PALAEOGEOGRAPHIC EVOLUTION OF FRANCE IN THE MIDDLE JURASSIC

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(see text-fig. p. 68)

The Middle Jurassic corresponds to a period of formation of wide calcareous shelves replacing the Toarcian marly sedimentation in many areas. The carbonate maximal extension occurred in the Bathonian and in the Lower Callovien. Simultaneously, high, or even very high-energy facies, comparatively uncommon in the Lower Jurassic, widely developed then. A general resumption of the terrigenous sedimentation, already announcing the large Oxfordian filling up sequences, occurred in the Upper Callovian.

1. SEDIMENTARY EVOLUTION

1.1. The basins

Three basins were permanent in the Middle Jurassic : the Souabe Basin, the Dauphiné-Helvetic Basin (both cratonic) and the Piedmont Basin (oceanic).

The Souabe Basin to the NE, first limited to the Rhenish trough in the Aalenian, extended as far as Lorraine in the Lower Bajocian ("Hyperlioceras discites Marls") and became connected with the "Acuminata muddy environment" in the Upper Bajocian. After a slight regression in the Bathonian ("Rhynchonella Marls"), the calcareo-argillaceous facies spread again in the Callovian (base of "Woëvre Clays").

The basin SE limit oscillated between the northern Jura and the area north of Colmar.

The Vosges-Black Forest area was underwater in the Middle Jurassic.

The Dauphiné-Helvetic Basin, to the SE, was subsident and filled up with rhythmical, thick, monotonous successions that become more calcareous in the Middle Aalenian and in the Lower Bajocian. From the Upper Bajocian, sedimentation became more argillaceous and the "Terres Noires" started in the Upper Bathonian.

The basin was limited by the north Jura swell in the Aalenian. Then, communications seemed to appear towards the Souabe Basin. To the S, the perenniality of the Verdon swell and, pro-

bably, of the southern swell should be mentionned. To the W and to the E, the basin extension did not change much and its limits corresponded either to flexures or to active faults.

Swells existed within the basin and correspond to zones of hiatuses or of condensed calcareous sedimentation. They appeared at the end of the Middle Bajocian.

The Piedmont Basin : in the basin outer part, series of small basins, in which calcareo-argillaceous sediments deposited, occurred in the Aalenian-Lower Bajocian. Sedimentation became more calcareous with the presence of breccias in the Bajocian. In the basin inner part, sedimentation remained extremely reduced to the Bajocian.

The deposition of a rhythmical, pelitic succession which, metamorphised, will form the so-called "Schistes lustrés" of the outer Piedmont, most probably started in the Bathonian and, in any case, in the Upper Dogger. The ophiolites, which marked the beginning of the ocean expansion, occurred in the inner Piedmont and in the Ligurian Piedmont.

The events affecting the Alpine Basins also influenced, although they were attenuated, the sedimentation of the large calcareous shelves extending over the remaining parts of the French territory.

1.2. The calcareous shelves

- To the north, a huge calcareous shelf, on which sedimentation was reduced in the Aalenian and in the Lower Bajocian and, on which erosional phases were numerus up to the Middle Bajocian, extended between the Armorican Land, the Ardennes Land and the Souabe Basin. In the Middle Bajocian, it broke up into the Armorican shelf and the Eastern shelf separated by the Seine-Loire trough. In the Upper Bajocian, this trough extended to the S and to the E and developed into the "Acuminata muddy environment" surrounded to the E, to the N and to the W by environments of high hydrodynamism.

In the Bathonian, the two shelves, particularly the eastern one, widened while the trough was narrowing. Sub-marine "dunes" were formed on the shelf borders thus isolating protected zones where the Comblanchien limestones were deposited.

The resumption of subsidence first let do the disappearance of the Armorican shelf (Lower Callovian), then to the disappearance of the eastern shelf (Upper Callovian).

- The southern half of France, located between the "Atlantic Province" and the western border of the Dauphiné Basin, corresponded to wide calcareous shelves constituting the central shelf.

Facies of open environment type and of low energy ("micro-filament limestones") were deposited in its western part. Gulfs in which sedimentation was more argillaceous (Charentes, Parentis, Pays Basque) became individualized on the Atlantic border.

Further E, high energy environments occurred in the Lower Bathonian, isolating protected or even confined environments (stipites beds, Chara beds) known from the Creuse Valley to the N, as far as the Ariege Pyrenees to the S and the Causses to the E.

The general conditions did not appear to change much in the Callovian.

2. MOBILE AREAS

They were numerous in the Middle Jurassic and corresponded to faults, to flexures or to swell borders.

2.1. The Seine-Sennely Flexure limited the Armorican shelf to the E in the Bajocian-Bathonian and marked the most western extension of the eastern shelf in the Callovian. It consisted of a hinge-zone separating two compartments of the basement moving sometimes in one direction, sometimes in the other.

2.2. The north Jura Flexure, between the Salins folded belt and Le Lomont similarly separated the Souabe Basin from the Dauphiné Basin in the Aalenian and in the Bajocian.

2.3. The inner Jura Flexure marked the separation, in the Middle Jurassic, between the facies of a shelf type located to the W and deposits of a basin type located to the E. At certain periods (Upper Bathonian-Callovian), it corresponded to a swell on which sedimentation was reduced and showed many hiatuses.

2.4. The Ardèche and Cévennes border probably corresponded to a group of tilting blocks, and limited by faults trending NNE-SSW. The border formed a swall and was possibly partly emerged in the Aalenian and in the Bajocian ; however, communications between the Dauphiné Basin and the Causses persisted to the Middle Bajocian. Movements of wider magnitude isolated the Causses in the Middle or Upper Bajocian and in the Lower Bathonian. In the Upper Bathonian, they originated, as everywhere else, a resumption of sedimentation that, in Ardèche, corresponded to the deposition of a calcareo-argillaceous succession overlying the outer-shelf deposits. Then, a break in sedimentation started in the Middle Callovian (Coronatum Zone) ; it occurred earlier and lasted longer in the Ardèche and Cévennes border than anywhere else.

2.5. The Dauphiné Ridge and its dependencies (the Turriers swell) : it played an important part in the Middle Jurassic. From the Aalenian, the ridge started to take shape to the N (Aiguilles rouges) and to the S (Digne area). The more intense movements of the Middle Bajocian induced a north ward extension of the ridge that reached the Grenoble area. From the Bathonian, the ridge subsisted but was covered with condensed shelf deposits showing breccias and hiatuses of variable extension.

Further east, the Turriers swell played a similar, although minor, part. It seemed particularly well marked in the Upper Dogger.

2.6. The Briançonnais area : limited to the W and to the E by faults and flexures, it constitued a wide, positive area in the Middle Jurassic. Thus, in the Aalenian-Bajocian, it consisted of a festoon of isles temporarily emerged as shown by the absence of sedimentation and by phenomena of karstification. In the Lower Bathonian, the Briançonnais was, at least locally, covered by sediments deposited in a confined environnment ; then shelf sediments appeared in the Upper Bathonian with breccias marking the beginning of a progressive flooding connected with the general resumption of sedimentation that amplified in the Callovian.

3. CONCLUSION

After a break in sedimentation on the huge shelf that almost completely covered France in the Aalenian, sedimentation was progressively resumed in the Bajocian until it got generalized in the Upper Bajocian.

A tectonic phase at the end of the Middle Bajocian completely modified this palaeogeography by parcelling out theshelf with the appearance of the "Acuminata muddy environment". The Causses isolation and the appearance of the Dauphiné Ridge also occurred during this tectonic phase.

Another major event occurred at the beginning of the Upper Bathonian. It induced the resumption of sedimentation in the basins as well as a trangression on their borders. This event was probably related to the functioning of the oceanic rift, in the Liguria-Piedmont area, with which it may also have been synchronous.

Ultimate movements at the end of the Middle Callovian deeply modified the palaeogeography and already outlined the main features that guided sedimentation in the Upper Jurassic.

UPPER JURASSIC

The last third part of the Jurassic system will lead to the Purbeckian or latest Jurassic regression which was to affect the whole country except the Alpine Province. Symmetric to the Liassic marine transgression and marine extension, this evolution also occurred by steps. Long before the Purbeckian emersion, many continental influences were recorded, especially at the end of the Oxfordian and in the Upper Kimmeridgian.

Simultaneously, the different stages of the Upper Jurassic occupied smaller and smaller areas except in the Alpine Province. It is likely a progressive reduction of the sedimentary areas was correlative to the continuous emergent tendency and to the extension of emerged areas. It was amplified by erosions that started as early as in the Jurassic and that persisted in the Cretaceous, the first layers of which frequently fossilize a surface truncating the Jurassic beds. This evolution was governed by the deformations occurring at the end of the Jurassic marked by changes in the palaeogeography between the Jurassic and the Cretaceous.

As a result of this general regressive tendency in the Upper Jurassic, not only the transgressive structures that help to follow the successive steps of the Liassic expansion disappeared but also the marginal deposits of the original basin and consequently the actual extension of the basin and of the seas in the Upper Jurassic can be traced only as hypothesis.

Faunas, either because they belonged exclusively to one of the two faunal provinces which then divided France, or because of their strict relationship with a clearly defined environment (as, for instances, the Gravesia fauna), then become the best witnesses of a once wider extension of sedimentary areas owing to the ways of communication they help to trace across the now bare areas.

L O W E R A N D M I D D L E O X F O R D I A N (pars)

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1. BOUNDARIES

This interval includes the Mariae Zone and the Cordatum Zone of the Lower Oxfordian and the base of the Middle Oxfordian (Plicatilis Zone, Vertebrale Subzone). Locally, it may also include the top of the Callovian last zone (Lamberti Zone) and/or the base of the Antecedens Subzone of the Plicatilis Zone.

1.1. Lower boundary

It often corresponds to a surface of discontinuity at the top of the frequently incomplete Callovian, followed by a resumption of sedimentation during the interval and, in the more complete successions, by an often fossiliferous horizon of limestone or nodules containing ferruginous oolites in places.

1.2. Upper boundary

It corresponds to a lithologic change occurring in the Antecedens Subzone of the Plicatilis Zone with the fast extension of calcareous facies in the areas of hiatuses (=resumption of sedimentation or Argovian "trangression") as well as in the basins.

2. SEDIMENTARY AREAS

In areas of active sedimentation, marly or nodular calcareous facies with many different local names although they represent very close aspects were predominant. In basin areas, such a succession is integrated into the great sequence that starts as early as the Upper Bajocian. It consists of minor sequences which are better individualized on the basin borders.

2.1. The Paris Basin and its borders

2.1.1. Non outcropping parts of the basin

Lithologic data obtained by boring are not very explicit and the interval is described as a whole consisting of marl, but differences in thicknesses allow distinguishing two areas in which sedimentation was more active : one, located between the Ardennes and a stable area bordering the Burgundian uplift area, was widely opened to the ESE towards the Jura, the other was located on the lower reaches of the Seine, then bents towards the "loop" of the Loire between the above-mentionned stable area and the Armorican border.

2.1.2. The Armorican border

The marly sediments of the Mariae Zone are interrupted by the "ferruginous oolite" of the Cordatum Zone and by clastic deposits (Cordatum Zone and Vertebrale Subzone) near the Perche promontory. A sedimentation of marls set in again on the coast but it rapidly changes into the lumachellic, quartzo-ferruginous limestones of the Plicatilis Zone (Vertebrale Subzone). The comparatively low thicknesses increased more rapidly beyond the La Risle flexure near the subsident area of the Lower Seine.

2.1.3. The southern border (Berry)

Marls containing pyritized fossils extend quite widely towards the south and reappear, beyond an area of partial hiatus (glauconitic or variegated marls), at the mouth of the Loire trough, where they become thicker towards the south.

2.1.4. The eastern border (Lorraine)

The clays of the Woëvre, still locally Oxfordian, are overlain by cherty layers containing a rich benthic fauna and interrupted in the south by a minor discontinuity in the Cordatum Zone. To the north, these layers change into the "ferruginous oolite" first of lenticular extension and then invading the whole Vertebrale Zone near the Ardennes. South of Commercy, often silicified lumachellic limestone pre-date corallian colonies.

2.2. The Alpine Province and its dependencies

2.2.1. The Jura shelf

From the beginning of the Oxfordian, a subsident trough, oblique to the Tertiary directions, developped on the Bresse and the Jura and largely communicated with the Paris Basin and the Dauphiné Basin. Variations in thicknesses show the existence of three zones of maximum deposition : one depended towards the future Rhenan trough, the Doubs trough, the Bresse trough. The facies of marls with pyritized fossils occupies the whole succession in the Bressan axis. Elsewhere, this facies was overlain by nodular limestones locally containing and/or silicified fossils. A minor discontinuity with a slight cartographic unconformity truncates the top part of the succession on the Morez axis and on the basin SE border.

2.2.2. The Dauphiné-Helvetic Basin and its borders

The Lower and Middle Oxfordian there corresponds to the top of the "Terres Noires" facies. The isopachs shown on the map for the upper member, also including the Callovian, have been drawn by Artru (1972). Measurements of the interval studied here in several cross-sections show that it represents between 1/3 and 1/2 of the total thickness, thus, although the numbers are almost without value, the isopachs lines represent the distribution of thicknesses fairly well.

The calcareous nodules are very seldom missing ; they are particularly abundant along the southern border of the Pelvoux Massif. Stromatolithic bioherms develop locally (Buis-les-Baronnies) to the East, clastic intercalations are present under the form of turbidites (Embrun 1/2 window and Barcelonnette window) or of tectogenous breccias (Subbriançonnais units) linked to an active faulting period on the border of the Briançon swell.

2.2.3. The Piedmont Basin and eastern Corsica

Thin, black schists (1-10 m) occurring between the clastic sediments of the Dogger and the radiolarites of the Middle and Upper Oxfordian, there, represent the Lower Oxfordian.

2.3. The Atlantic Province

Under the reserve made further on, the Atlantic Province is limited to the Charentes Gulf where outcrops are scarce (Niort, Saint-Maixent) and where very few bore-holes have been drilled (Rochefort).

2.4. The Provence-Pyrenees Province

There, problems and difficulties are to be met concerning age determinations, due to the presence of thick dolomitic successions. Beside the areas where the presence of hiatuses is proved, azoïc dolomites and limestones (western Provence) and biomicrites (white massive limestones), deposited in a confined environment affected by an early dolomitisation (central and eastern Pyrenees), are attributed to the Lower Oxfordian. The existence of an at least partial hiatus is likely and, therefore, is shown on the map.

3. AREAS OF REDUCED SEDIMENTATION OR OF NON-SEDIMENTATION

They occupied large areas and the Lower Oxfordian is totally or partly absent from the borders of the basins and the swells.

3.1. Southern and western borders of the Dauphiné-Helvetic Basin

A continuous zone of almost complete hiatus borders this basin to the west, from the southern part of the Black Forest to the Gulf of Lions through the inner edge of the Jura, the Ile Crémieu and its southern glacis, the Ardèche border and the Cévennes border. After the hiatus most probably corresponding to a swell zone, although this is not demonstrated, this area of marginal gap reappears on the borders of the Provence shelf (and its prolongation on the middle Verdon swell). These hiatuses delineate a swell-belt and also an area with slopes on which sediments remained in place only locally.

3.2. Mont Blanc and the Briançon swell

The Lower Oxfordian is absent from the NE extremity of the Mont Blanc Massif which constituted a swell zone within the Dauphiné-Helvetic Basin. It is also non-existent on the Briançonnais swell located on the eastern limit of the Dauphiné-Helvetic Basin.

3.3. The Burgundian promontary

The Lower Oxfordian is absent on the NE extremity of the Burgundian promontary, on the Parisian side as well as on the Rhodanian side 'except locally). The "ferruginous oolite" is dated from the Plicatilis Zone and the Vertebrale Subzone in which reworked older faunas are to be found. The hiatus, which was complete in the central part of the promontory, progressively became partial on the "expansion" across the Loire trough.

3.4. The western swell

An area of partial or total hiatuses extended from Touraine to the Pays Basque through the Aquitaine. In Touraine, the reduced succession to be met with in bore-holes, between the Callovian and the Spongiae Marls, has not been dated. It was connected to an area of partial hiatuses (absence of the Lower Oxfordian) on the Poitou threshold and on the border of the Charentes Gulf. In the Pays Basque, a slight discontinuity within the "Calcaires à filaments" (Aussurucq limestone) separates the Callovian layers from the upper part satisfactorily dated of the Uppermost Middle Oxfordian (R. Enay, under press). In Aquitaine as well as in the central and eastern Pyrenees, there is no proof of the existence of a hiatus, but successions which are believed to represent the Lower Oxfordian are of uncertain age. In eastern Aquitaine, a part of the successions attributed to the Lower Oxfordian is believed in fact to be of Callovian age according to recent data, still unpublished.

4. EPEIROGENESIS - SYNSEDIMENTARY TECTONICS

After the discontinuity occurring at the end of the Callovian and representing a tendency to the closure of the basins, the Oxfordian marks the beginning of a new period in the opening of the basins that will develop in the Upper Jurassic. This is due to cratonic movements (faulting and flexuring) the manifestation of which is particularly evident in the Alpine Province : the Briançonnais border, the Cévennes fault zone, the Durance fault. The Jura trough and its trenches and the Burgundian promontory probably indicate a structuration along palaeo-faults and palaeo-flexures trending N 60° and N 120°. In the Paris Basin, the synsedimentary tectonic is not so clear ; it is marked by faults ans fault zones of the Lower Seine at Sennely and between Bray and Juvanzé.

5. PROBLEMS TO BE SOLVED

The presence or not of a stratigraphic break corresponding to the Lower Oxfordian in Aquitaine, in the central and eastern Pyrenees and in part of the Provence shelf, has still to be proved by dating successions attributed to the Oxfordian.

MIDDLE OXFORDIAN (p. p. maxima)

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1. BOUNDARIES

This map covers the major part of the Middle Oxfordian. Only the Vertebrale Subzone (and sometimes the base of the Antecedens Subzone) were treated with the former map.

1.1. Lower boundary

It corresponds to the resumption of sedimentation and to the development of calcareous facies in the Antecedens Subzone or in the Transversarium Zone.

1.2. Upper boundary

It corresponds to the end of the sequence that started at the base of the stage and to the beginning of a new sequence characterized by deposition of thin clastic material (marls), of coarse clastic material (sandstones) and often attributed to the Sequanian.

2. SEDIMENTARY AREAS

Calcareous shelves and coral-reefs, that nearly completely disappeared in the Lower Oxfordian, were again widespread in the Middle Oxfordian. In areas of open shelves and of basins, the sedimentation also became more calcareous, of alternating type (= hydraulic limestones) often with algal bioherms containing Sponges and here reaching their maximum development (= Spongitian).

2.1. The Paris Basin and its borders

2.1.1. The calcareous shelf

In the non-outcropping parts of the basin only the most common type of facies is repre-

sented between the Callovo-Oxfordian marls and the Sequanian basal marker bed (Upper Oxfordian). The similarity with marginal outcrops is very satisfactory. A wide calcareous shelf in which patch coral reef lay by the side of biodetritic sediments, corresponding to filling or burying facies, extended from the Armorican Massif to Boulonnais and Lorraine. Marls persisted in the Lower Seine area (Le Havre) and the Manche area.

2.1.2. The "open" southern province

The hydraulic limestones consisting of alternating layers of argillaceous limestones and marls, containing sponges, fragments of sponges and bioherms, exist between the Poitou threshold and the Marne valley. This facies extends up to the ancient massif, on the limit of actual outcrops, i.e. between Châteauroux and the Loire valley, separating the nothern edge of the central calcareous shelf (cf. 2.2.) from the Châtel-Censoir "coral-reef" on the SW border of the Burgundian promontory.

2.2. The central shelf and its Aquitaine extension

At the periphery of the Limousin, between Châteauroux and Périgueux, remnants of a calcareous marginal shelf, that probably extended towards the SE on the western part of the Massif Central, are preserved. They are prolonged by dolomitised oolitic limestones, gravelly bioclastic limestones and dolomite with evaporites. These rocks are respectively interpreted as representative of a barrier and of an internal shelf in eastern Aquitaine ("Aquitaine" Atlas).

The black mostly primary dolomites of the central and eastern Pyrenees and of the Tremp Basin also belong to this internal shelf.

2.3. The Atlantic Province

2.3.1. The Charentes Gulf

This gulf extended towards the south and consists of marls, argillaceous limestones with sponges and bioherms. Argillaceous limestones mark the passage to the "Calcaires à Protoglobigérines" of Aquitaine.

2.3.2. Western Aquitaine and Pays Basque.

In the Arbailles area, the top of the filament-limestones contain some sponges and ammonites of Middle Oxfordian age (R. Enay, under press). They change laterally to the "Calcaires à Protoglobigérines" of Lacq ahead of the "barrier".

2.4. The Alpine Province and its dependencies

2.4.1. The Jura shelf

It remained unchanged, with a zone of active sedimentation (Marls or "hydraulic" limestones) trending SW-NE, widely open towards the present limit of outcrops on the eastern border of the Massif Central. To the SE, towards the High-Chain threshold, algal bioherms with sponges first develo-

ped at the base and then in the whole interval.

To the NE, in the Alsace and Franche-Comté-Jura, and in the Upper Saône area, a cherty calcareous shelf overlain by coral-reefs developed. It might be (but not necessarily) connected to the calcareous part of the Ardennes border and of the Lorraine border.

2.4.2. The Dauphiné-Helvetic Basin and its borders

In the basin itself, an alternation of marls and of argillaceous limestones, in which the limestone is predominant, surrounds the "Terres Noires" slope (Argovian rise).

The inner edge of the Jura (High-Chain threshold), the Ardèche-Cévennes border, the northern border of the Provence shelf with the Middle Verdon swell that corresponded to a hiatus zone in the Lower Oxfordian, keep the same uniformity : resumption of sedimentation and condensed succession in the Middle Oxfordian ; clotted, nodular, fine-grained limestones getting more argillaceous locally, with the marly ammonitico-rosso facies, corresponding to sedimentary slopes.

2.4.3. The Briançon swell (and its dependencies)

After the Lower Oxfordian hiatus, sedimentation is to be found again with pelagic limestones, frequently showing the ammonitico-rosso facies (type : Guillestre marble).

2.4.4. The Piedmont area and eastern Corsica

Radiolarites, overlying the Oxfordian Schists in outer Piedmont or directly overlying the ophiolites in inner Piedmont and Ligurian Piedmont, are attributed to the Middle (and Upper) Oxfordian.

3. AREAS OF REDUCED SEDIMENTATION AND OF NON-SEDIMENTATION

The resumption of sedimentation in the Middle Oxfordian and the extension of the calcareous sedimentation leads to the almost complete disappearance of the hiatus areas that occurred in the Lower Oxfordian.

Only the condensed, thin but complete successions, located on the border of the Dauphiné Basin, can be mentioned here. The ferruginous oolites facies persists in the Middle Oxfordian over the northern (Avallon) and the southern (Beaune) parts of the old Burgundian promontory. It even persists in the Upper Oxfordian round Nevers.

4. EPEIROGENESIS - SYNSEDIMENTARY TECTONICS

In the Dauphiné-Helvetic Basin, synsedimentary faults ensured the continuation of slopes to which the "marly ammonitico-rosso facies" were linked.

In the western Jura and on the Burgundian border, the two extensions of the calcareous shelf and the corallian "islet" of Beaune "coincided" with the northern border of the so-called variscian faults of Le Creusot-La Serre and of the Salinois fault zone.

Finally, the expansion of the calcareous shelf of the Paris Basin was particularly marked on both sides of the Lower Seine-Sennely fault zone and of the Bray-Juvanzé fault zone, while the median zone corresponded to the maximal advance of the "open" type facies towards the NW. The sudden termination of the Châtel-Censoir reef to the W was due to the Sancerrois faults and the Loire trough.

5. PROBLEMS TO BE SOLVED

The main difficulties and uncertainties consist in the absence or in the uncertain reliability of age determinations in the Aquitaine and Pyreneo-Provençal successions. Thus, further research is necessary so that the same level of knowledge as in other parts of France can be reached.

U P P E R O X F O R D I A N (pars)

Coordinated by : Raymond ENAY.

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1. BOUNDARIES

This map is restricted to the Bifurcatus and Bimammatum Zones, to the exclusion of the Planula Zone (or equivalents of these zones). Except in Normandy and in Boulonnais where successions are closer to the English ones (Dorset), the Planula Zone is represented by thick successions of limestones that persist in the Kimmeridgian.

1.1. Lower boundary

It is marked by the recurrence of clastic material : marls and more or less coarse-grained, locally argillaceous sandstone of the second Oxfordian sequence, often called "Sequanian".

1.2. Upper boundary

It is generally placed under the calcareous successions of the Planula Zone, except in Normandy where this zone corresponds to the recurrence of sandy and ferruginous limestones.

2. SEDIMENTARY AREAS

2.1. The Paris Basin and its borders

In the non-outcropping parts of the basin are traced the facies believed to be the most representative of the Sequanian sequence to be met with between the basal marker beds of the "Marnes à E. virgula" in the Upper Kimmeridgian and the basal marker beds of the Sequanian, dated from the Cautisnigrae Zone in Normandy and from the Bifurcatus Zone in Lorraine (R. Enay and A. Boullier, under press).

