930 (Article L 341-1 to L 341-17 code of the environment) allows to protect natural monuments, or sites if they present characteristics from an artistic, historical, scientific, legendary or picturesque point of view. There are now more than 2700 sites of this type.

This law protects many sites that show geomorphologic interest such as valleys, cliffs, glaciers and big rocks. It is also the case of more than 100 sand cave fossils sites (vertebrate fossils from the Tertiary period of the Campané Site at Sansan in Gers Department....).

3) The Law of 1976 dedicated to Nature Conservation (Article L.242-1 of the code rural) allows to take in account « The preservation of biotopes and noticeable geomorphologic or speleologic geological formation,» and «*the preservation of sites which have an exceptional interest for studies on life evolution and first human activities*».

This short list shows that it is possible to protect underground heritage with a combination of several laws. According to the local context, one law or another one will be used.

The common characteristic of these laws is that every new building construction that threaten to change something in the site are submitted to a special authorisation. These constraints are made very heavy in order to protect these valuable sites. They form a quality label acknowledged by the French government for these exceptional sites. The major difference between the laws of 1930 and 1976 is the constitution of a management committee for natural reserves that was not required for registered sites with the law of 1930.

This new disposition was decided when the Esparros Site (Hautes-Pyrénées) was classified in 1987 and now it applies to la Cigalère Cave, Lauzinas Cave, Réseau Lachambre, Clamouse Cave, Aven Armand, Aven d'Orgnac, Aven des Perles, and Thémines Cave. This disposition will be used for other classification proposals that are under progress at present.

These laws may also protect National Parks, considering the heritage they represent.

CONCLUSION

The heritage present in the French karst (geomorphology, mineralogy, archaeology, palaeontology, biology...) is outstandingly rich and varied. Numerous sites are still to discover and a lot of researches will be necessary in order to study and protect them. Pierre Chauve carried out the first inventory of this heritage, which will be published this current year, as part of his book "Des Grottes et des Sources" (Caves and Springs), "Pour la Science" edition. It will be the starting point of a national inventory of the heritage present in the karst. The knowledge and protection of this heritage are improving. About two

hundred and fifty caves are already protected by diverse regulations and so are some gorges (Gorges of the Tarn, Gorges of the Verdon etc...) and limestone plateaux. The national inventory of the geological heritage started in 2000 in an experimental region, Brittany, and it will be extended to the entire territory as early as this current year. It is possible to think that, in the few next years, a deeper knowledge of this heritage will be available and that nation-wide programs of study, protection and valorisation will be implemented.