2.1.1. The Armorican border and the Ardennes border.

From Anjou to Ardennes, on the whole NW part of the Paris Basin, the coral-shelf of the

Middle Oxfordian was burried under a cover of clastic material. On the Normandy coast, the Hennequeville sandy limestone, deposited in a marine littoral environment, is overlain by ammonite marls. To the S, this succession change laterally into estuarian sands containing plants and lumachelles. Called "Sables de Glos" and "Sables de Cherré" they are separated, on the Perche promontory, by the "Calcaires à Astartes" that bear the imprints of continental influences (lignite, plants). The succession is similar on the Ardennes border but show a more pronounced marine character, although fragments of plants are present in the Brunembert sandstone (Boulonnais).

2.1.2. The residual calcareous shelves

Calcareous shelves probably subsisted south of the clastic deposits as two bodies trending W-E and separated by a tongue of dominantly marly and calcareous facies. This agrees with the Lorraine "Sequanian" succession : discontinuity at the top of the coralline formations and of the associated facies of the Côtes de Meuse, dated Middle/Upper Oxfordian boundary by a fauna of brachiopods and a few ammonites ; "les Argiles noires à huîtres" with lenses of sandy limestones overlain by a succession containing many lumachellic or biodetritic lenses ("Argiles et calcaires argileux lumachelliques") and even coralline intercalations ("Calcaires coralliens inférieurs").

2.1.3. The southern border

Between these residual shelves and the central shelf, the marly-calcareous facies occupied a narrow, continuous stripe between Poitou and Haute-Marne. The "Marnes à spongiaires" of the Middle Oxfordian were overlain, in the Upper Oxfordian, by alternations of clay and limestone, starting in the Bimammatum Zone and forming small sequences ("Calcaires lités") evolving towards an enrichment in lime that reached its highest point in the Planula Zone. Sponges biostroms and bioherms exist at several horizons in the succession.

To the SW, the facies becomes more calcareous and this is indicative of the proximity of the north-limousin central shelf. East of Châteauroux, the marly-calcareous facies probably extended to the south, far beyond the existing outcrops ; it entered the Loire trough and, finally, completely covered the Châtel-Censoir "reef" in the Bimammatum Zone.

2.2. The central shelf and its Aquitaine extension

As in the Middle Oxfordian, remaining parts of a shelf-border, extending slightly to the W in the Upper Oxfordian, to the detriment of the marly-calcareous facies are preserved on the Limousin periphery, between Châteauroux and Angoulême. It also probably extended to the SE on the western part of the Massif Central.

In eastern Aquitaine (Quercy, Périgord), the Middle Oxfordian pattern is reproduced, owing to the absence of good age determinations. South of the Montauban dome, clastic deposits of an Upper Oxfordian age exist in the black argillaceous layers occurring within dolomicrosparites belonging to the so-called "Membre moyen à passées d'argiles" (Bouroullec and Deloffre, 1969) and already previously correlated with the "Marnes d'Hosta".

In the central Pyrenees, oolitic and gravelly limestones, with large trocholines interlayered in the lower dolomite, mostly secondary, prolong the Aquitaine "barrier", thus isolating the black, primary dolomite of the Tremp Basin, the eastern Pyrenees and Corbières.

The dolomitic successions of the Grands Causses undoubtedly partly belong to the Upper

Oxfordian. To the SE (Navacelles), the successions are more accurately dated : glauconitic marly limestones of the Bifurcatus Zone ; fine-grained limestones with horizons of dolomite or dolomitic breccias in the Bimammatum Zone. These successions of near-shore facies mark the transition of the Dauphiné Basin.

2.3. The Atlantic Province

2.3.1. Poitou-Charentes

The small shelf zone of Aiguillon-sur-Mer remains isolated. The "Marnes à spongiaires" containing sponges bioherms and biodetric intercalations on the border of the central shelf, are the predominant facies. They are connected to similar successions occurring in the south part of the Paris Basin. Argillaceous limestones appear in the Bimammatum Zone.

2.3.2. Aquitaine

Their southern equivalents are the "Marnes à Ammonites", so-called by oil geologists and showing an increasing clastic content towards the south. In the Pays Basque, the outcrops consist of the "Marnes d'Hosta" that start with a condensed horizon composed of several layers of nodular limestone ("Dalles à Perisphinctes" of Lamare). Its fauna is characteristic of the Bifurcatus Zone (R. Enay, under press). They progressively change into a succession of alternating clay and limestone.

2.4. The eastern shelf (Burgundy - Haute-Saône - Jura)

The tendency that started in the Middle Oxfordian was accentuated. In the Upper Oxfordian, the calcareous shelf extended, at one and the same time, towards the W, over Franche-Comté and over eastern Burgundy, to the detriment of the marly-calcareous facies.

In front of the calcareous shelf, on the Mâconnais and on the Bressan border of the Jura, biodetritic limestones with "thorny balls" ("boules épineuses") of stromatolithic origin overlay the marls and argillaceous limestones. In three successive periods, they extended towards the SE within the layered limestones. The map shows their maximal extension at the top of the Bimammatum Zone.

Between Pont d'Ain and Bienne in the Swiss Jura, marls and layered limestones extend on the southern and inner Jura, forming marly-calcareous sequence with sponges biostromes and bioherms near Ile Crémieu. Thicknesses increase towards the SE and the Dauphiné-Helvetic Basin, steeply near and on the inner edge of the Jura where they exceed 250 metres.

2.5. The Alpine Province and its extensions

2.5.1. The Dauphiné-Helvetic Basin

The Upper Oxfordian succession starts with marls containing layers of argillaceous limestones becoming more and more numerous and indicating a progressive return to the calcareous sedimentation of the Planula Zone ("Rauracian" cliff.). This facies extend up to the existing limit of outcrops on the eastern border of the Massif Central. Marginal facies (Navacelles) exist in the Grand Causses (2.2.) where they constitute a transitional zone.

2.5.2. The Provence border and shelf

On the middle Verdon swell, the "clotted" facies goes up to the base of the Bimammatum Zone and, then is overlain by fine-grained limestones with some recurrences of "clotted" beds. To the south, between Marseille and the Mercantour, the same thin, fine-grained limestones, in places dolomitized, surround the grey, fetid, very thick and insufficiently dated neo-Jurassic dolomite.

2.5.3. The Alpine inner zones (Briançonnais, Piedmont, eastern Corsica)

In the Briançonnais and Subbriançonnais units, the calcareous pelagic sedimentation continued in the Upper Oxfordian. The index-form of the Bifurcatus Zone was found in the Guillestre Marble. The Piedmont radiolarites are also believed to have continued in the Upper Oxfordian.

3. AREAS OF REDUCED SEDIMENTATION AND OF NON-SEDIMENTATION

They were then totally absent. Everywhere sedimentation was active and fed with an important afflux of external sediments. Terrigenous material and turbid waters inhibited the precipitation of carbonates.

4. EPEIROGENESIS - SYNSEDIMENTARY TECTONICS

The recurrence of clastic sediments at the base of the Upper Oxfordian is probably the result of epeirogenic movements. In SW Aquitaine, Bouroullec and Deloffre (1969) believed that such movements originated a local destruction of the forest soil thus creating temporary rhexistasic conditions. This explanation can also apply to the other basins above-mentioned. A climatic cause, not necessarily excluding the preceding, may also be considered to explain the wide extension of this event, at least in western Europe (R. Enay, 1966).

The synsedimentary character of palaeo-faults and of palaeo-flexures is no longer evident, probably owing to the important afflux of sediments. In spite of these always high rates of sedimentation, indications of a tendency to emergent conditions are limited (Armorican border, Aquitaine) ; this implies a correlative deepening of the basins and the maintenance of the tendency to opening conditions as indicated by the Briançon pelagic facies and the Piedmont radiolarites in the inner Alpine zones.

5. PROBLEMS TO BE SOLVED

Apart from non-outcropping areas where successions are only approximately standardized, except for some major markers, the main remaining problems concern the establishment of strict age determinations and correlations of the Aquitaine successions, the Pyrenees successions and the Provence successions.

L O W E R K I M M E R I D G I A N

(and Uppermost Oxfordian)

Coordinated by : Raymond ENAY.

With the collaboration of : S. DEBRAND-PASSARD and M. RIOULT.

1. BOUNDARIES

Only in Normandy and in the SE part of France is the Oxfordian-Kimmeridgian boundary well defined by Ammonites. The map corresponds to the end of the "Sequanian" sequence and covers the Pseudocordata/Planula Zones of the Uppermost Oxfordian, the Baylei and the Cymodoce Zones of the NW European province, the Plantynota, the Hypselocyclum and the Divisum Zones of the sub-Mediterranean region.

1.1. Lower boundary

It corresponds to a lithologic change in areas where good palaeontologic markers exist : sandy and ferruginous limestones in Normandy ; limestones (the "Rauracian" cliff) in the Alpine province and its borders. Elsewhere, the boundary is placed at the base of or within the so-called "Sequanian" successions.

1.2. Upper boundary

It is clear-cut in all places where the "Marnes à E. virgula" overlie the pebbly and glauconious surface of discontinuity that terminates the "Sequanian" succession and the "Pterocerian" limestones. In the SE of France, the boundary fall within the alternation of marls and limestones ; the clearer change corresponds to the development of the "Tithonian" cliff in the Upper Kimmeridgian.

2. SEDIMENTARY AREAS

2.1. The Paris Basin and its borders

2.1.1. Covered parts of the basin

Only very approximate knowledge of the successions overlain by the marker beds of the

"Marnes à E. virgula" is derived when boring. Over the clastic and the biodetritic deposits, the argillaceous limestones (still containing sandy and biodetritic parts) seem to predominate in the upper part of the succession. They correspond to several facies grouped under the name of "Calcaires à Astartes" in the area of marginal outcrops.

2.1.2. Armorican border

The "Calcaires à Astartes" are well developped in Maine and Perche. On the Norman coast, they change to marls, organized in small sequences and overlain by a bed of limestone terminated by a glauconitic hard-ground with phosphatic grains and limonitic crusts.

2.1.3. Lorraine

Similar small sequences with hard-grounds exist in the limestones (upper part) and in the underlying upper Astartes limestones. They overlay calcareous layers containing scattered oolites and called "Colithe de La Mothe" is of an uncertain age within the Oxfordian.

2.1.4. Northern border of the Massif Central

Chalky and micro-gravelly facies containing a few ammonites of the Planula Zone, represent an extension of the "Colithe de La Mothe" to the SW, down to the Loire Valley. Beyond, in Berry, they change to fine-grained, sub-lithographic limestones with lumachellic layers and a fairly rich fauna of the Planula Zone. They are overlain by the lithographic to sub-lithographic "Calcaires à Astartes", chalky or oolitic in places, containing glauconiticlayers in their upper part and showing the first Kimmeridgian faunas.

2.2. The central shelf and its Aquitaine-Pyrenees extension

Nearly completely absent (or eroded ?) on the Poitou threshold where it was previously located, it develops from Angoulême towards the south, through Aquitaine, similarly to the pattern that has already been traced in the Middle and in the Upper Oxfordian : oolitic "barrier" with dolomitised gravels ; dolomites containing evaporites and breccias, south of the Montauban Dome, in an internal position ; "Calcaires à Astartes" and breccias of Quercy-Périgord.

In the central and eastern Pyrenees and in the Tremp Basin, except in areas of complete dolomitisation and erosion, are found black limestones with Chara and breccias laterally changing into the gravelly Dasycladacaea limestones of the Basal Kimmeridgian and, probably, of the Uppermost Oxfordian.

In the Grands Causses, beyond the wide, stripped zone of the Toulouse "Craton" (s.l.), successions of fine-grained limestones, containing gravelly and biodetritic layers of an uncertain age, partly belong to the interval under consideration.

2.3. The Atlantic Province

2.3.1. The Vendean border

The monotonous argillaceous limestones of the Uppermost Oxfordian were overlain, in

the Lower Kimmeridgian, by slightly more heterogenous facies in which Corals bioherms (Pointe du Chay) developed in an environment of fine-grained or argillaceous limestones. They were surrounded by a more or less important rim of biodetritic deposits. They mark out an axis of Armorican direction between Ile de Ré-La Rochelle and Angoulême where the calcareous shelf begins (2.2.).

2.3.2. The Aquitaine Gulf

Marls and black marly ammonite limestones appear, between the Garonne and the Adour, along a NW-SE axis. To the north, argillaceous micrites, with ammonites and Lituolidae, mark the passage to the Charentes-type successions. To the south, these micrites no longer contain ammonites ; only the benthonic foraminiferas persist.

2.4. Eastern shelf (Burgundy - Haute-Saône - Jura)

In spite of a brief recurrence, in the Lower Kimmeridgian, of the ammonite facies limited to a SE fringe, the calcareous shelf then reached the border of the Dauphiné-Helvetic Province.

The true coral-reefs rapidly regressed in the Planula Zone and then, always remained of limited extent (Olten reefs in Switzerland). They were replaced by biodetritic, oolitic or gravelly facies that laterally changed to fine-grained limestones in internal or external position.

The maximum extension was reached at the Oxfordian-Kimmeridgian boundary with the "Calcaire à Momies principal". Interbedded in biodetritic successions along a SW-NE stripe, between Revermont and Olten, it moved forward over the "Calcaires pseudolithographiques" of the southern Jura and of Ile Crémieu, until it stopped within the ammonite facies.

Behind, in Franche-Comté and in eastern Burgundy, marls ("Marnes à Natices", "Marnes séquaniennes") alternate with fine-grained or argillaceous limestones ("Calcaires à Astartes", Calcaires à Ptérocères", "Calcaires de La Vorburg"). In the lower part of the studied interval, these limestones show, limnic intercalations containing plants and charas, and clastic deposits ; Lower Kimmeridgian ammonites of sub-Mediterranean affinities occur at the top.

2.5. The Alpine Province and its extensions

2.5.1. The Dauphiné-Helvetic Basin

The "Rauracian" Calcareous Cliff of the Planula Zone is overlain by an alternation of limestones and of argillaceous limestones forming a slope. The marly facies occurring in the basin centre change into more calcareous successions on the borders. Slump structures appear locally ; their importance will go increasing in the overlying stages.

2.5.2. The Cévennes border

The passage from the Dauphiné facies to the marginal facies is observed only at the mouth of the Causses Gulf and in Languedoc. This passage is progressive and due to the reduction in thickness of the interval, to the thinning of the argillaceous layers and to the development of biodetritic intercalations.

2.5.3. The Provence shelf and its borders

In a similar way, the calcareous successions of north Provence, containing ammonites, more or less rapidly change laterally into the dolomitic facies of western Provence and of the Alpes-Maritimes.

2.5.4. The inner Alpine zones

Everywhere, sedimentation was calcareous, with the persistence of the fine-grained or nodulous pelagic facies of Briançonnais and of the Piedmont Kimmeridgian-Tithonic marble interbedded between the Oxfordian Radiolarites and the Cretaceous Black Schists.

3. EPEIROGENESIS - SYNSEDIMENTARY TECTONICS

The rare terrigenous deposits are the only and discrete witnesses of active epeirogenesis. The other continental manifestations (limnic intercalations, layers containing plants or charas) rather indicate a predominance of sedimentation over subsidence, involving a tendency to emersion that was to be interrupted at the end of the Lower Kimmeridgian.

Slopes subsisted in the Dauphiné Basin, marked by synsedimentary slumps on its borders, or corresponding to sub-marine canyons.

4. PROBLEMS TO BE SOLVED

They still concern the age determination of shelf successions which do not contain enough characteristic forms : this concerns areas such as Aquitaine, the Pyrenees, central Jura. Another problem concerns the Oxfordian-Kimmeridgian boundary in the major part of the Paris Basin.

U P P E R K I M M E R I D G I A N

Coordinated by : Raymond ENAY.

With the collaboration of : S. DEBRAND-PASSARD and M. RIOULT.

1. BOUNDARIES

The Upper Kimmeridgian map corresponds fairly well to the sub-stage. It covers the Mutabilis, the Eudoxus and the Autissiodorensis Zones of the NW European Province and the Acanthicum, the Eudoxus and the Beckeri Zones of the Mesogean areas.

1.1. Lower boundary

Nearly everywhere, it corresponds to a change in sedimentation. In the deposition province of the "Marnes à E. virgula", a marly sedimentation suceeds the Lower Kimmeridgian limestones after a surface of discontinuity characterized by the presence of pebbles and, frequently, of glauconite. In areas dependent on the Alpine Province, this break also exist at the base of the Acanthicum Zone, but is not so clear. The development of calcareous facies ("Tithonian" cliff) in the Eudoxus Zone often constitute a clearer boundary.

1.2. Upper boundary

It is often marked by a fast recurrence of a calcareous sedimentation overlying the "Marnes à E. virgula" (Calcaires du Barrois). In Mesogean areas, this type of sedimentation, that already appeared in the Lower Kimmeridgian, continues in the "Tithonian" cliff without any clear cut off.

2. SEDIMENTARY AREAS

2.1. The Paris Basin

The "Marnes à E. virgula" are found in Lorraine and on the south border of the basin. They consist of an alternation of marly layers with shelf beds containing Exogyra virgula and of white, argillaceous, fine-grained limestones, often terminated by a perforated surface ("Calcaires blancs inférieurs"). This formed a succession of argillaceous-calcareous sequences.

In Normandy, the succession is more argillaceous and contains a wider variety of faunas, especially ammonites that show close affinities with the English faunas. The bituminous shale facies of the Kimmeridge Clays, on the Dorset coast, is known in the Channel area north of latitude 50° and northwards. In Boulonnais, marly limestones are overlain by clays containing several sandy intercalations.

2.2. The Atlantic Province

From Charentes down to southern Aquitaine, about the same facies and faunas are to be met as in the south part of the Paris Basin. Wide communications existed through Poitou before the ante-Cretaceous denudation. To the south, near the Pyrenees, the succession becomes more calcareous and slightly biodetritic, with Lituolidae.

2.3. The Causses and the French-Spanish eastern Pyrenees

Biodetritic, argillaceous limestones containing Lituolidae reappear in the marginal "sierras". Then, from the Tremp Basin to the Grands Causses, the Upper Kimmeridgian consists of laminated limestones and of dolomites deposited in an internal shelf environment.

2.4. The eastern shelf

It then comprises the whole Jura Province which is remarkably organised and consists of a barrier with coral-reefs, overlain by vadose horizons, on the Ile Crémieu and on the southern inner Jura ; backward, occur a channel, partly filled with calcareous or bituminous laminites containing plants, terrestrial vertebrates and fishes (Cerin, Armailles, Orbagnoux) and with calcarenites containing reef columns ; supratidal horizons containing oncolithes, black pebbles etc... go across this filling ; beyond, to the NW, marly limestones with Pteroceras are transitory to the "Marnes à E. virgula" of western Jura and of Haute-Saône ; the succession and the faunas of these "Marnes à E. virgula" are remarkably similar to those of the Paris Basin with which wide communications existed.

2.5. The Provence shelf

The Upper Kimmeridgian consists of fine-grained limestones containing some dolomitic lenses and progressively changing to the south into black, fetid, neo-Jurassic Dolomites. To the north, these fine-grained limestones laterally pass on to the Dauphiné facies.

2.6. The Alpine Province

2.6.1. The Dauphiné-Helvetic Basin

The calcareous-marly alternations of the Lower Kimmeridgian persist in the lower part of the Upper Kimmeridgian, but most of the interval consists of a fine-grained limestone which is part of the Tithonian cliff. This facies exists up to the actual limit of outcrops on the eastern border of the Massif Central, except at the entrance of the Causses Gulf (Navacelles) where it changes laterally into dolomites, as in Provence.

2.6.2. Inner Alpine zones

On the Briançon swell, the fine-grained or nodular pelagic limestones persist. They show neritic influences in the "Subbriançonnais" units of the Seolanes (Embrunais Nappe) and in the areas corresponding to the Larche map.

In Piedmont, marbles overlying the Oxfordian radiolarites are attributed to both the Kimmeridgian and the Tithonian.

3. EPEIROGENESIS - SYNSEDIMENTARY TECTONICS

The recurrence of a detritic sedimentation in the clay depositional environment of the "Marnes à E. virgula" is probably due to the weathering of emerged areas and might correspond to epeirogenic movements.

In the Dauphiné Basin, slopes persisted and were marked by synsedimentaty slumps that were to reach a maximum intensity in the Tithonian-Berriasian.

4. PROBLEMS TO BE SOLVED

The main problems are linked to uncertainties in age determinations in the Pyrenees-Provence Province as well as in central Jura in spite of the satisfactory logic of the above-mentioned reconstitution.

L O W E R P O R T L A N D I A N

Coordinated by : Pierre DONZE.

1. PRELIMINARY REMARK

In the context of the Upper Jurassic, the Portlandian of France corresponds, as a whole, to conditions of marine regression. In the Lower Portlandian, however, the sea still occupied wide areas, the unquestionably marine deposit character of which is attested by the vast extension of the Gravesia genus ammonites. This regressive tendency was clearly accentuated in the Upper Portlandian and reached its maximum in the Lower Berriasian. Thus, an important reduction of areas occupied by truly marine formations occurred with the correlative development of de-salted type formations.

Two maps, one for the Lower Portlandian, the other for the Upper Portlandian show these changes. However, the boundary is not isochronous over the whole map : in Manche and in Boulonnais where great affinities existed with Dorset, as well as in the Paris Basin, it is placed below the "Portland Sand", i.e. at the base of the Portlandian in the English sense (Albani Zone), while, for the rest of France, it was found easier to place it over the Gravesia Zone, i.e. stratigraphically lower.

It has also to be recalled that, from a chronostratigraphic point of view, the term "Tithonian" used for Mesogean facies is about similar to the term "Portlandian" used in its French acceptation.

2. BOUNDARIES

Manche, Boulonnais, the Paris Basin : from the Gravesia Beds up to the Albani Zone or its equivalents.

Rest of France : Gravesia Beds or Lithographicum Zone.

3. SEDIMENTARY AREAS

3.1. Western Manche, Boulonnais, the Paris Basin

In Manche, foliated clays and bituminous shales containing Virgatosphinctoides and Saccocoma have been recognized in bore-holes drilled off Cotentin and the Calvados Coast ; they correspond to the "Oil shale" facies of the Dorset bore-holes and extend as far as the probably tectonic limit near the 50° north latitude. Sand and sandstone ("Grès de la Crèche") overlain by an argillaceous formation with ammonites and phosphatic bars occur in Boulonnais. In the subsurface, in the Paris Basin, the formation consists of a calcareous formation at the base, overlain by marly-limestones or marls and then by another calcareous formation. But this series is not constant : it progressively evolves towards the NW with adjunction of argillaceous and detritic material. In the basin NE part, the diagram remains identical in spite of a greater variety of sediments : fine-grained, bioclastic, oolitic ("Oolithe de Bure") and dolomitic limestones. Towards the basin SE part, on the other hand, the Portlandian practically comprises only the Gravesia calcareous lower formation. An erosional phase in the Morvan-Vosges Threshold area most probably removed the series upper part on both sides of the Morvan and the whole Portlandian series on the threshold itself.

3.2. The Aquitaine shelf

In the Portlandian, the Aquitaine shelf did not behave as an homogeneous area. From the Upper Jurassic, positive cratonic movements occurred along an axis trending from the Gironde towards Montauban, an area where a hiatus started from the Lower Portlandian.

In Charentes, the development of Gravesia marine limestones, is observed to the NE, towards the Atlantic Province, while fine-grained or bioclastic limestones, showing a few indications of the existence of a coral-reef environment, predominate to the SE. In spite of the absence of direct proofs, communications with the Paris Basin then possibly existed.

To the S, subsident areas became individualized : the Mirande Basin, between the Adour and Parentis, tended to open to the W, towards the Atlantic Province. In these basins, sediments are relatively monotonous and the Anchyspirocycline argillaceous limestones predominate. To the E, fairly important evaporitic deposits (Mirande Basin) are representative of a confined environment.

Moreover, the latest-Jurassic epeirogenic movements together with salt migrations generating a series of anticlinal ridges, induced the ablation of an important part of the deposits.

3.3. The Dauphiné Basin and its borders

In the Lower Portlandian, the Dauphiné Basin, open to the E towards the Alpine sea, was bordered to the N, to the W and to the S by the Jura shelf, the Languedoc shelf and the Provence shelf. On these shelf-borders a coral-reef environment tended to develop but it remained limited.

Micritic formations containing ammonites and many Saccocoma are dominant in the basin. There, the sedimentary regularity has often been disturbed by turbidites bringing neritic clastic material, by synsedimentary slumps and by deep-sea currents originating sub-marine erosional channels. To the N, on the Jura shelf, the succession is characterized by the presence of a bioturbated calcareous formation ("Calcaires à tubulures") overlain by laminated dolomites. Other lithofacies such as algal limestones and black pebble-breccias which, for simplification, have not been shown on the map, also occur, mainly in southern Jura. To the W, erosion was observed everywhere but in the

Causses where Dasycladaceae and Anchyspirocyclines limestones were deposited. To the S, on the contrary, formations of an inner and outer shelf-type widely developed. Algal limestones containing Anchyspirocyclines occur in Languedoc, and it is admitted that communications with Aquitaine, through the Toulouse area, possibly existed. The sea also probably extended beyond the present-day Pyrenees emplacement, as far as the Tremp Basin. The Provence shelf extended very far to the E, the Maures-Esterel area being then only an immerged mole.

Beyond the Catalogne fault, near the coast and S of Cerbère, dolomite patches attributed to the Portlandian are believed to be allochtonous.

3.4. Inner Alpine Zones

The facies is generally pelagic in Briançonnais. Neritic influences locally occurred in Subbriançonnais : Medianes Nappe, Prealps, Séolanes and Salé units.

In Piedmont, the supra-Oxfordian Marbles are attributed to the Kimmeridgian-Tithonian.

3.5. Corsica

- Autochtonous. S of Corte, the ancient massif cover consisted of white limestones, containing re-sedimented neretic material, attributed to the Tithonian.

- Nappes. Tithonian pelagic limestones overlay radiolarites in the Balagne Nappe and in the "Schistes lustrés" Nappe.

U P P E R P O R T L A N D I A N

Coordinated by : Pierre DONZE.

1. BOUNDARIES

Manche, Boulonnais, the Paris Basin : from the Albani Zone or probable equivalents.

Rest of France : over the Gravesia Beds or the Lithographicum Zone.

2. SEDIMENTARY AREAS

2.1. Manche, Boulonnais, the Paris Basin

In western Manche and in Boulonnais, the sandy marine sedimentation, with ammonites, persisted up to the end of the Portlandian. Indications of emersion (Purbeckian) appear at the top of the stage marked by the presence of calcareous beds containing brackish or fresh-water fossils.

In the Paris Basin, the Upper Portlandian crops out only on the southern border and in Pays de Bray. Micritic bioclastic and locally oolitic limestones, with de-salted facies, and anhydrite beds in the basin centre, were met with in bore-holes. To the NW, sediments become more argillaceous and contain more clastic material. In this direction, the basin considerably narrowed and was wedged up between the Armorican shelf and the then emerged "London-Brabant-Ardennes" Massif.

2.2. The Aquitaine shelf

In the Upper Portlandian, positive cratonic movements persisted along the Gironde-Montauban axis, in such a way that the NW extremity in turn became a hiatus zone (Gironde Mole).

To the N, in Aquitaine, sedimentation was then varied : micritic bioclastic and oolitic limestones with evaporitic formations and rocks deposited in a desalted environment. In Périgord and in Quercy, a supracotidal environment is now represented by laminites showing mud-cracks and by green marls.

To the S, deposits are more unquestionably marine but they correspond at the best, to the infracotidal environment. They also occur to the W, towards the Atlantic Province, near the Parentis Basin outlet, under the form of gravelly, locally oolitic biomicrite. At the back, in the major part of Aquitaine, the confinement induced an important dolomitic sedimentation. In the most confined areas (Adour and Mirande Basins), evaporitic formations are also present (dolomicrite and anhydrite) and locally brecciated due to partial dissolution ("Garlin Breccias").

2.3. The Dauphiné Basin and its borders

The palaeogeographic scheme is, in its broad outlines, analogous to the one described for the Lower Portlandian. However, the accentuation of the marine regression up to the Lower Berriasian led to the appearance to the N, in the Jura, of an important episode of de-salinity corresponding to the so-called "Purbeckian" facies, by reference to the analogous deposits of the Purbeck Peninsula, on the Dorset Coast (which, in reality, started later and affected the whole Berriasian) ; to the S, on the Provence shelf, the marine regression corresponded only to the development of coral-reef facies, the de-salted facies being well characterized only from the Upper Berriasian. Therefore, from this point of view, there was no symmetry between the northern border and the southern border of the Dauphiné Basin. On the Jura shelf sedimentation was very varied on its whole : micritic bioclastic oolitic limestones, argillaceous limestones, clays, pebble-limestone and varied breccias. From a palaeogeographic point of view, isopic zones can be shown up, displaying the increasing continental character of the series from the SE to the NW. The important thinning of the series on the Jura western border, while the series remain normal or even become thicker in Bresse, indicate that this area then corresponded to a mole bordering the subsident Bresse trough.

While, the coral-reef environment only slightly developed (Echaillon "reef") N of the Dauphiné Basin, it widely extended along the S and SW borders where a fairly continuous barrier was built between the Alpes-Maritimes and the Cévennes. Back-reef formations extended over wide areas from the Nice Coast as far as the Causses and Languedoc, and possibly reached the Tremp Basin. Although the influence of the mole of the Maures-Esterel area started to be felt, it was still probably under water.

In the basin itself, the Lower Tithonian sedimentation persisted in the Upper Tithonian with micrites in which the Calpionellids appeared ; as previously this sedimentation was locally disturbed by turbidites, erosions and sub-marine slumpings.

2.4. Inner Alpine Zones - Corsica

Formations globally attributed to the Malm or to the Tithonic also include the stage upper part as proved by the local presence of Calpionellids.

THE PALAEOGEOGRAPHIC EVOLUTION OF FRANCE IN THE UPPER JURASSIC

by R. ENAY

The Upper Jurassic palaeogeography cannot be explained from a single pattern valid for the whole sub-system. To the Alpine Province, which was not really affected by the latest-Jurassic regression, is opposed the whole Alpine foreland, the palaeogeography of which is marked much sooner by the evolution leading to the Purbeckian general emersion. When considering this evolution as a whole, one can distinguish :

- the emerged areas and those evolving towards an early emersion ;
- the intracratonic sedimentary environments of the Alpine foreland ;
- the Alpine Province or the European continental margin.

The interpretative maps (Plates 37 to 42) help to follow the evolution of these different environments.

1. THE EMERGED AREAS AND THE ZONES EVOLVING TOWARDS AN EARLY EMERSION

The only areas the emersion of which is a certainty - although their limits remain hypothetical - were the Armorican Land and the Ardenno-Rhenish Land which persisted throughout the Jurassic. Their extension even increased in the Upper Jurassic and indications of emergence are numerous : successions of detritic deposits of coastal and estuarian environments, locally containing black pebbles and plants, occur in Normandy and in Boulonnais ; layers with lignite and plant debris, palaeosols and Vertebrate imprints, dinosaur remains etc..., are also present.

Before the Uppermost Oxfordian there was no trace of other emerged areas. The zones emerging in the Upper Jurassic were hitherto largely or even totally flooded and thus integrated into the sedimentary areas : zones of active sedimentation E of the Paris Basin and stable zones with ferruginous oolites and with hiatuses of the Lower Oxfordian, replaced by subsident calcareous shelves in the Middle Oxfordian. Many arguments (facies, thicknesses, fauna) plead in favour of direct communications through the Massif Central (Loire trough) between the Paris Basin and the south-eastern Basin.

New areas emerged in the Upper Oxfordian. Due to the presence of a sedimentary cover, they could not originate such detritic discharges as the ones marking the resumption of erosion on the

Ardennes or on the Armorican Massif. However, a clear tendency to emersion showed up at the end of the Oxfordian or at the beginning of the Kimmeridgian, with the development of protected or confined environments in which continental influences became numerous : layers containing lignite and plants (Franche-Comté, Burgundy, Poitou) and/or Charophytes and fresh water fauna (the Berne Jura, Quercy, Périgord) ; breccias with black pebbles and Charophytes (Pyrenees). The repartition of these indications corresponds to an extension of the areas already emerged, i.e., the Ardenno-Rhenish Land to the E (for those of the western Jura and of Switzerland), but also to the appearance of new emerged areas on the Massif Central and possibly on the Vosges.

These emerged areas remained separated down to the Lower Portlandian (end of the Gravesia sea) : the repartition of the species of the genus imply wide communications between the basins. Then, the emerged areas joined and thus, the different confined Purbeckian Basins and the Dauphiné marine Basin became isolated.

2. THE INTRACRATONIC SEDIMENTARY AREAS OF THE ALPINE FORELAND

Except, may be, in Aquitaine - but the diagram considered is based on uncertain ages - there is no valid organisation-type of the sedimentary provinces for the Upper Jurassic. Within the framework of the tendency to emersion initiated in the Upper Oxfordian, series of a basin type and sediments of calcareous shelves or even of confined environment, succeeded each other, thus expressing the variations of subsidence and the antagonism between the deepening and the filling up by sedimentary deposits.

The Lower Oxfordian, prolonging the Callovian palaeogeography, clearly showed the opposition between a stable area located in the centre and the SW part of the country and cut across by the Loire trough, thus isolating the Burgundian Block, and between an area of comparatively thick marly sedimentation, surrounding those stable areas under the form of a wide arc in which zones of more active sedimentation appeared : the Charentes Gulf, the Lower Seine, the Lorraine trough and the Bresse trough. The benthonic forms were even more numerous and more varied in the marly or marly-calcareous facies of Normandy and of Lorraine than in the ferruginous oolitic beds in which ammonites were often largely predominant. These facies did not correspond to any important variation in depth. They rather expressed a different behaviour of the substratum which was stable in the depositional environments of the ferruginous oolites while it was moderately subsident in the muddy environments containing oysters and pelecypods.

This wide opening of the marine environment and the generalization of marly facies (from the Callovian) was accompanied with an advance to the S of the Cardioceratids fauna of boreal origin that mingled with the mesogean forms as far as the southern border of the Dauphiné-Helvetic Basin.

In the Middle Oxfordian, the fast expansion of the calcareous shelves, both in the stable areas and in zones of active sedimentation, resulted in an homogenization of subsidence and in a reduction of depth. The thickness of deposits on the calcareous shelves reaches or exceeds 100 m (for less than two ammonite zones) and thus strongly contrasts with the more condensed deposits (10 - 20 m) of the basin facies containing ammonites, sponges and, locally, algal bioherms. This is compatible with comparable or slightly different values of subsidence, compensated, in the calcareous shelf areas, by an active sedimentation prograding towards the basin ; the latter maintained few deeper bathymetry due to a shortage of sedimentation compared with the deepening.

Simultaneously to those environmental modifications, the boreal faunas retreated and the mesogean faunas largely advanced to the N ; the Perisphinctids reached Normandy and the S of England

where they are associated with boreal Cardioceratids ; the more strictly mesogean forms (Oppeliids, Gregoryceras) did not go beyond to Perche promontory to the W and Lorraine to the E.

In the Paris Basin, the reduction of the calcareous shelves and their disappearance in the Upper Oxfordian might be connected with the resumption of erosion and the afflux of coarse or fine terrigeneous sediments ; however this is most probably due to the progressive setting up of a restricted marine environment owing to filling up resulting in the excess of sedimentation over subsidence. This environment corresponded to the many facies grouped under the name of "Calcaires à Astartes" containing a fauna varied but rich in individuals corresponding to a few taxa and in which the continental influences previously referred to are generally recorded. At the end of the Oxfordian and in the Kimmeridgian the marly marine facies, similar to the ones of the English successions, were localized in Normandy and in the Lower Seine.

This Upper Oxfordian event was also marked, although not so clearly, in the other calcareous shelves that persisted down to the end of the Oxfordian or the Lower Kimmeridgian ; an open marine province subsisted round the central shelf and its Aquitano-Pyrenean extension. It connected Aquitaine to the SE of France from which the sub-mediterranean elements known in the S part of the Paris Basin, arrived.

Simultaneously and in relation with this evolution, the differentiation between the Anglo-Norman fauna with sub-boreal Ringsteadia and the sub-mediterranean fauna with Epipeltoceras, Idoceras, now known as far as Yonne and Berry, increased in the Upper Oxfordian.

In spite of the wide extension of the "E. virgula" muddy environment and of the "Gravesia sea", the Upper Kimmeridgian and the Lower Portlandian corresponded to a period of reduction of the open marine-type of facies : the "basin" facies were limited to the south Aquitan Gulf and to the offing of the Lower Seine with the characteristic bituminous laminite facies of the Kimmeridge Clays ; the last shelves or reef-barriers were located on the border of the slope delimiting the Dauphiné-Helvetic Basin (inner Jura, Provence and Cévennes border...).

In these restricted marine environments, the fauna was, on the whole, not very varied, but rich in individuals as soon as conditions were favorable. The multiplication of ammonites itself was episodic, associating forms adapted to characteristic environments and external elements, often of mesogean origin.

At the end of the "Gravesia sea", the confinement was accelerated, driving back the last marine fauna towards Boulonnais and England up to the Purbeckian emersion.

3. THE ALPINE PROVINCE OR THE EUROPEAN CONTINENTAL MARGIN

The only permanent marine area in the Jurassic, the Alpine Geosyncline consisted of differentiated cratonic zones in the Lower and Middle Jurassic.

The Dauphiné and Helvetic Province, due to its position near the material sources, received abundant sedimentation that compensated active subsidence. The Upper Jurassic series, geographically little differentiated, except near some of the borders, showed a general evolution from marls towards limestones. The tectonic control on sedimentation, together with modifications in the depositional characteristics (predominance of argillaceous deposits), are marked by the rythmical arrangement of the successions ; more calcareous layers representative of major events occurring in the history of the intracratonic provinces appeared at three different horizons. This history can be recalled as follows : "Argovian rise", synchronous with the expansion of the calcareous shelves and with the Argovian resump-

tions of sedimentation ; the "Rauracian cliff" contemporaneous with the emergent tendency of the Upper Oxfordian ; the "Tithonian cliff" that terminates the Jurassic succession. These three separate calcareous phases joined into only one in the condensed pelagic calcareous successions of Briançonnais and Piedmont.

The thickness and the relative monotony of the successions were insufficient to hide fully the structure of the basin partly inherited from previous periods. On the borders as well as in the basin, slopes still subsisted ; they were more or less steep depending on the periods, and marked by hiatuses, by condenses nodulous beds of an ammonitico-rosso type, by slump structures or by turbidites... Their situation in the Upper Jurassic seems to indicate a slight progradation of the borders towards the basin.

The evolution of the cratonic margin and of the oceanic province is easier to trace. The Briançonnais swell, which provided detritic material up to the Lower Oxfordian progressively disappeared after the resumption of sedimentation of the Middle Oxfordian that initiated its progressive submersion. The outer Piedmont cratonic margin and the Liguria-Piedmont oceanic province were already largely submerged. Within the Atlantic (Tethysian) succession consist of black schists, radiolarites and pelagic limestones, the radiolarites are indicative of a deep environment (leptogeosyncline), but the evolution of the clays towards limestones is simultaneous with the one occurring in the Dauphiné Basin and in the intracratonic areas.

4. CONCLUSION

The same general evolution of facies and of successions is always met in this palaeogeographic evolution of the main sedimentary provinces, in spite of differences due to local or regional factors. The main phases of terrigenous or of calcareous sedimentation are still recognizable in environments as different as high-energy calcareous shelves or series of the Piedmont leptogeosyncline. The environments and the corresponding differences in bathymetry are bound to the basin evolution that opposes deepening and opening on the one hand, sedimentary deposits and filling up on the other.

The tectonic control on sedimentation was one of the factors of this antagonism. Thus, from the Cévennes border to the inner Jura, a mobile zone separated the Alpine Province and the intracratonic sedimentary basins up to the end of the Jurassic (or latter). Stable areas showing hiatuses or condensed sedimentation and subsident areas showing thick successions, coexisted on both sides and were separated by active flexures or faults. The deepening always predominated over sedimentation and thus the conditions remained those of a marine basin, open up to the end of the Jurassic in the Alpine Geosyncline and even in the Dauphiné Basin in which successions are thicker ; in the meantime, the extra-Alpine Province irremediably evolved towards emersion.

The sedimentary flux, in volume as well as in nature, was controlled mainly by factors external to the basins. The calcareous sedimentary phases coincided with the northwards expansion of the Mesogean influences (Middle Oxfordian) or with a limitation of exchanges and communications between the boreal and the mesogean provinces (Uppermost Oxfordian, Upper Tithonian). However, the opposite is not true : if the generalization of an argillaceous sedimentation in the Lower Oxfordian (or even in the Middle Callovian), seems to result in the wide opening of the seas to boreal influences as shown by fauna, the recurrence of clays and of coarse detritic discharges in the Upper Oxfordian did not correspond to a new boreal advance after the expansion of the calcareous shelves and of the mesogean faunas in the Middle Oxfordian ; the Upper Oxfordian started with a real resumption of erosion marked by the destruction of the forest soil due to temporary rhexistasic conditions. Very quickly,

except in the Anglo-Norman basin and in spite of the "Marnes à E. virgula" episode, sedimentation became calcareous again and this might be explained by an extension of the forest pedogenesis on the wider and wider emerged areas. Then, the calcareous sedimentation also invaded the S of England in the Upper Portlandian, after communications with the boreal basin and the North sea had been cut.

CONCLUSIONS

The sedimentary history of the Jurassic Basins, summarized in the conclusions of each sub-system, leads to general considerations on the evolution of France in the Jurassic.

The structural influence of the Hercynian frame existed throughout the Jurassic. The sedimentary and palaeogeographic units were limited by deep fractures or flexures located on these deep fractures inherited from the Hercynian.

Three major structural directions controlled the more or less subsident movement of blocks or mobile compartments delimited by late-Hercynian fractures : structures trending SW-NE (N 30 to N 50) ; structures trending NW-SE (N 120 to N 150) and structures trending N-S (N 340 to N 20).

The evolution of the Jurassic series corresponds to the succession of opening phases and of phases marked by a tendency to closure or to filling up due to the predominance of sedimentation over deepening. The tendency to opening dominated during the Liassic expansion ; after the spreading of the seas in the Middle Jurassic, the tendency to closure increased in the Upper Jurassic up to the Purbeckian emersion.

This evolution expresses an extension connected with the mobilization of the European cratonic margin the evolution of which was, in the Jurassic, the evolution of a passive margin of an Atlantic type. This extension corresponded to the generalized distension of the European Craton linked with Tethysian opening.

Finally, at the end of this "palaeogeographic synthesis of the Jurassic in France" the perenniality of certain palaeogeographic and structural features commands attention ; throughout the Jurassic these features bind the Hercynian heritage with the Tertiary evolution : stable areas, emerged or not, on the future ancient massifs : ways of communication on the emplacement of the future Oligocene Trough and Basins of the Massif Central.

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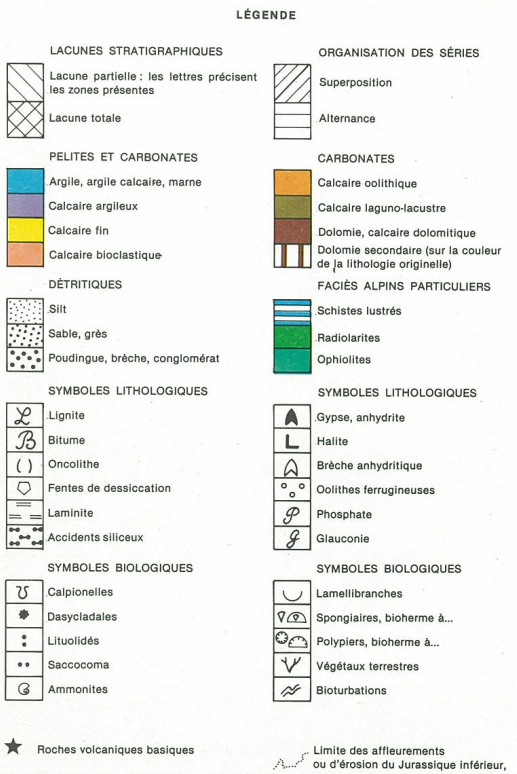
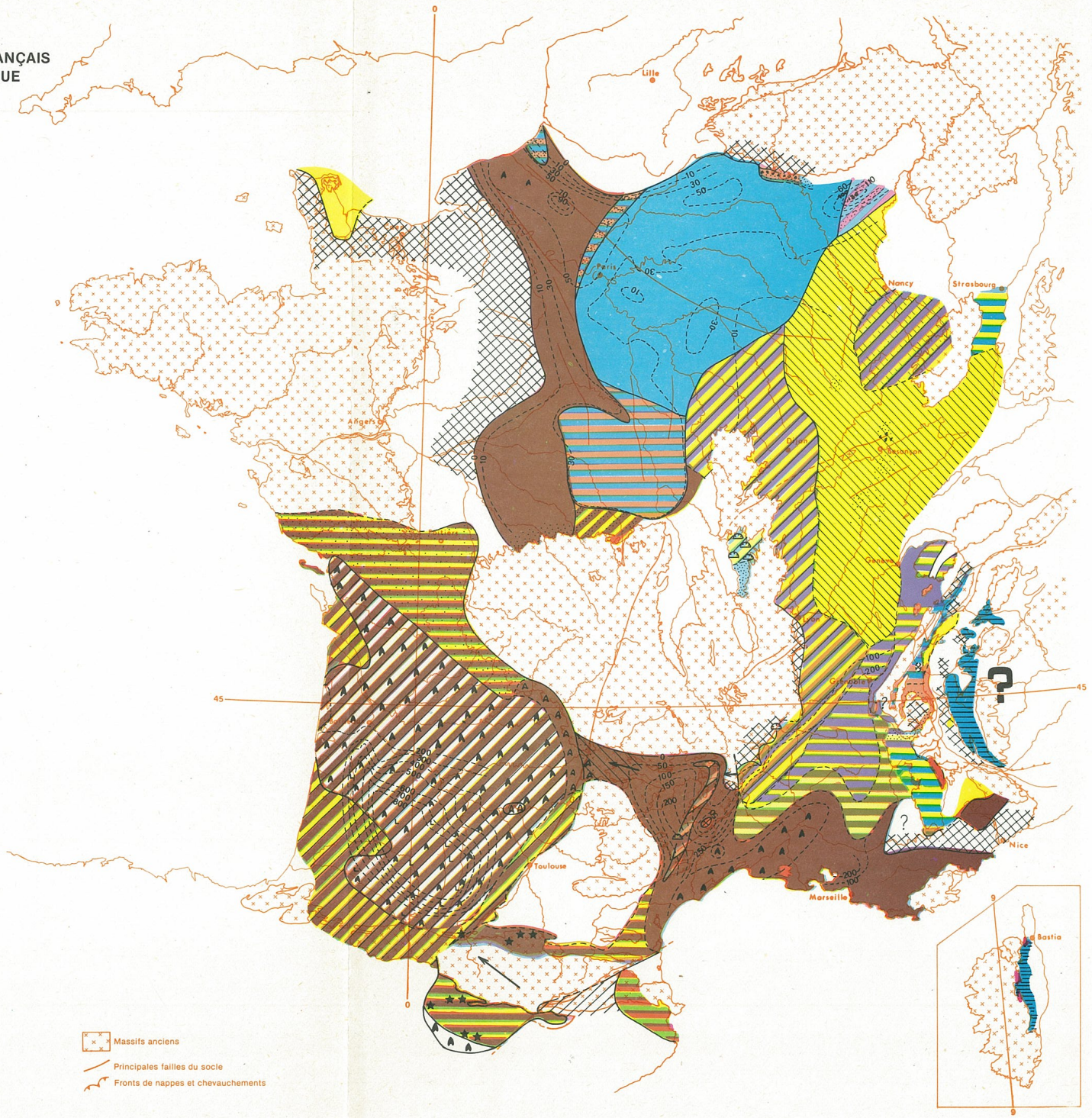
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

HETTANGIEN

CARTE DES FACIÈS

Coordonnée par R. MOUTERDE





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SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

SINÉMURIEN INFÉRIEUR OU ST.S.

CARTE DES FACIÈS

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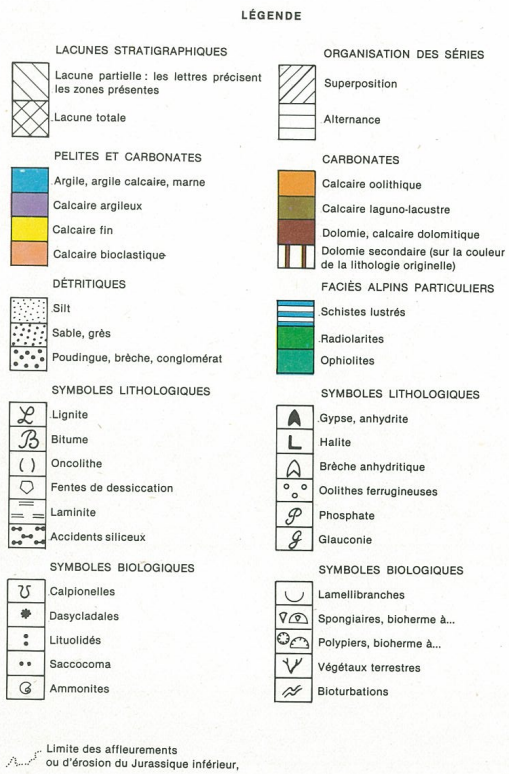

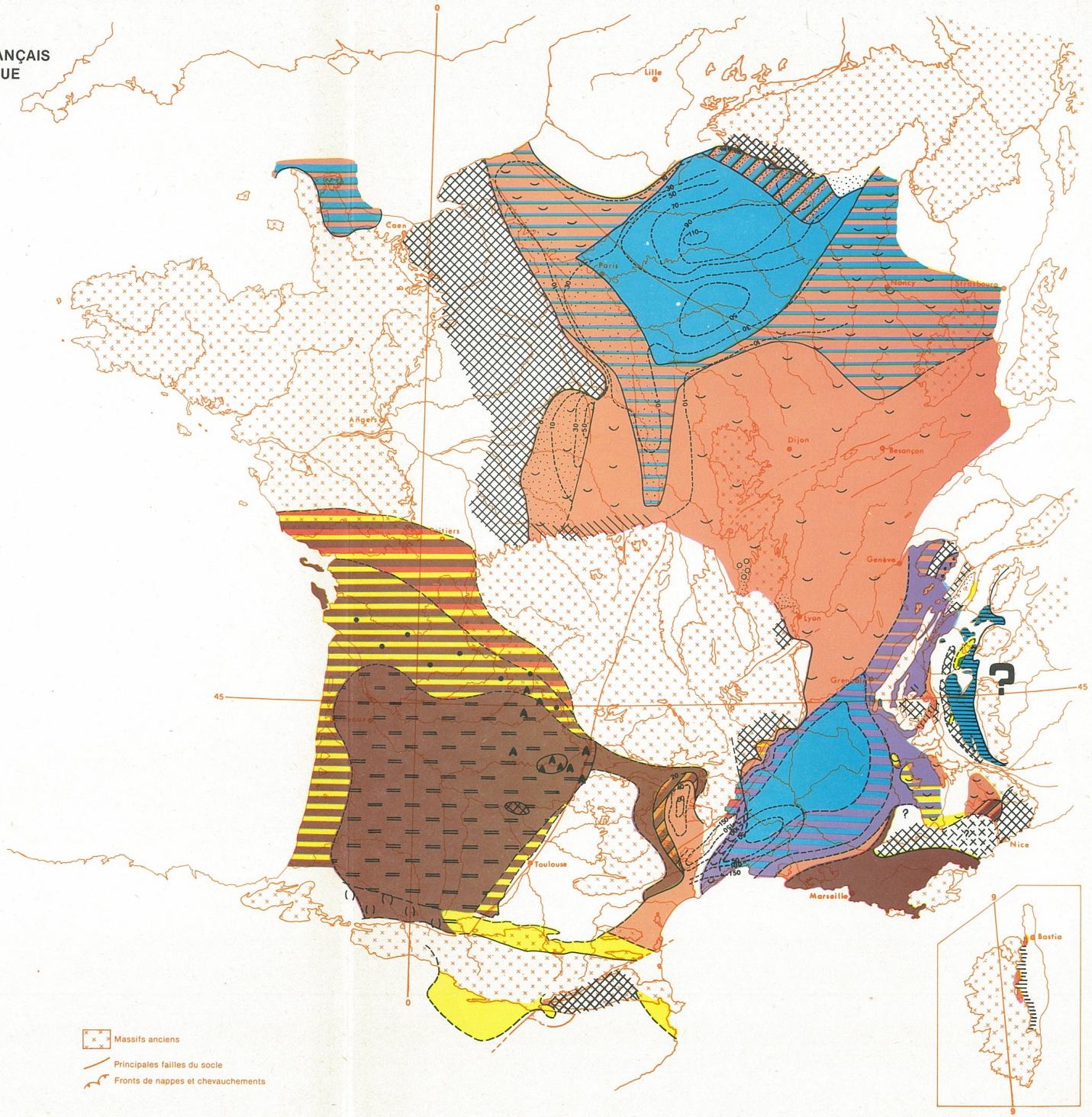

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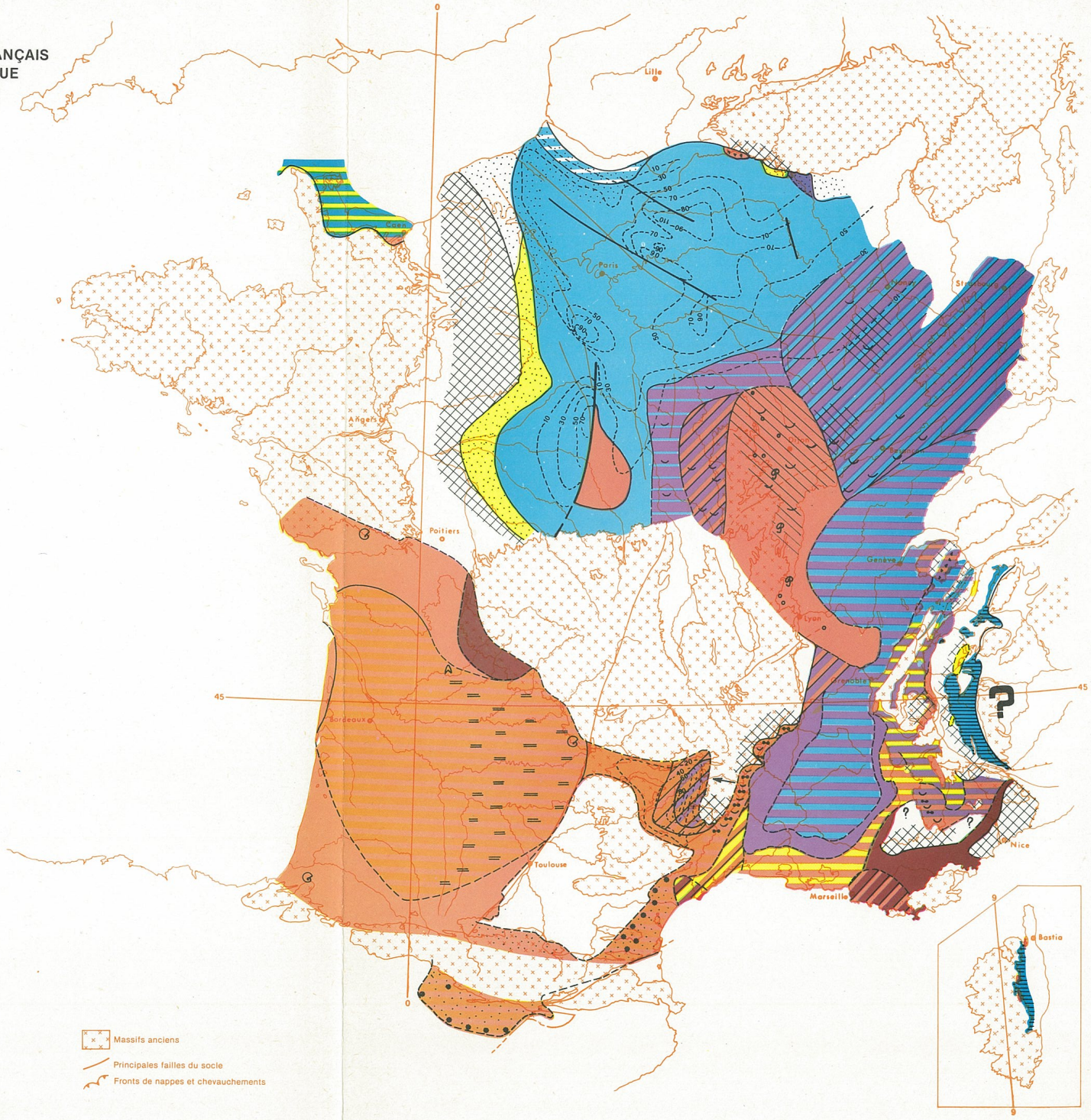
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

LOTHARINGIEN

CARTE DES FACIÈS

Coordonnée par R. MOUTERDE



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

Limite des affleurements ou d'érosion du Jurassique inférieur,

Massifs anciens

Principales failles du socle

Fronts de nappes et chevauchements

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SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

CARIXIEN

CARTE DES FACIÈS

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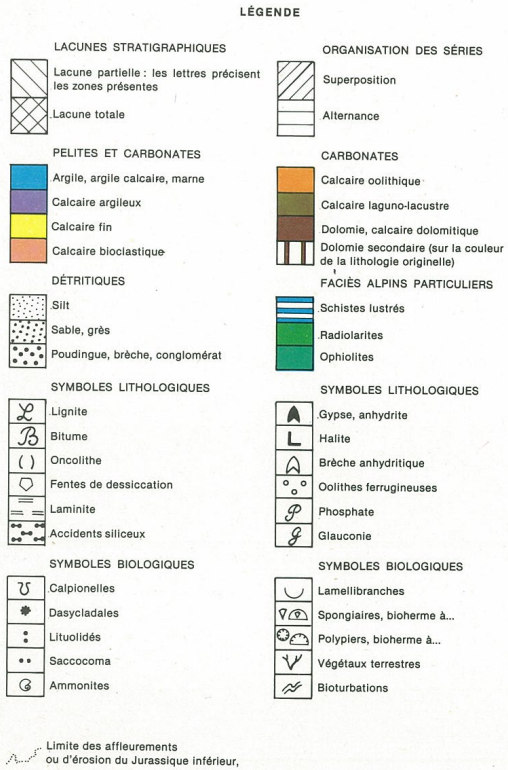

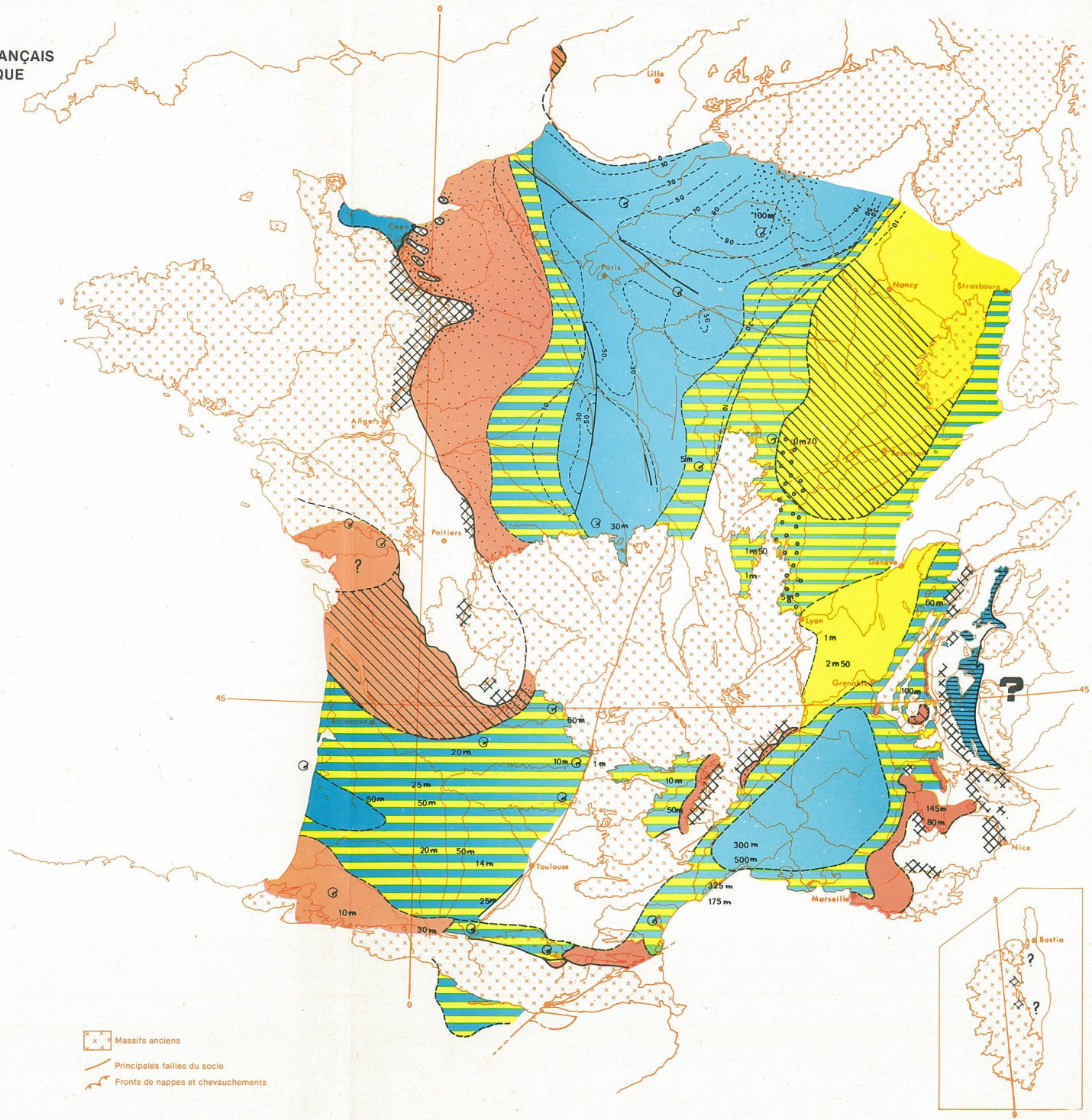

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SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

DOMÉRIEN SUPÉRIEUR
CARTE DES FACIÈS

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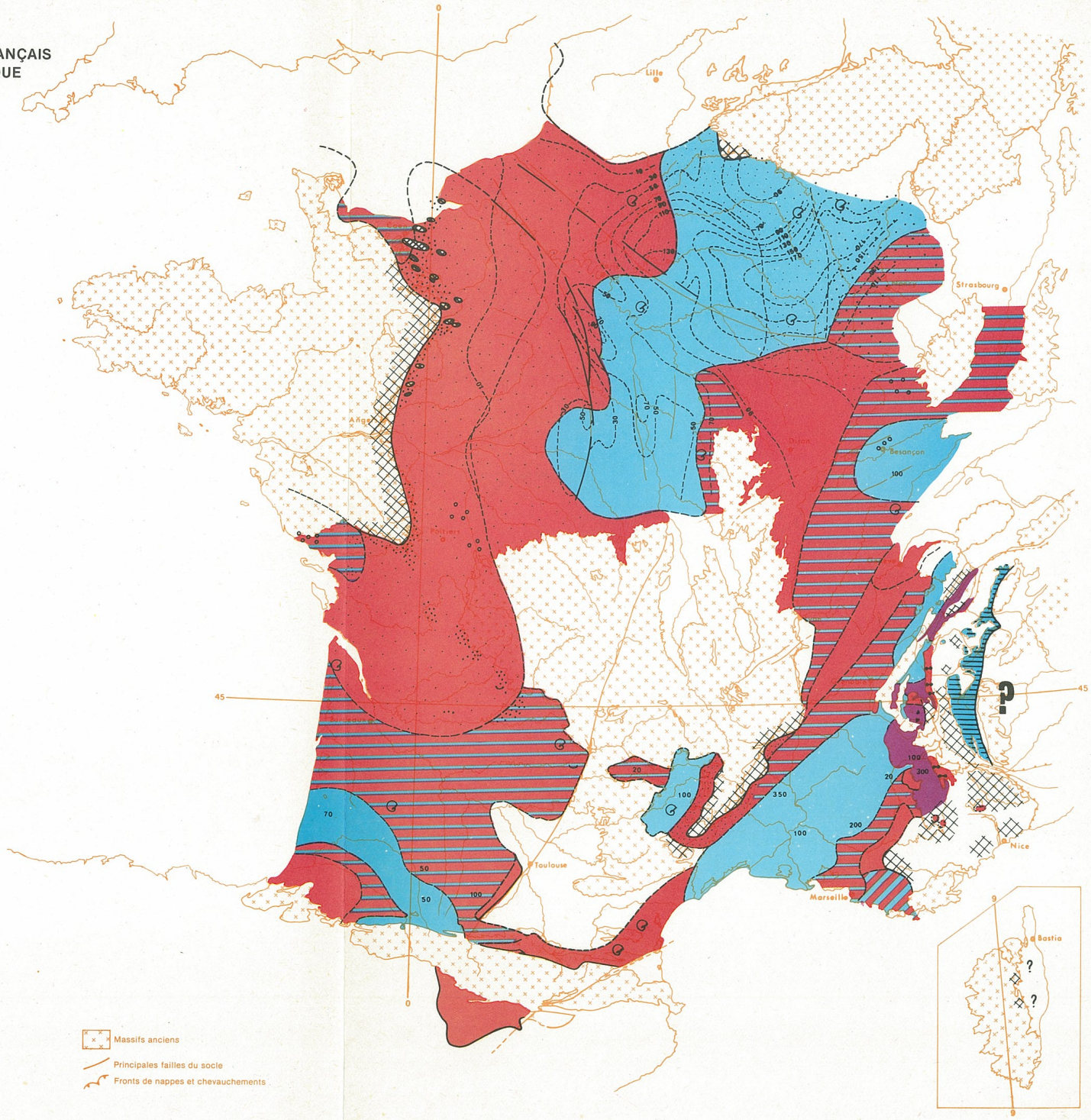

LÉGENDE

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- Lacune totale

ORGANISATION DES SÉRIES
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Massifs anciens

Principales failles du socle

Fronts de nappes et chevauchements

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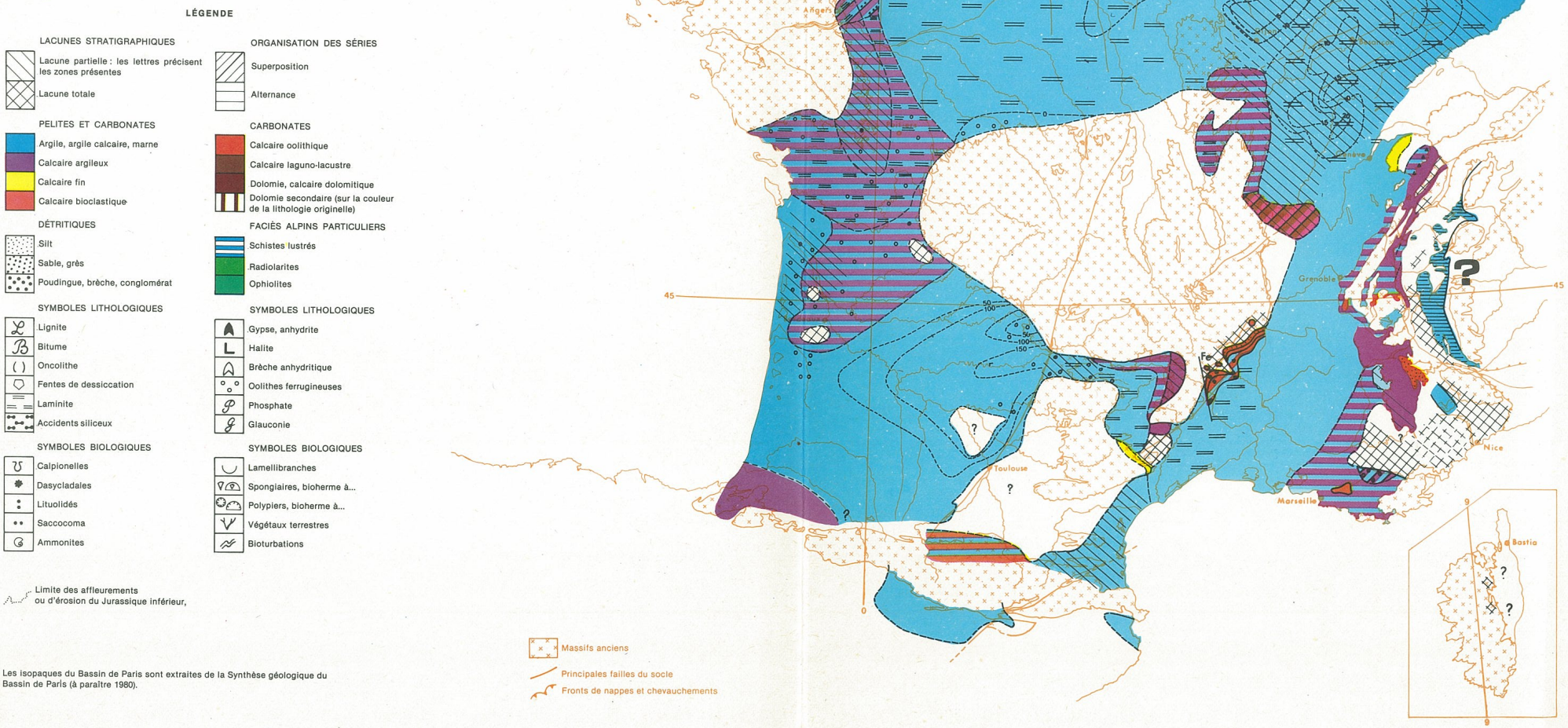
Les épaisseurs indiquées sont celles du Domérien total.

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

TOARCIEN INFÉRIEUR ET MOYEN

CARTE DES FACIÈS

Coordonnée par J. GABILLY et R. MOUTERDE



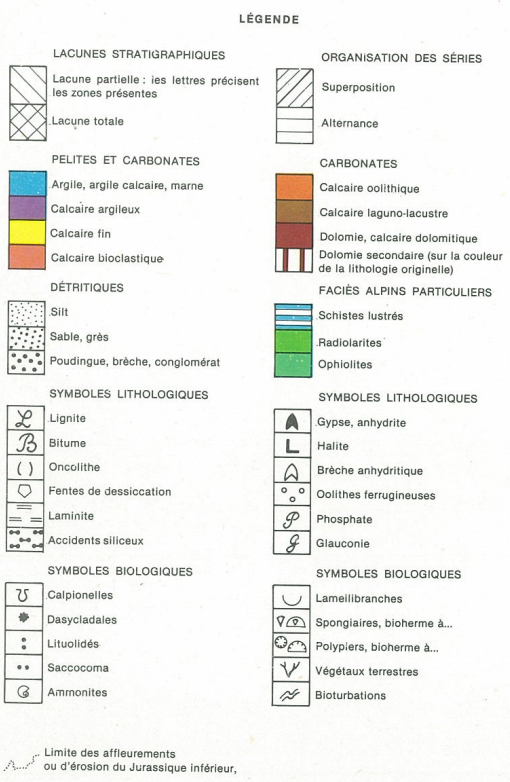
Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

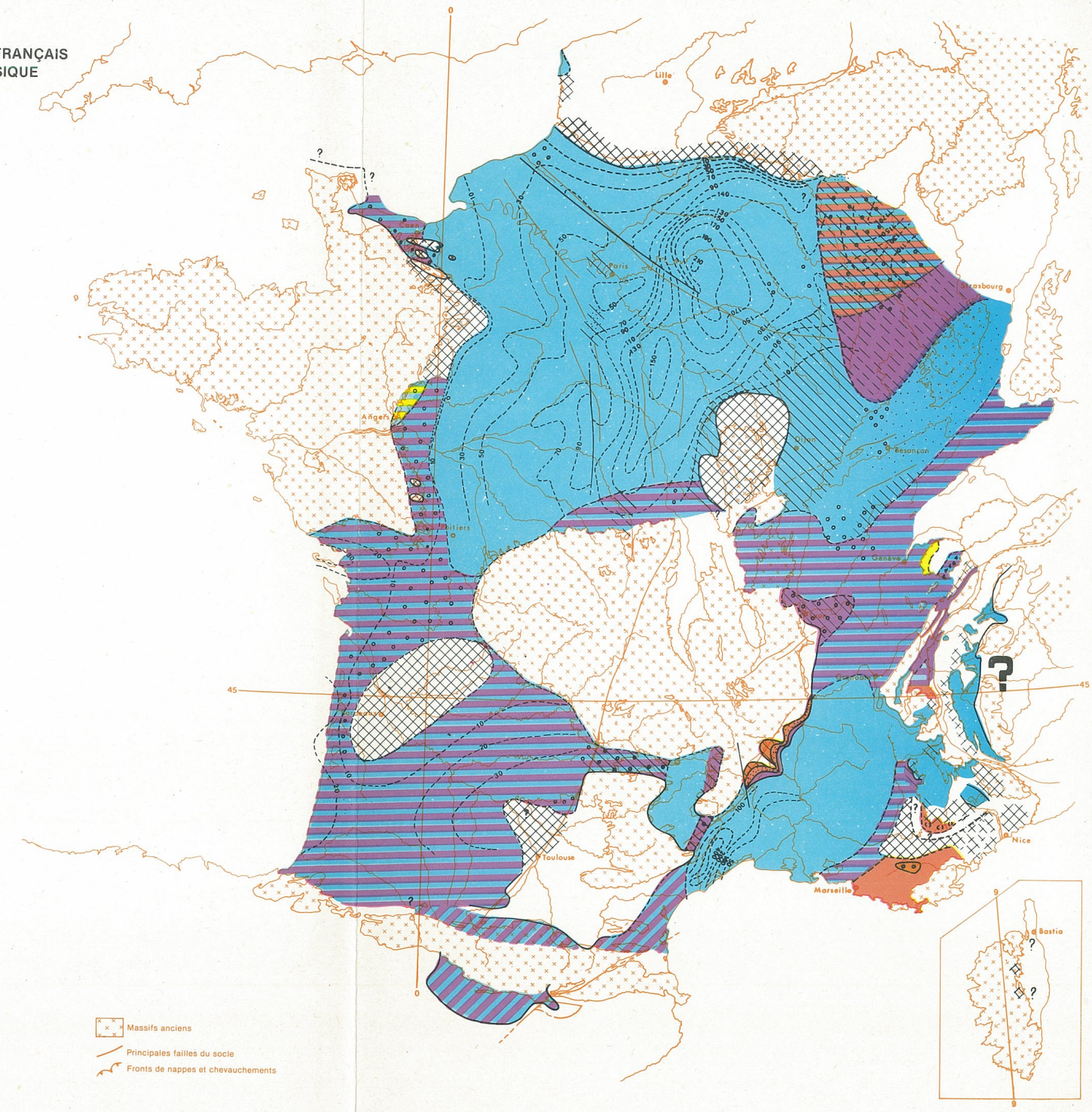
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

TOARCIEN SUPÉRIEUR

CARTE DES FACIÈS

Coordonnée par J. GABILLY et R. MOUTERDE





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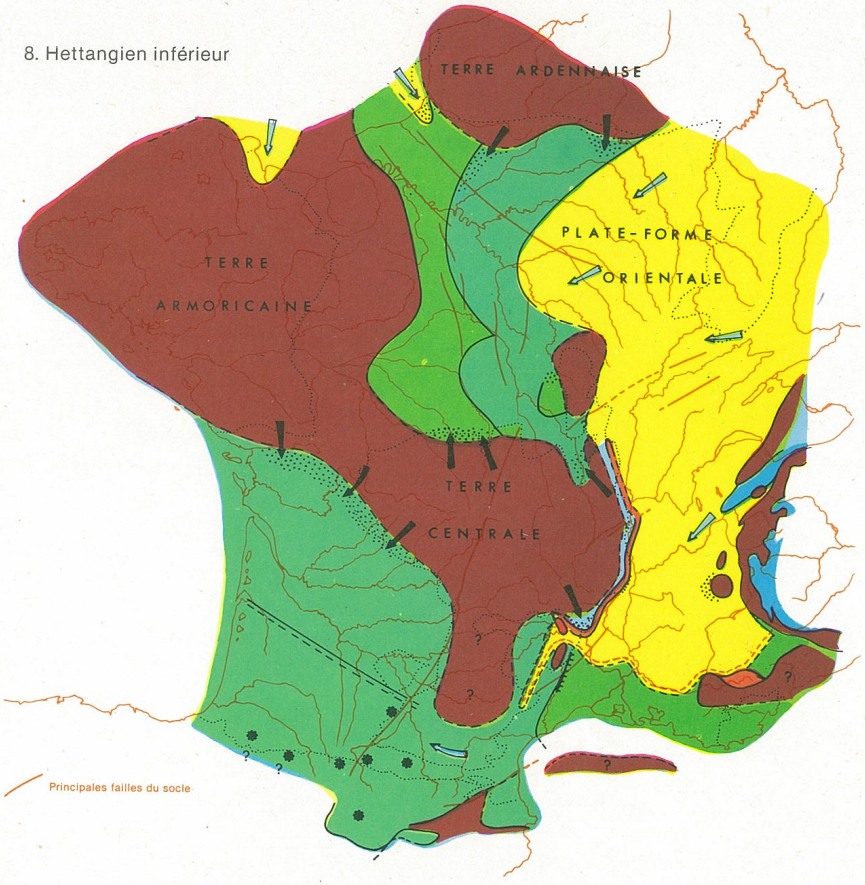
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

HETTANGIEN

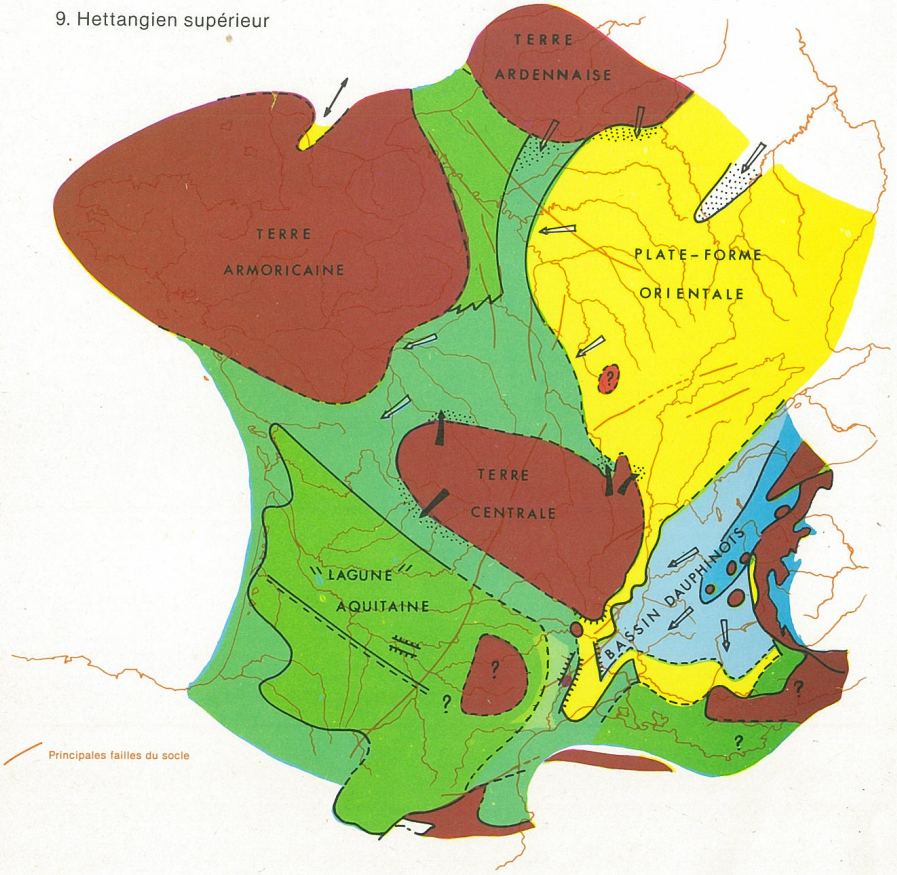
CARTES INTERPRÉTATIVES

Coordonnées par R. MOUTERDE et S. ELMI

8. Hettangien inférieur



9. Hettangien supérieur



LÉGENDE

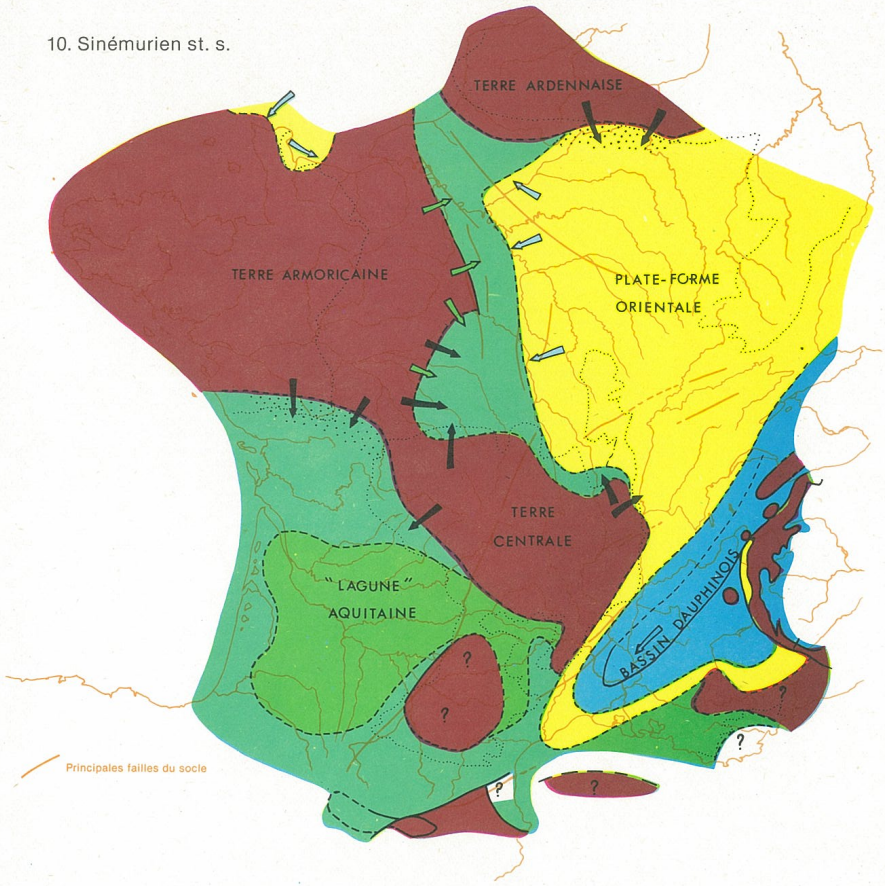
- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATEES
  - De haute énergie
  - De basse énergie
  - Vasière de plate-forme carbonatée
  - Milieu protégé
  - Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques

Milieux ouverts

- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux — Détritiques
- haut bas Pentes, talus — Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique inférieur
- Limite sud de **Psiloceras**
- Roches volcaniques basiques

Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
Les domaines de sédimentation occupent leur emplacement actuel à l'exception des Préalpes non représentées.

10. Sinémurien st. s.



LÉGENDE

- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATÉES
  - De haute énergie
  - De basse énergie
  - Vasière de plate-forme carbonatée
  - Milieu protégé
  - Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques

Milieux ouverts

- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux — Détritiques
- haut / bas Pentes, talus — Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique inférieur

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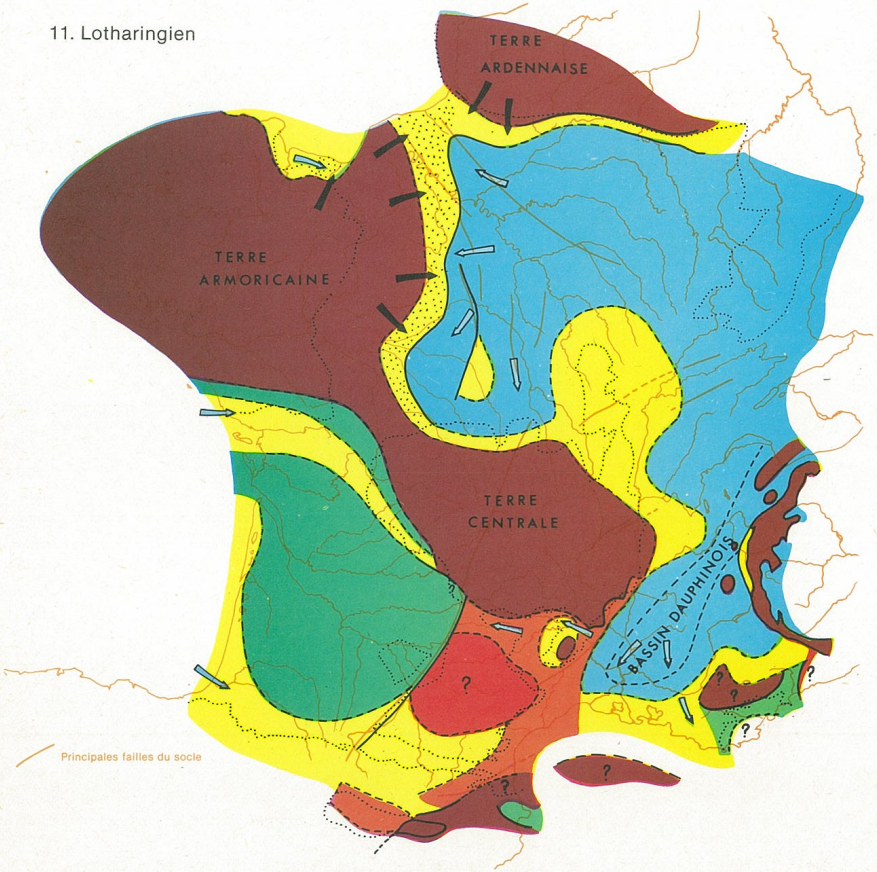
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

SINEMURIEN

CARTES INTERPRÉTATIVES

Coordonnées par R. MOUTERDE

11. Lotharingien



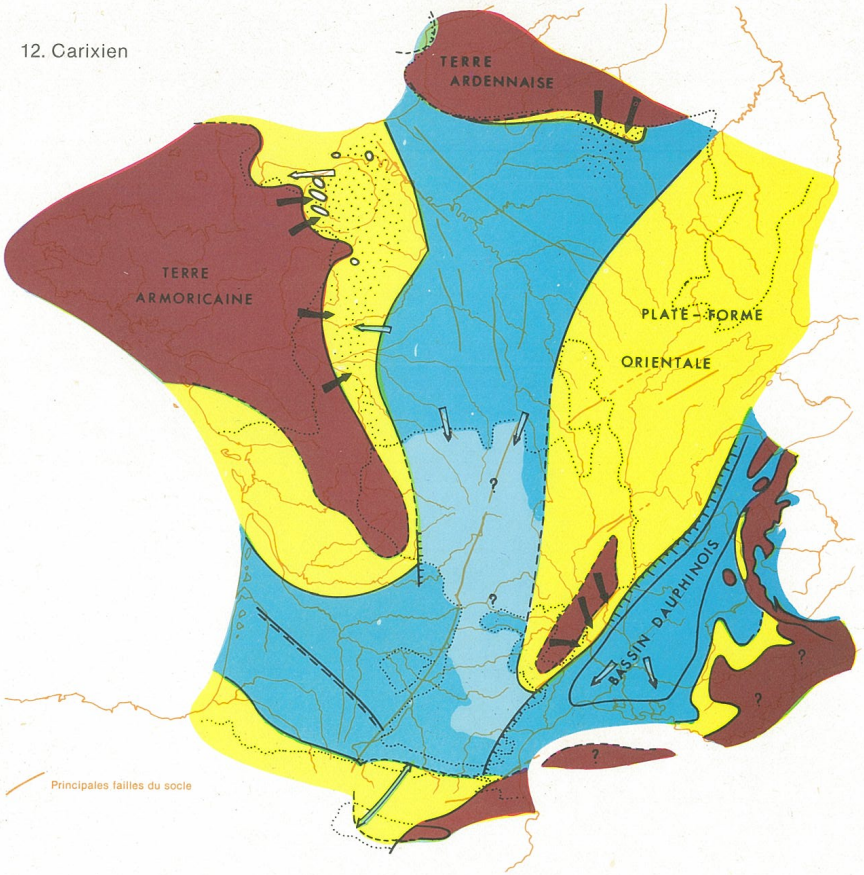
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

PLIENSBACHIEN

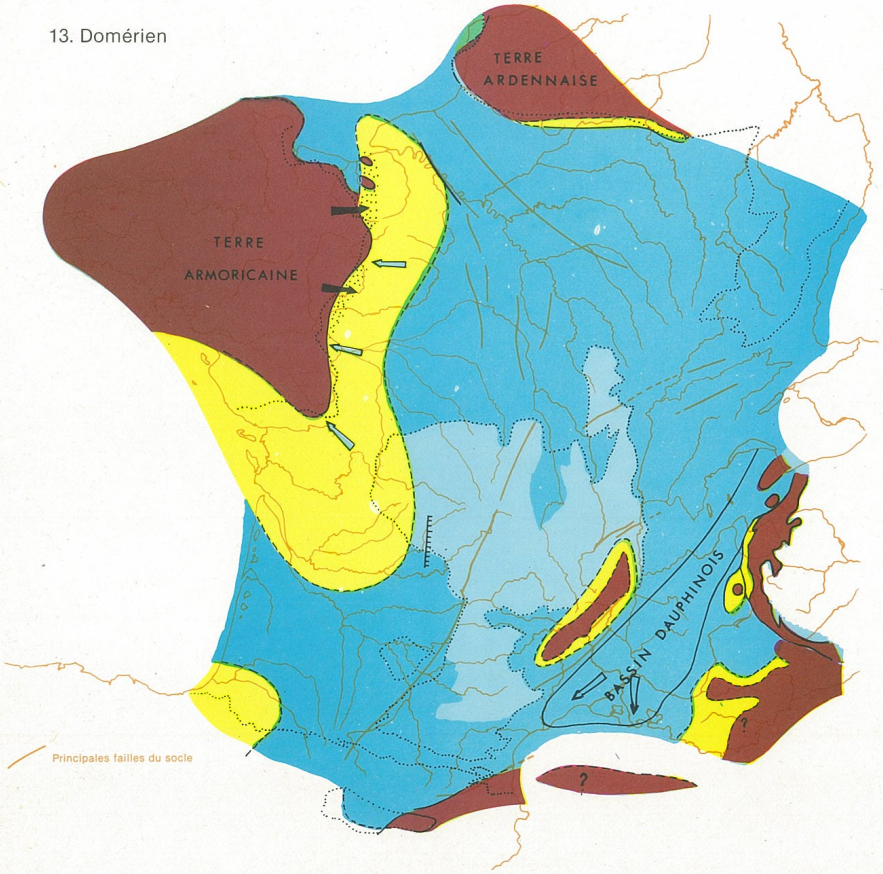
CARTES INTERPRÉTATIVES

Coordonnées par A. LEFAVRAIS-RAYMOND

12. Carixien



13. Domérien



LÉGENDE

- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATEES
  - De haute énergie
  - De basse énergie
  - Vasière de plate-forme carbonatée
  - Milieu protégé
  - Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques

Milieux ouverts

- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux
- Détritiques
- Pentes, talus (haut / bas)
- Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique inférieur

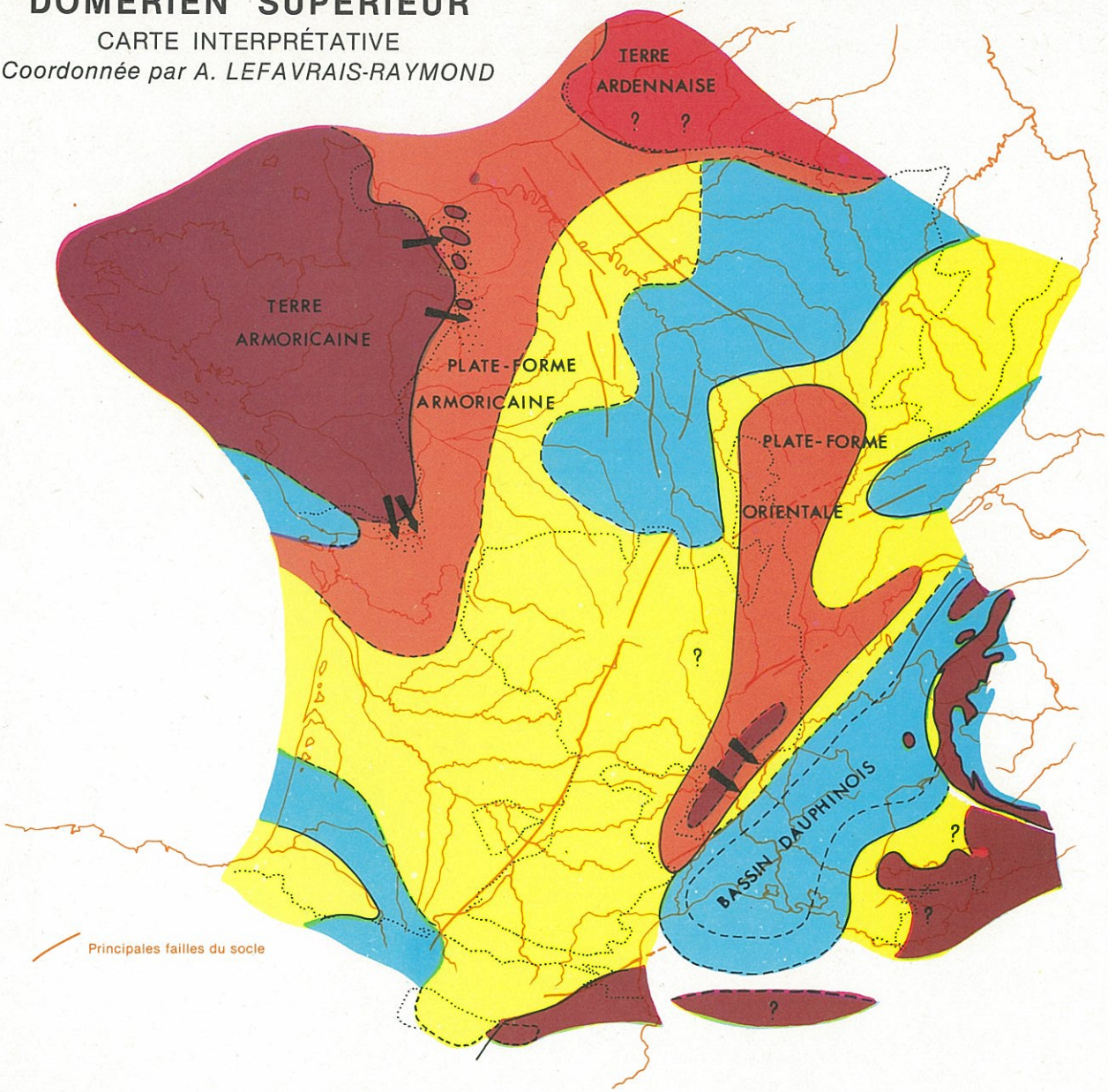
Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
Les domaines de sédimentation occupent leur emplacement actuel à l'exception des Préalpes non représentées.

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

DOMERIEN SUPÉRIEUR

CARTE INTERPRÉTATIVE

Coordonnée par A. LEFAVRAIS-RAYMOND



LÉGENDE

- Domaine océanique
- Bassin plus (1) ou moins (2) subsident

PLATES-FORMES CARBONATÉES

- De haute énergie
- De basse énergie
- Vasière de plate-forme carbonatée
- Milieu protégé
- Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques

Milieux ouverts

- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux
- Détritiques
- haut bas Pentes, talus
- Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique inférieur

Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
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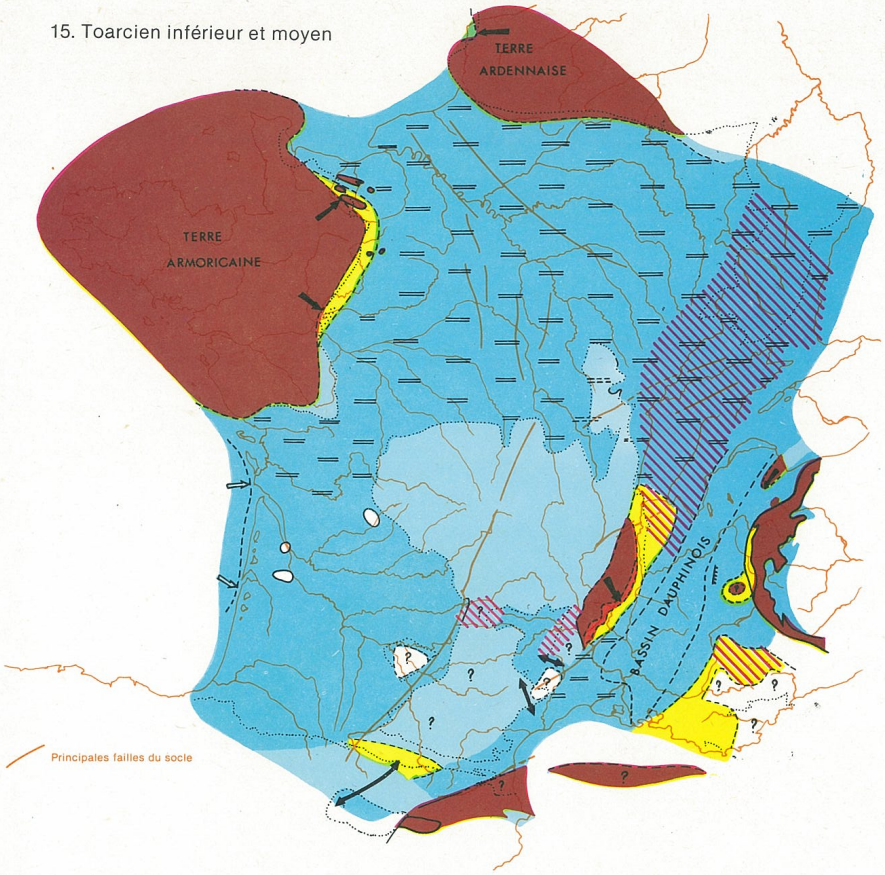
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

TOARCIEN

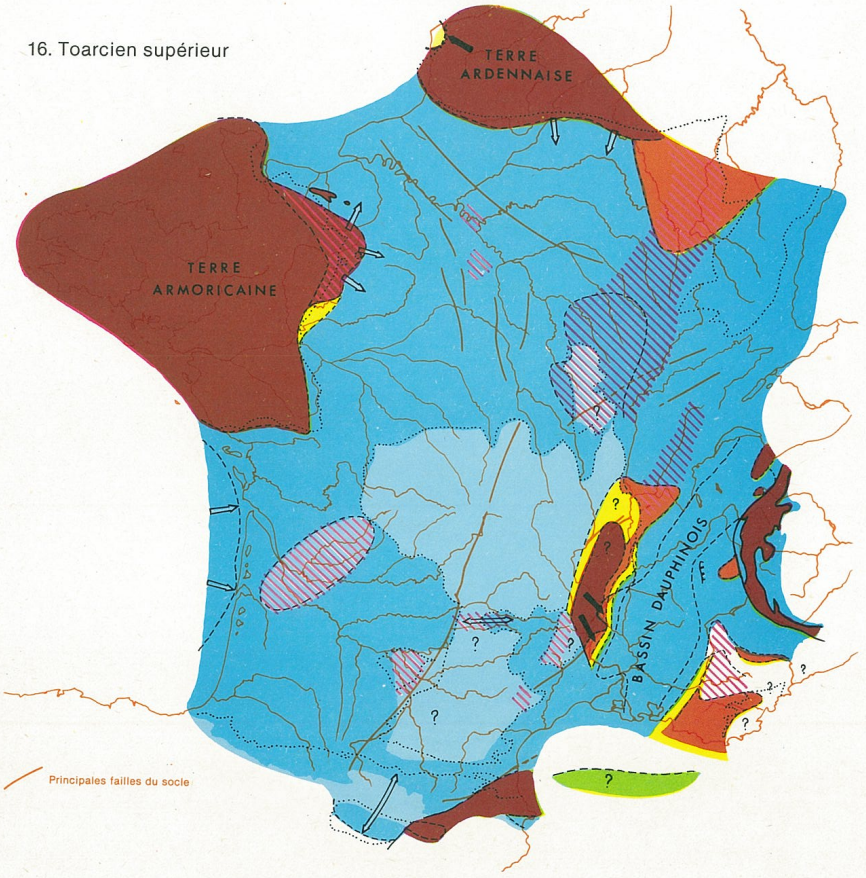
CARTES INTERPRÉTATIVES

Coordonnées par J. GABILLY et R. MOUTERDE

15. Toarcien inférieur et moyen



16. Toarcien supérieur



LÉGENDE

- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATEES
- De haute énergie
- De basse énergie
- Vasière de plate-forme carbonatée
- Milieu protégé
- Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques
- Milieux ouverts
- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux
- Détritiques
- haut bas Pentes, talus
- Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique inférieur
- Laminites (schistes cartons)

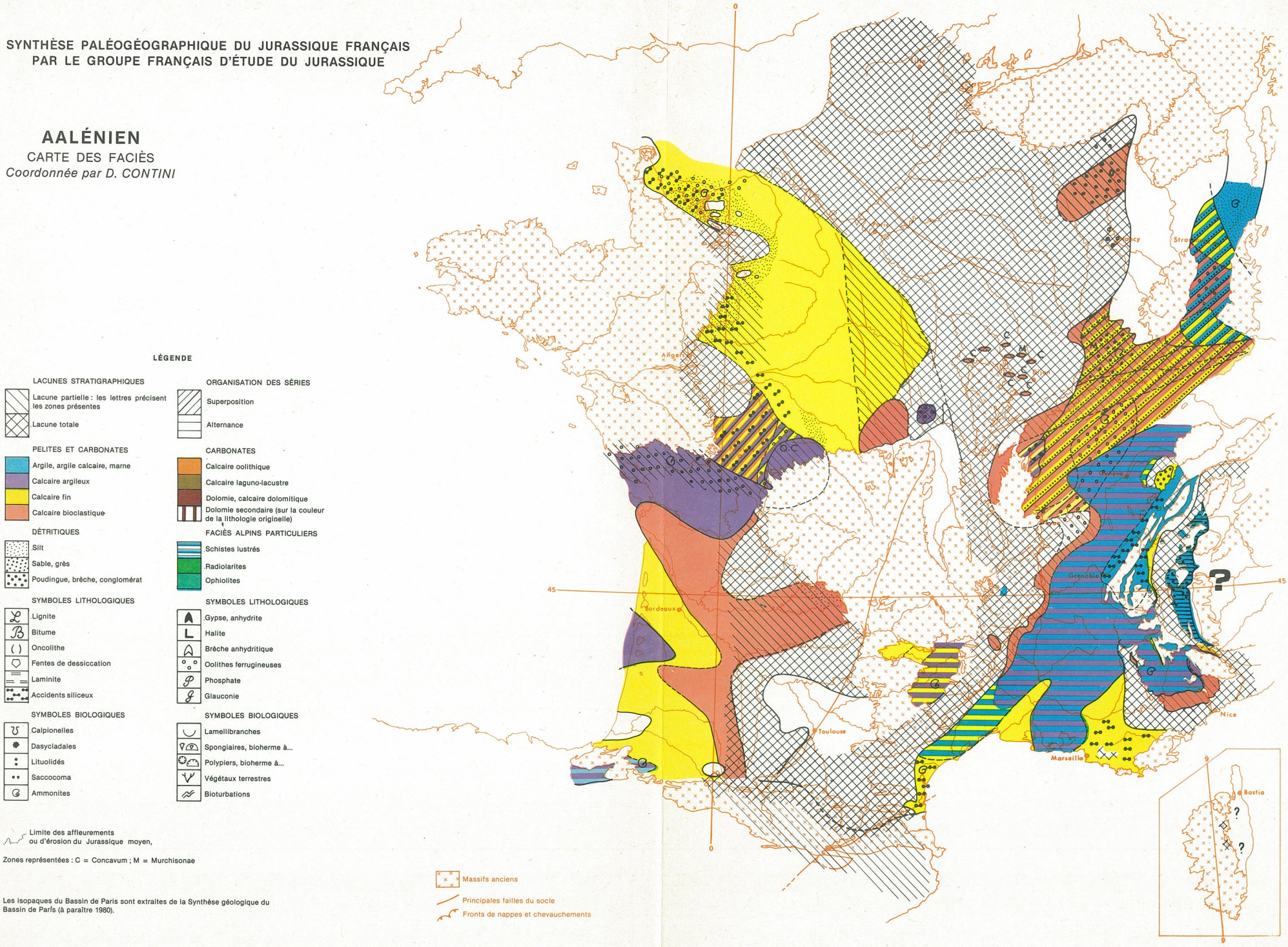
Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
Les domaines de sédimentation occupent leur emplacement actuel à l'exception des Préalpes non représentées.

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

AALÉNIEN

CARTE DES FACIÈS

Coordonnée par D. CONTINI



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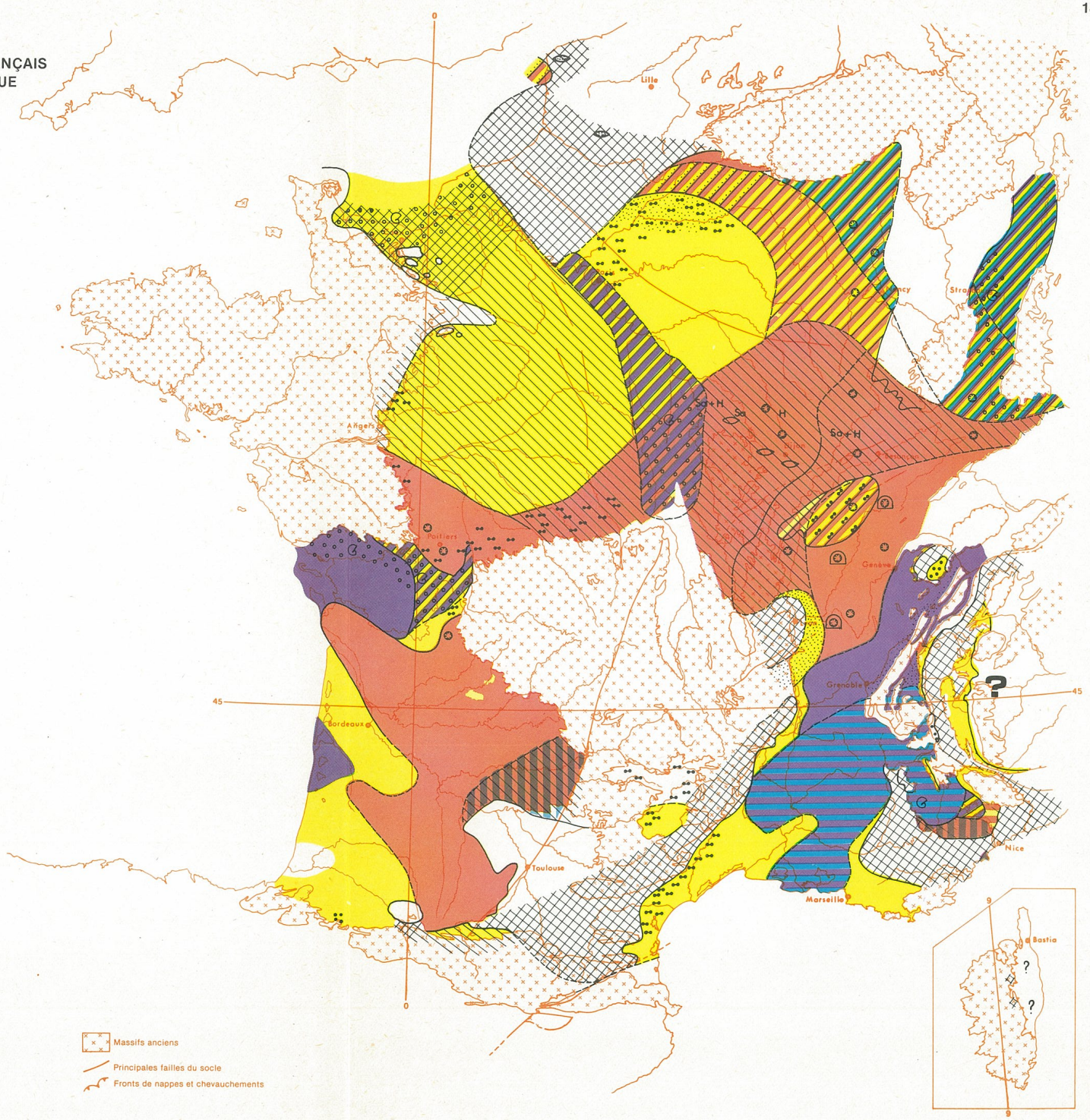
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

BAJOCIEN INFÉRIEUR ET MOYEN

CARTE DES FACIÈS

Coordonnée par D. CONTINI



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

Limite des affleurements ou d'érosion du Jurassique moyen,

Zones représentées : H = Humphriesianum ; Sa = Sauzei

Massifs anciens

Principales failles du socle

Fronts de nappes et chevauchements

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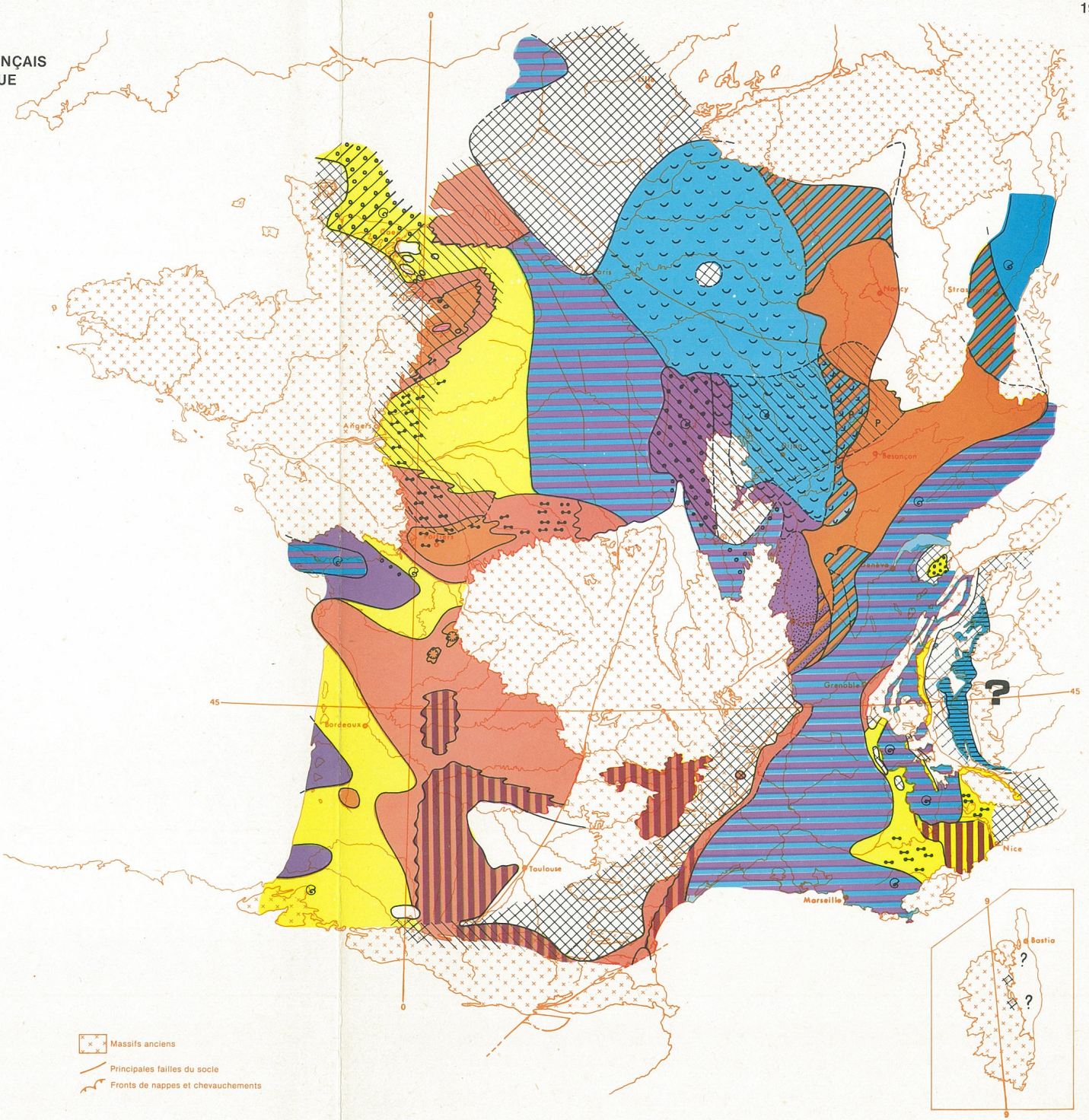
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

BAJOCIEN SUPÉRIEUR

CARTE DES FACIÈS

Coordonnée par D. CONTINI



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

ORGANISATION DES SÉRIES
- Superposition
- Alternance

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche-anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

Limite des affleurements ou d'érosion du Jurassique moyen,

Massifs anciens

Principales failles du socle

Fronts de nappes et chevauchements

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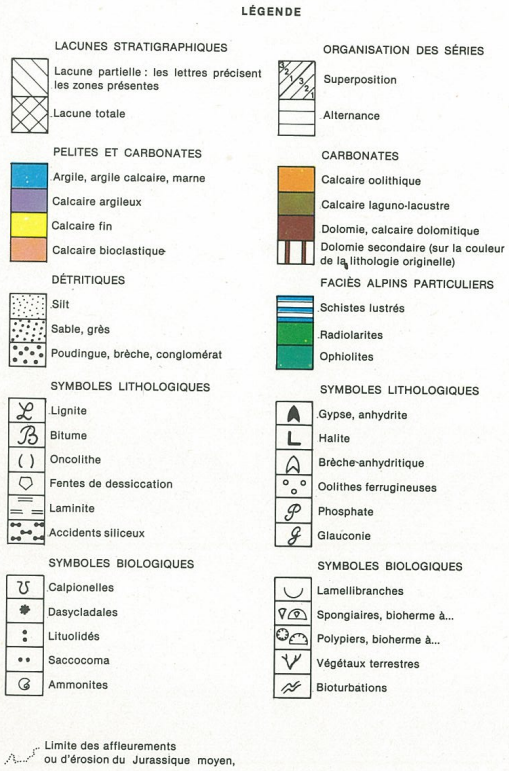
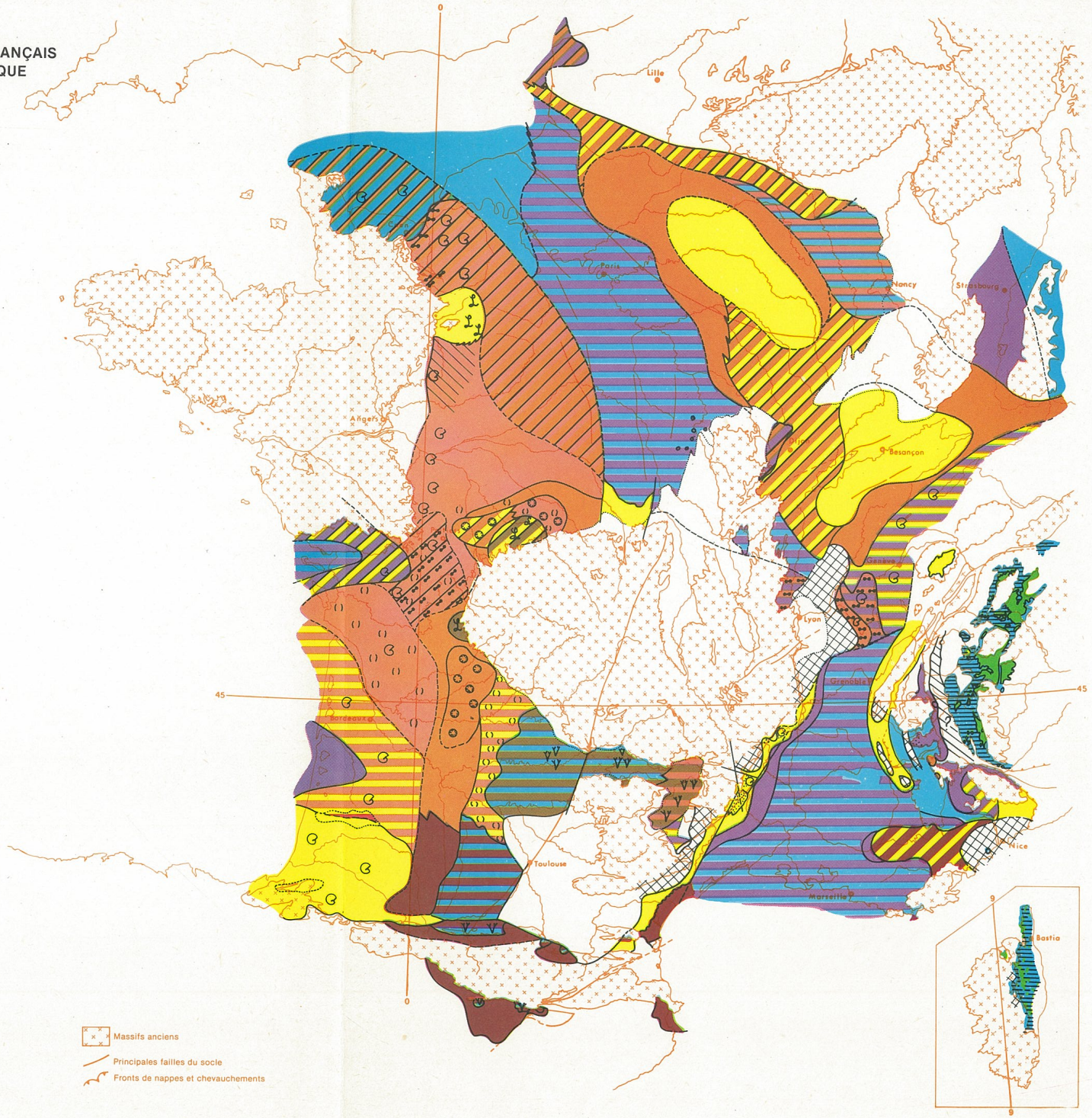
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

BATHONIEN INFÉRIEUR ET MOYEN

CARTE DES FACIÈS

Coordonnée par C. MANGOLD





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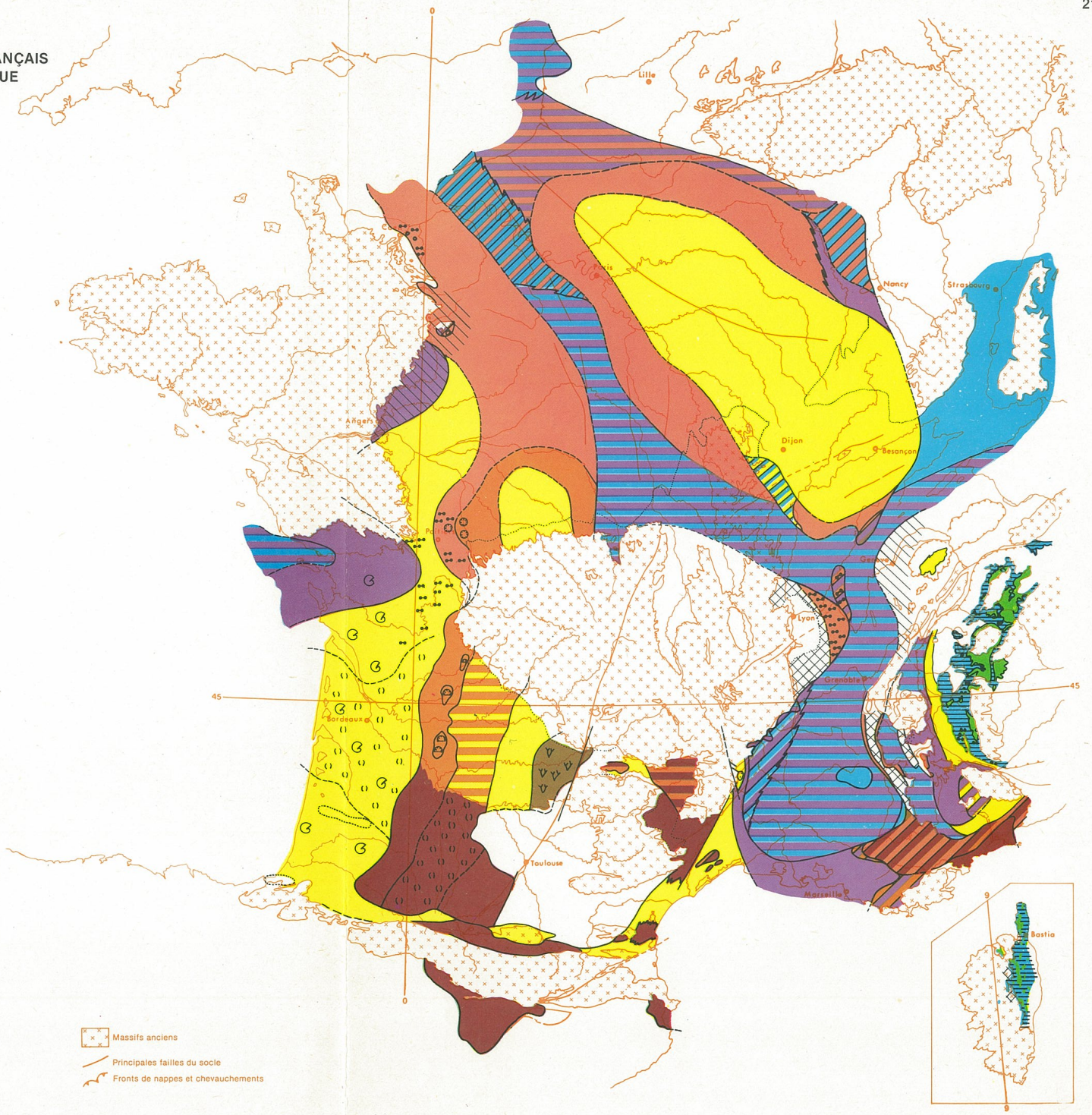
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

BATHONIEN SUPÉRIEUR

CARTE DES FACIÈS

Coordonnée par C. MANGOLD



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

Limite des affleurements ou d'érosion du Jurassique moyen,

Massifs anciens

Principales failles du socle

Fronts de nappes et chevauchements

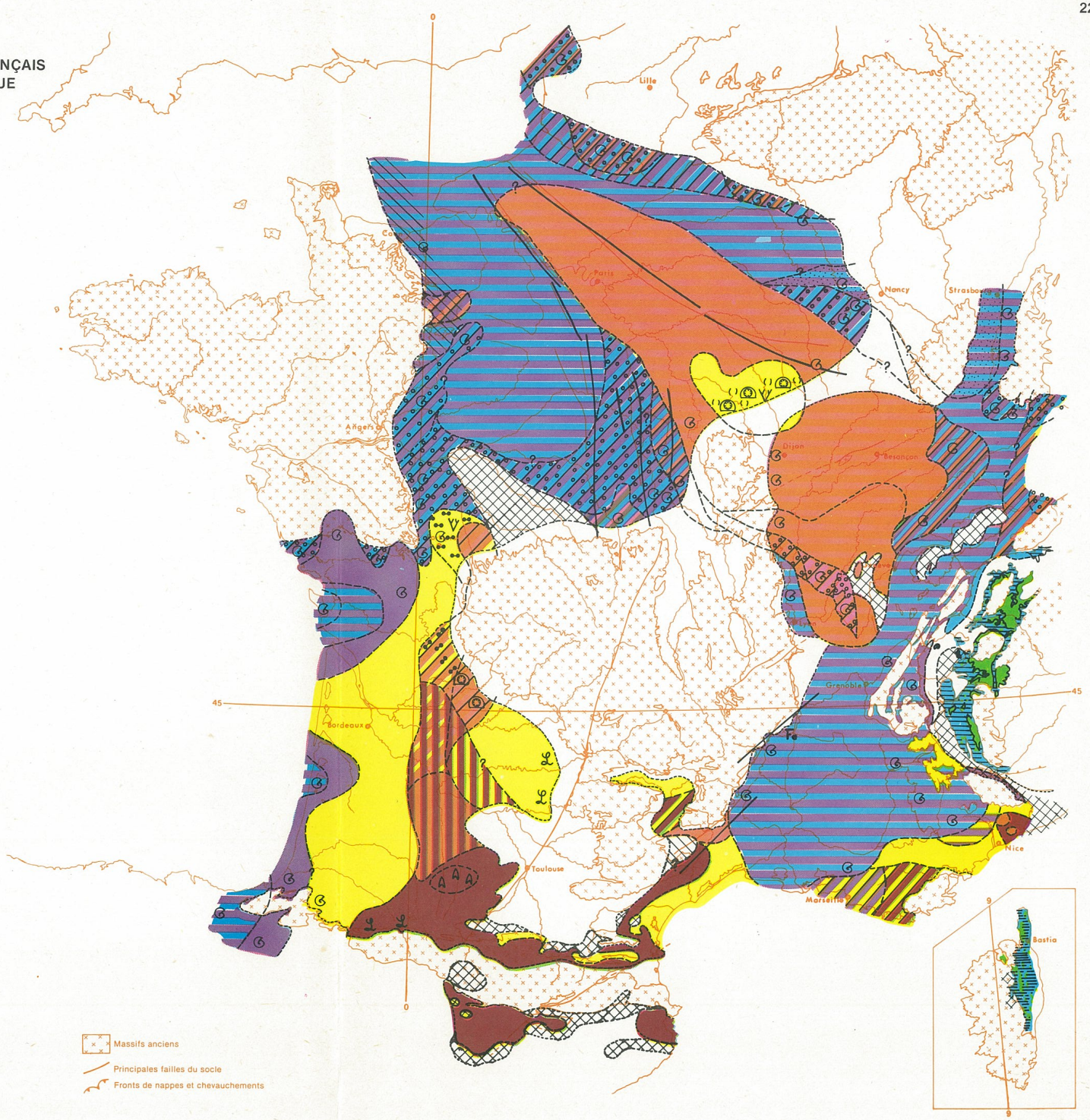
Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

CALLOVIEN INFÉRIEUR

CARTE DES FACIÈS

Coordonnée par J. THIERRY



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

Limite des affleurements ou d'érosion du Jurassique moyen,

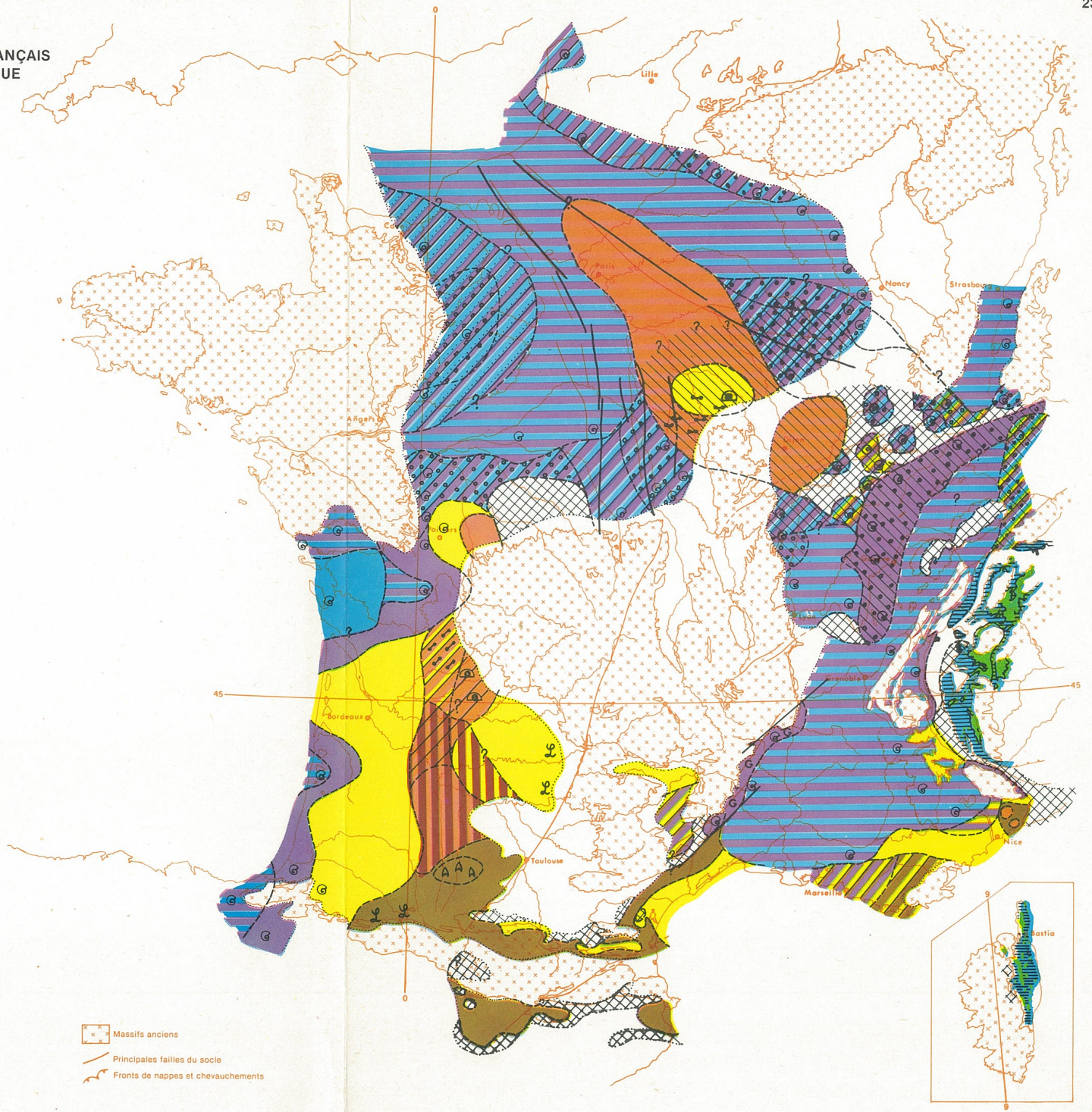
Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

CALLOVIEN MOYEN

CARTE DES FACIÈS

Coordonnée par J. THIERRY



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
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SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche-anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

- Limite des affleurements ou d'érosion du Jurassique moyen,
- Massifs anciens
- Principales failles du socle
- Fronts de nappes et chevauchements

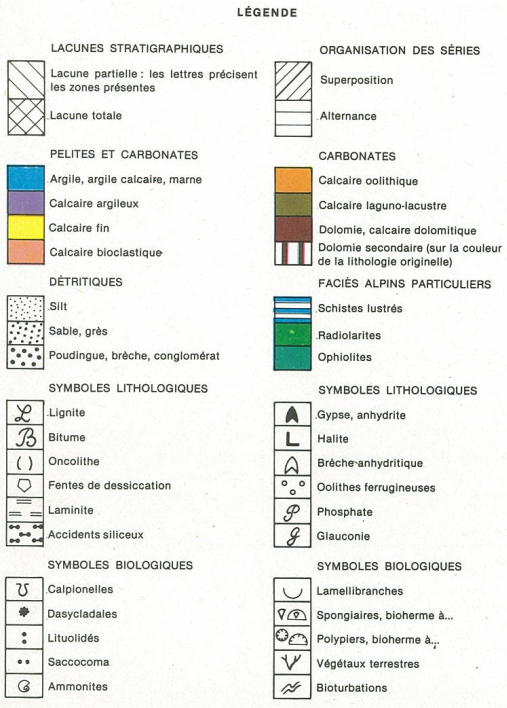
Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

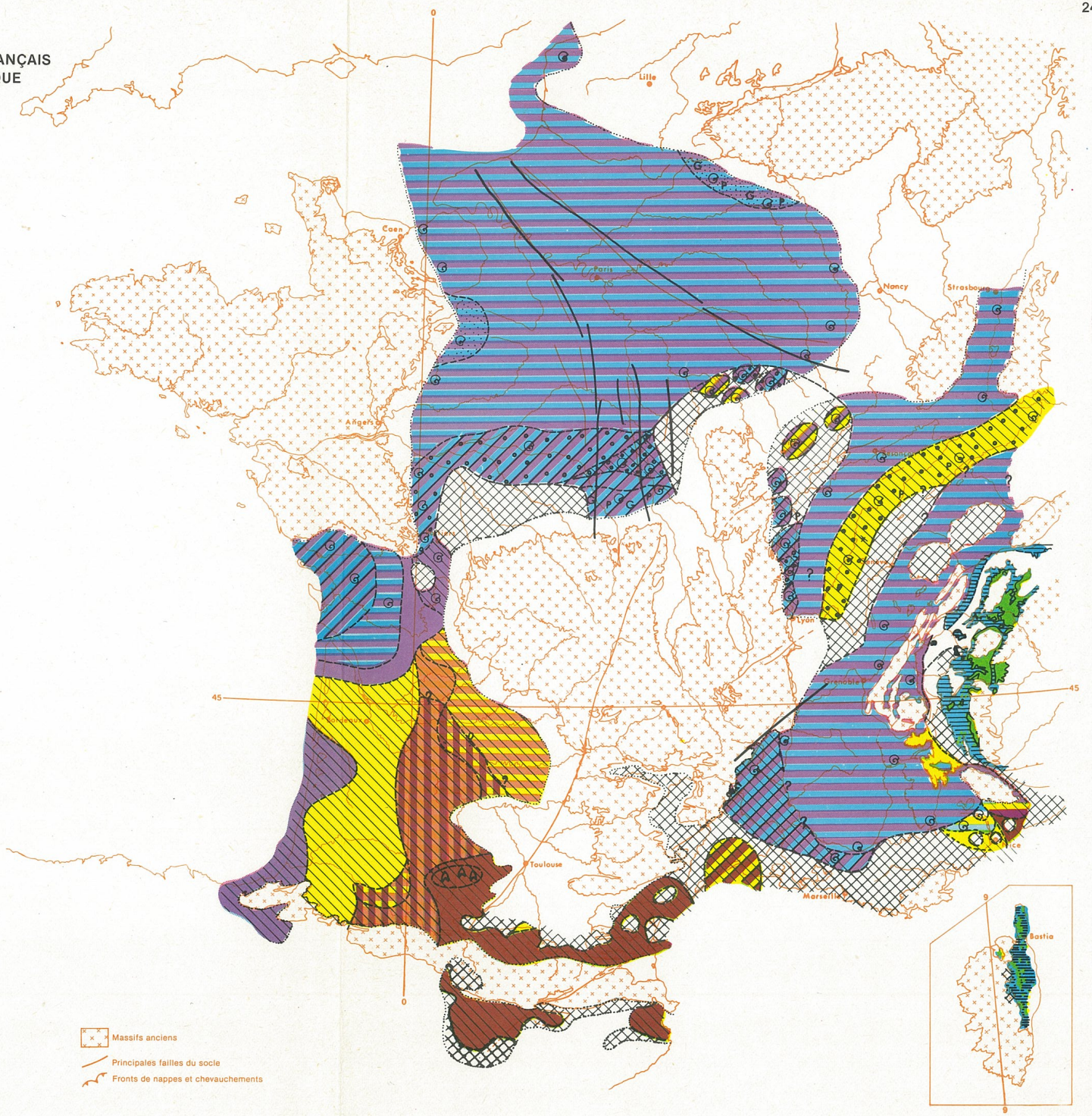
CALLOVIEN SUPÉRIEUR

CARTE DES FACIÈS

Coordonnée par J. THIERRY



Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

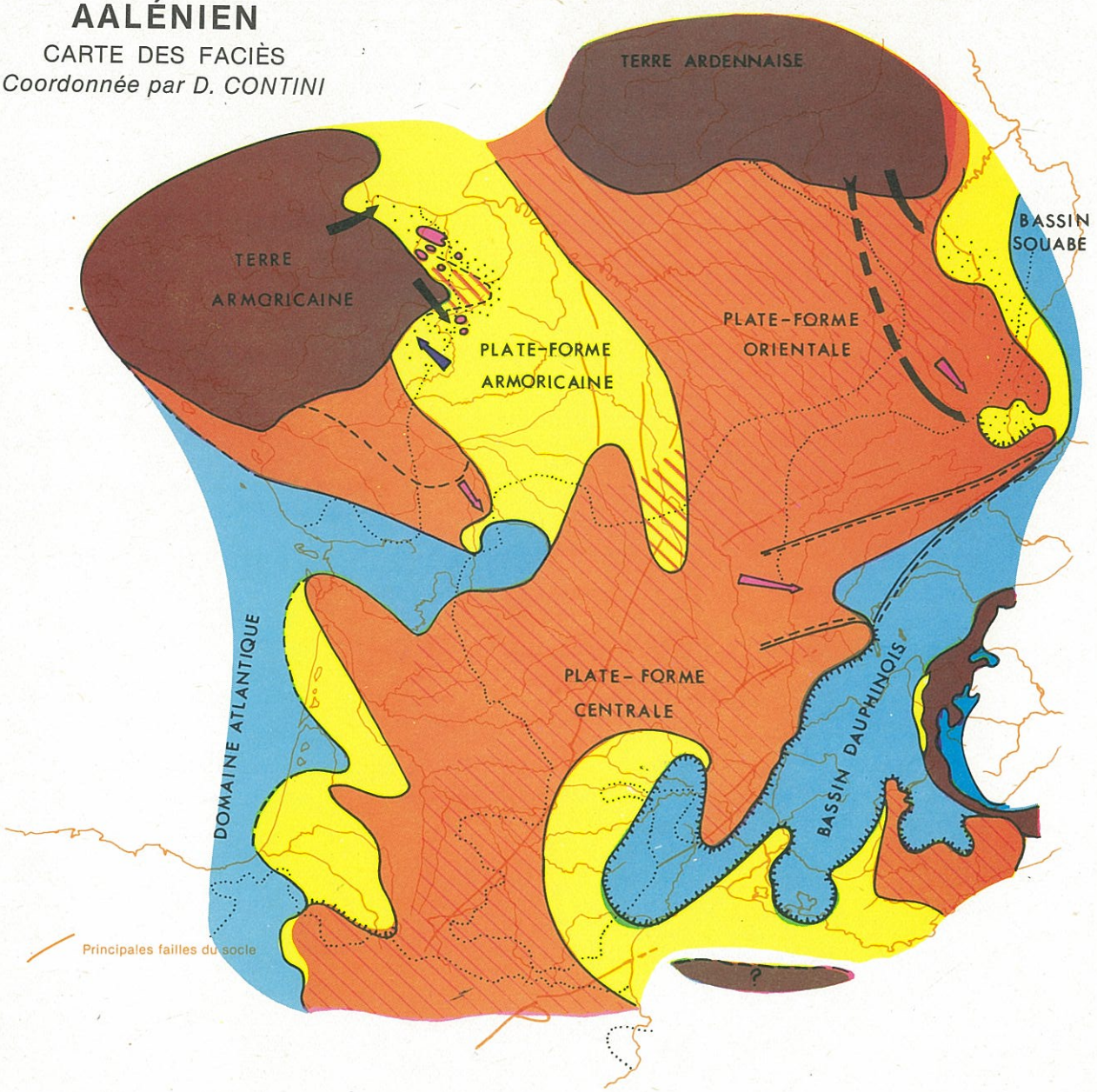


SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

AALÉNIEN

CARTE DES FACIÈS

Coordonnée par D. CONTINI



LÉGENDE

- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATEES
  - De haute énergie
  - De basse énergie
  - Vasière de plate-forme carbonatée
  - Milieu protégé
  - Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques

Milieux ouverts

- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux — Détritiques
- haut bas Pentes, talus — Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique inférieur

Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
Les domaines de sédimentation occupent leur emplacement actuel à l'exception des Préalpes non représentées.

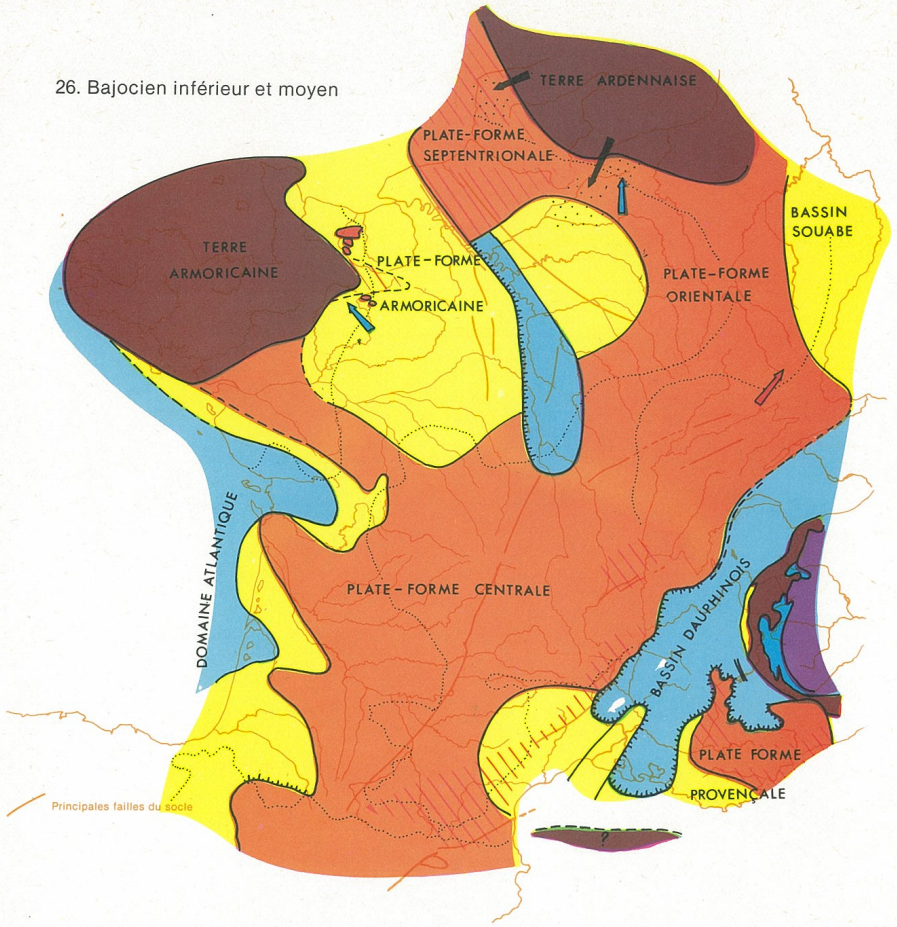
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

BAJOCIEN

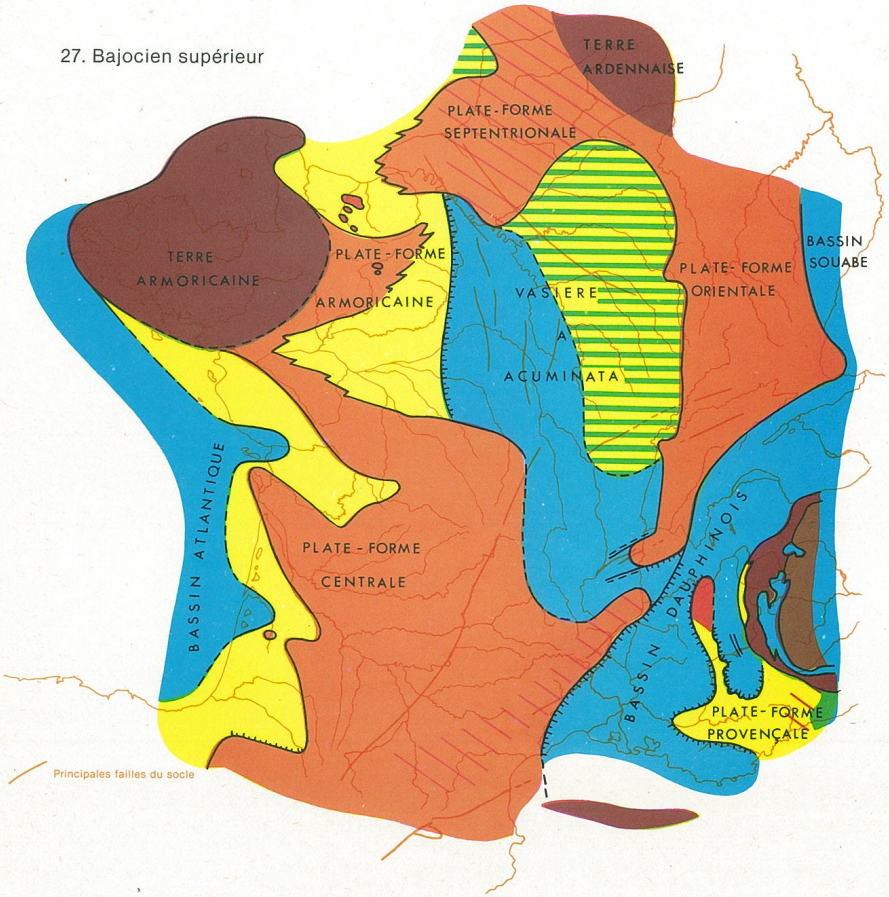
CARTES INTERPRÉTATIVES

Coordonnées par D. CONTINI

26. Bajocien inférieur et moyen



27. Bajocien supérieur



LÉGENDE

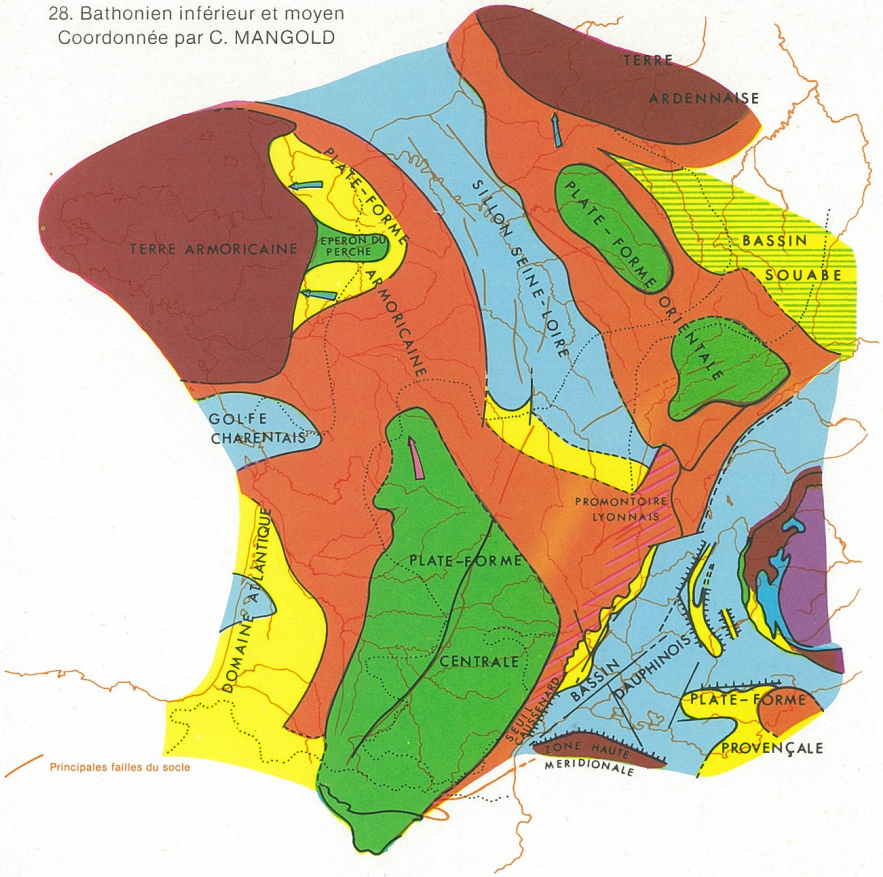
- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATEES
  - De haute énergie
  - De basse énergie
  - Vasière de plate-forme carbonatée
  - Milieu protégé
  - Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques

Milieux ouverts

- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux — Détritiques
- haut / bas Pentes, talus — Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique moyen

Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
Les domaines de sédimentation occupent leur emplacement actuel à l'exception des Préalpes non représentées.

28. Bathonien inférieur et moyen
Coordonnée par C. MANGOLD



LÉGENDE

- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATEES
  - De haute énergie
  - De basse énergie
  - Vasière de plate-forme carbonatée
  - Milieu protégé
  - Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques

Milieux ouverts

- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux
- Détritiques
- Pentes, talus (haut / bas)
- Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique moyen

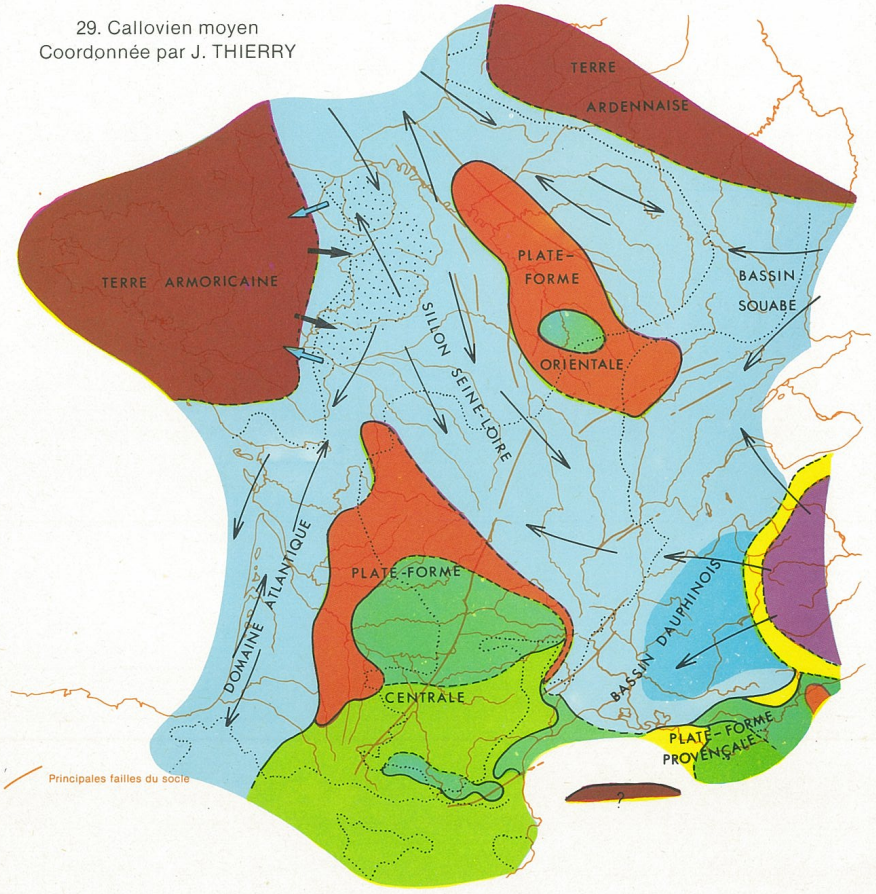
Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
Les domaines de sédimentation occupent leur emplacement actuel à l'exception des Préalpes non représentées.

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

BATHONIEN CALLOVIEN

CARTES INTERPRÉTATIVES

29. Callovien moyen
Coordonnée par J. THIERRY

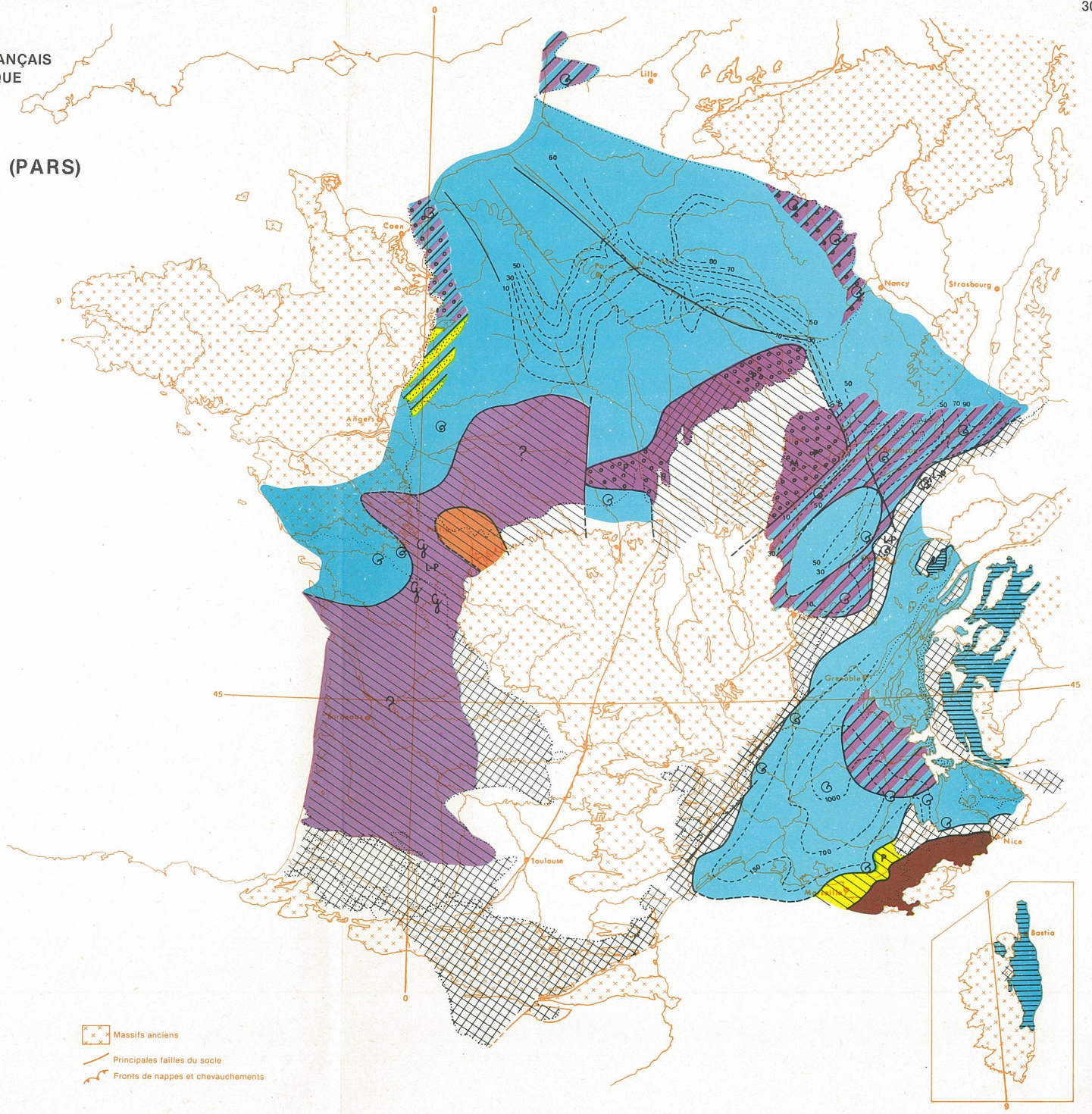


SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

OXFORDIEN INFÉRIEUR ET MOYEN (PARS)

CARTE DES FACIÈS

Coordonnée par R. ENAY



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

Limite des affleurements ou d'érosion du Jurassique supérieur

Zones représentées : M = Mariae ; P = Plicatilis (pars)
Zones représentées : L-M = Lamberti à Plicatilis (flaques)

Massifs anciens

Principales failles du socle

Fronts de nappes et chevauchements

Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

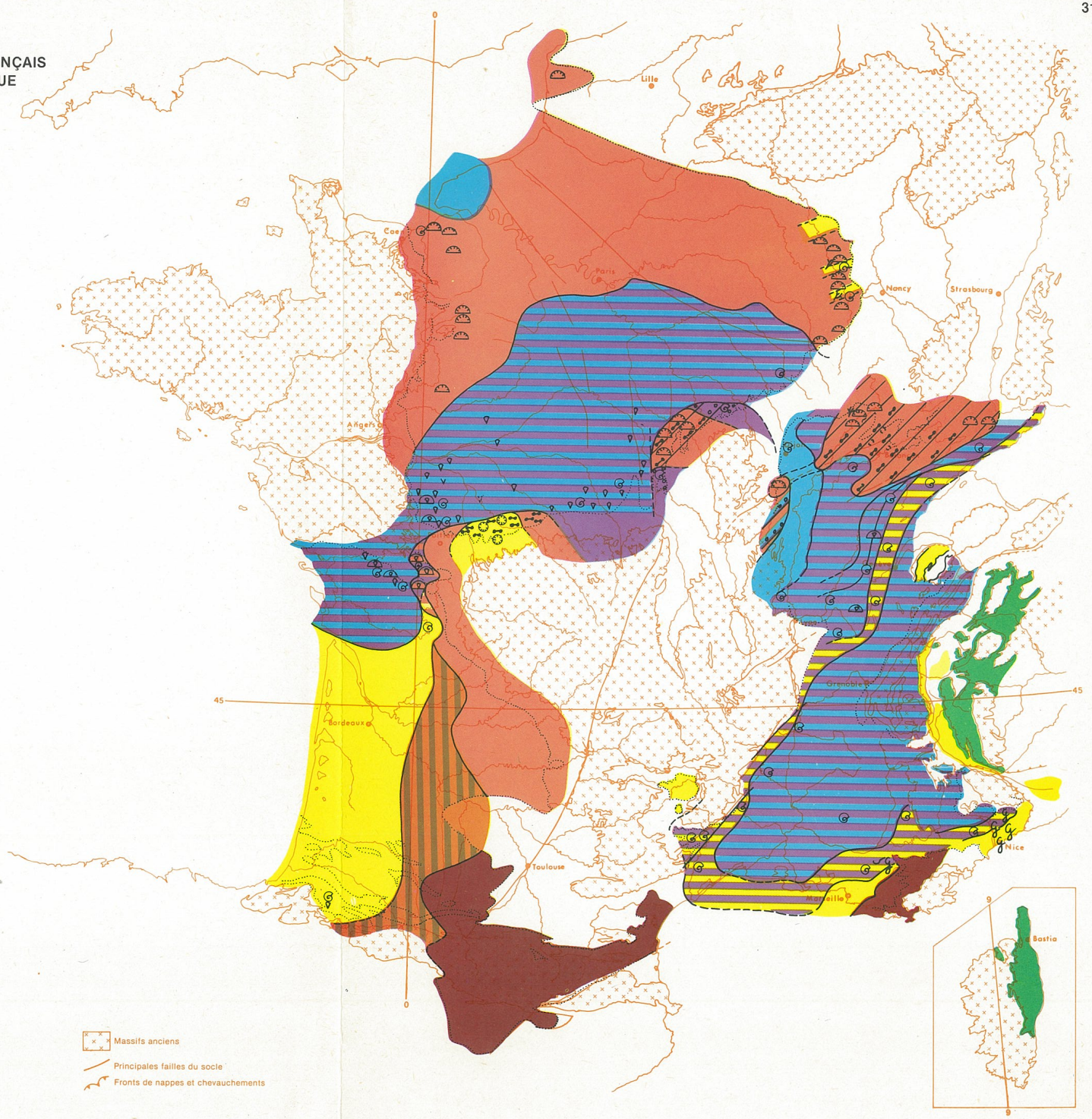
Pour les Alpes isopaques du membre supérieur des Terres Noires (Artru, 1972) incluant le Callovien.

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

OXFORDIEN MOYEN

CARTE DES FACIÈS

Coordonnée par R. ENAY



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

- Glissements sous-marins
- Limite des affleurements ou d'érosion du Jurassique supérieur
- Massifs anciens
- Principales failles du socle
- Fronts de nappes et chevauchements

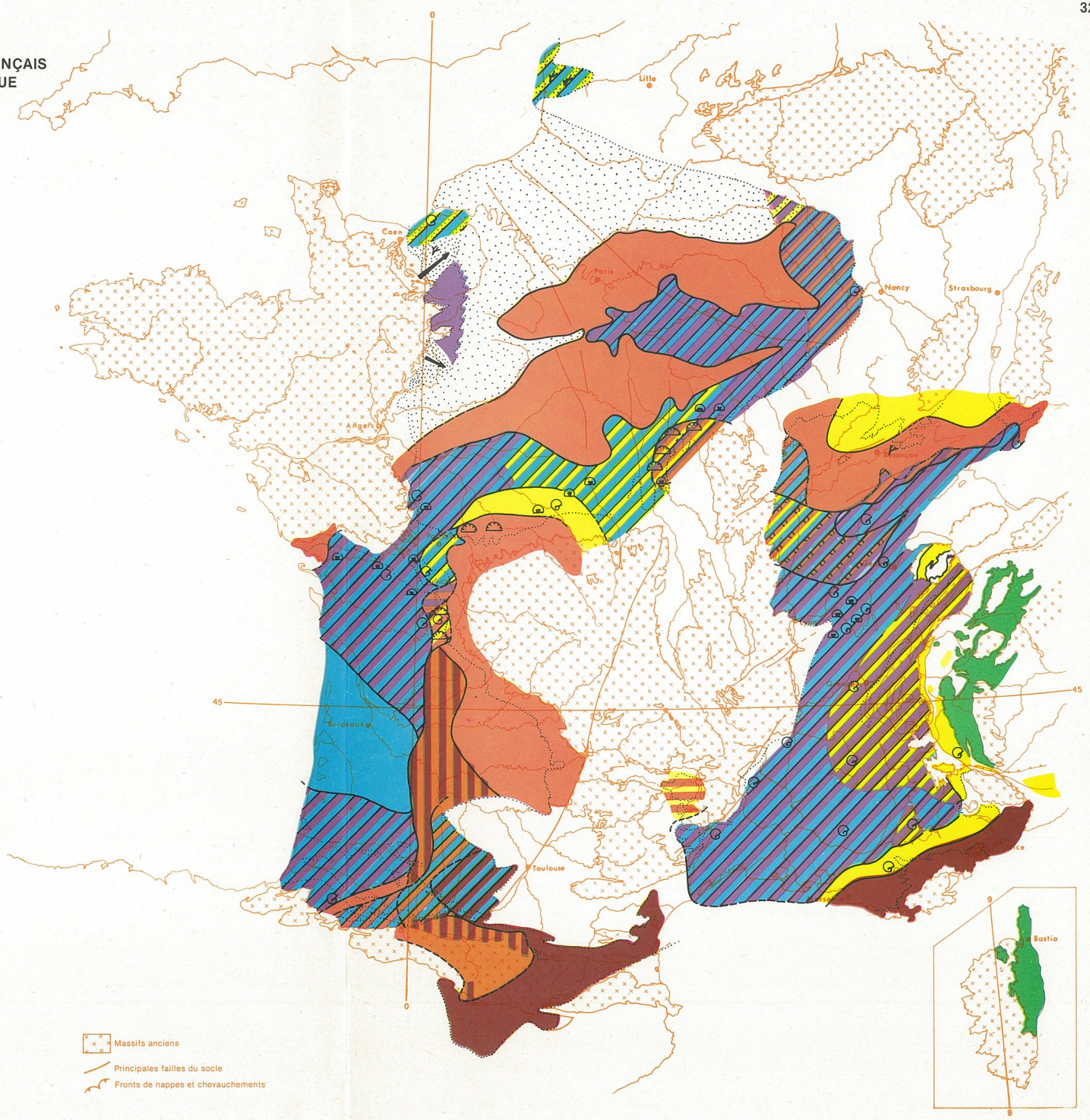
Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

OXFORDIEN SUPÉRIEUR

CARTE DES FACIÈS

Coordonnée par R. ENAY



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations
- Stromatopores

- Limite des affleurements ou d'érosion du Jurassique supérieur
- Massifs anciens
- Principales failles du socle
- Fronts de nappes et chevauchements

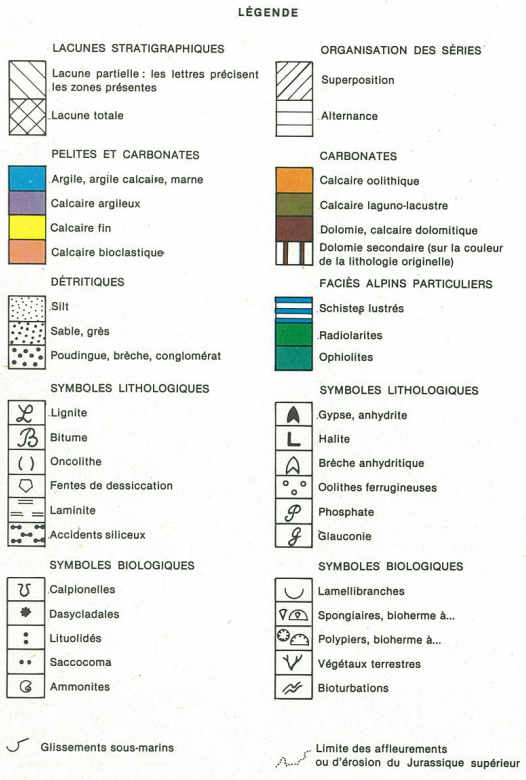
Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

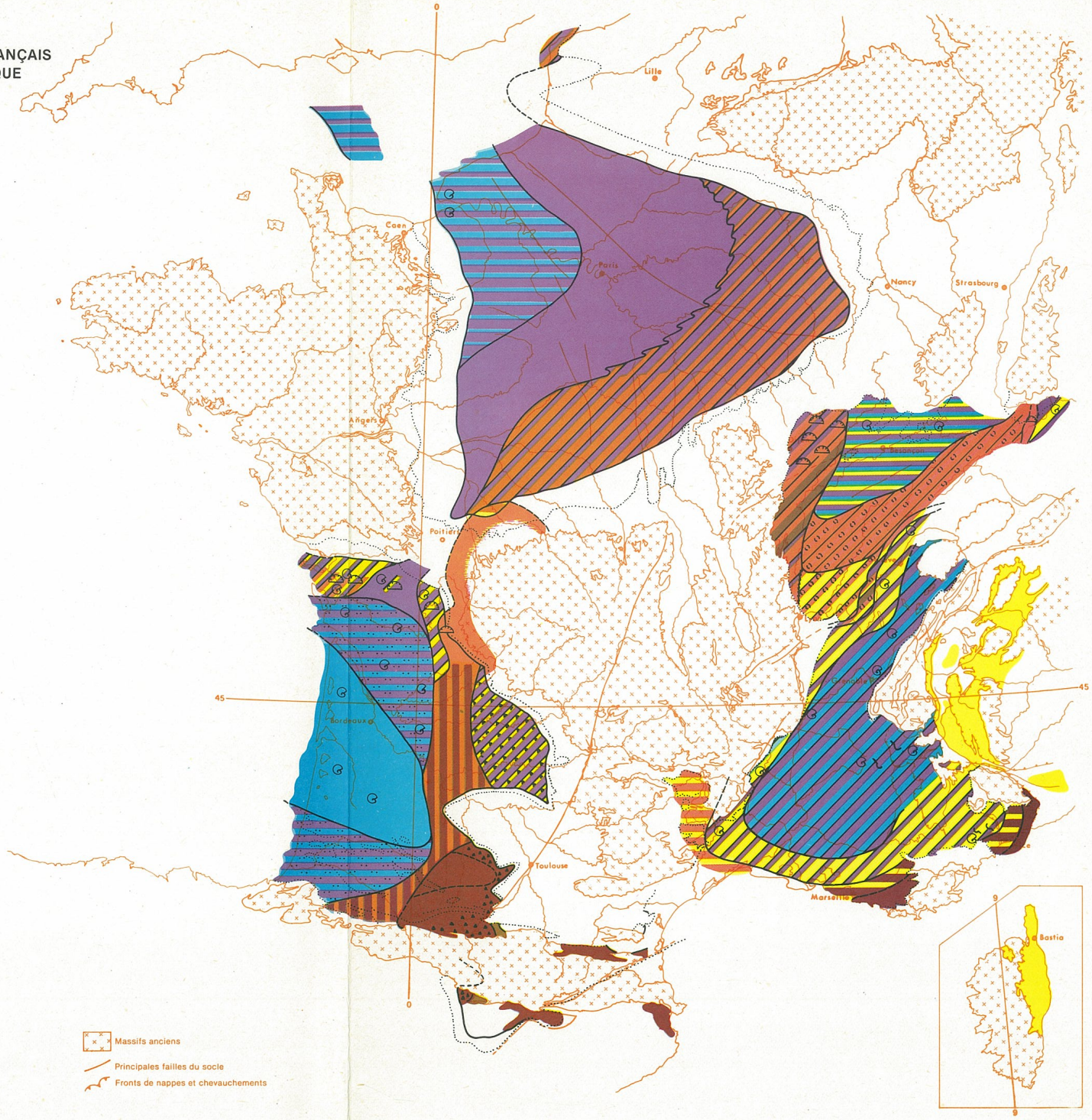
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

KIMMERIDGIEN INFÉRIEUR
(ET OXFORDIEN TERMINAL)

CARTE DES FACIÈS

Coordonnée par R. ENAY





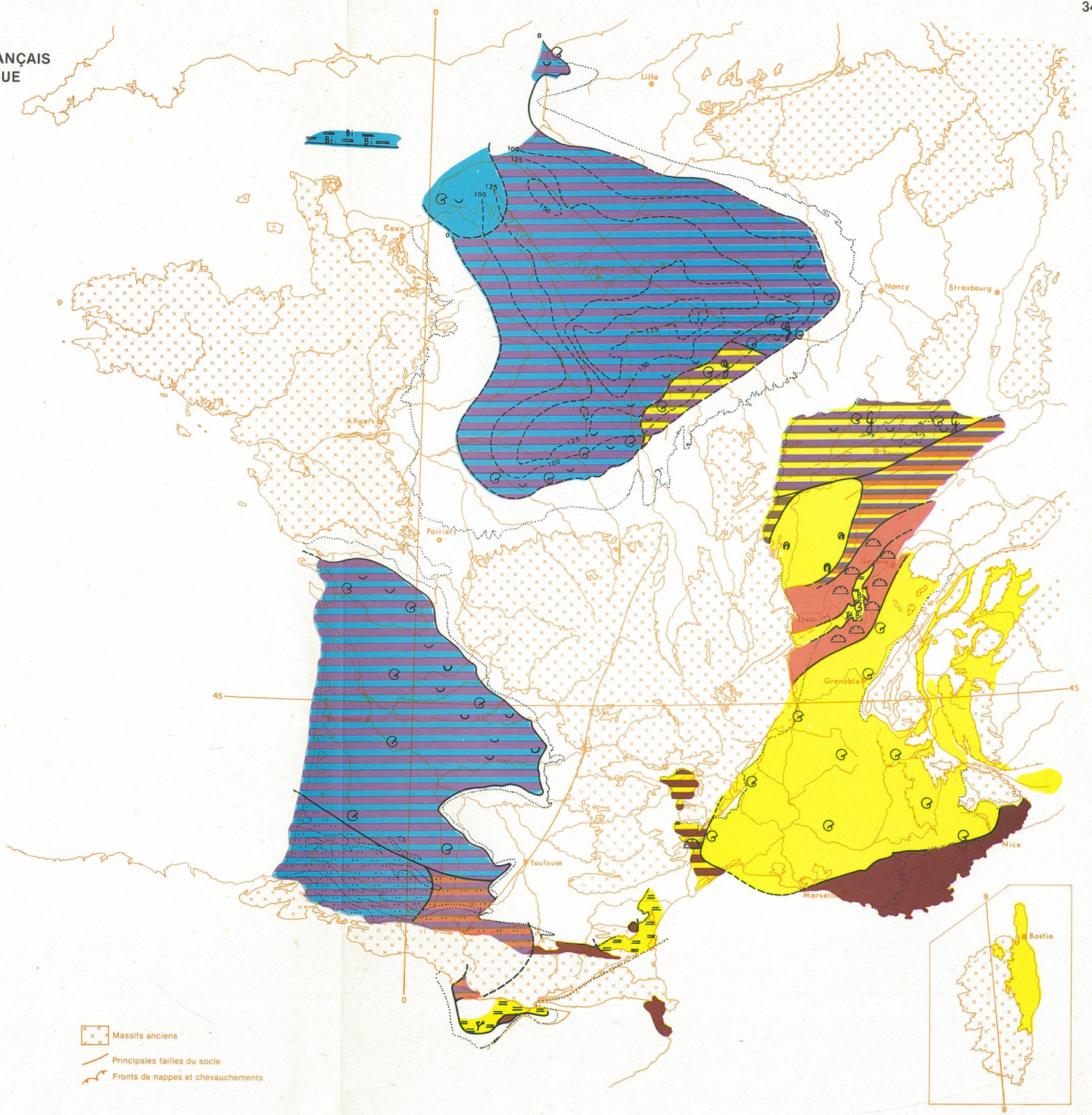
Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

KIMMERIDGIEN SUPÉRIEUR

CARTE DES FACIÈS

Coordonnée par R. ENAY



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations
- Stromatopores

- Limite des affleurements ou d'érosion du Jurassique supérieur
- Massifs anciens
- Principales failles du socle
- Fronts de nappes et chevauchements

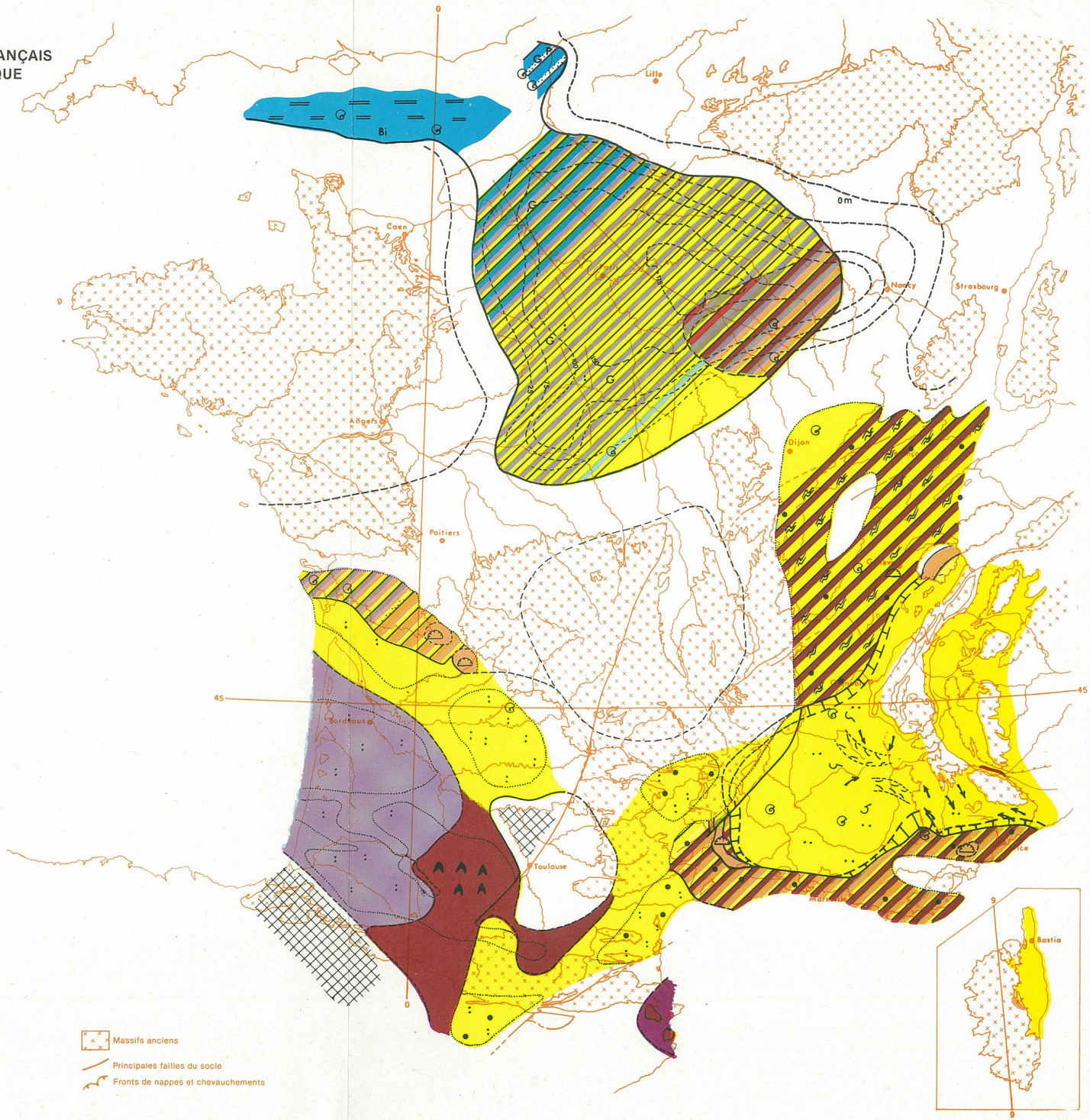
Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

PORTLANDIEN « INFÉRIEUR »

CARTE DES FACIÈS

Coordonnée par P. DONZE



LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

ORGANISATION DES SÉRIES
- Superposition
- Alternance

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Gypse, anhydrite
- Halite
- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

- Glissements sous-marins
- Direction de déplacement du matériel
- Limite des affleurements ou d'érosion du PORTLANDIEN
- Talus sous-marins
- Vallées d'érosion sous-marines

Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

PORTLANDIEN « SUPÉRIEUR »

CARTE DES FACIÈS

Coordonnée par P. DONZE

LÉGENDE

LACUNES STRATIGRAPHIQUES
- Lacune partielle : les lettres précisent les zones présentes
- Lacune totale

ORGANISATION DES SÉRIES
- Superposition
- Alternance

PELITES ET CARBONATES
- Argile, argile calcaire, marne
- Calcaire argileux
- Calcaire fin
- Calcaire bioclastique

CARBONATES
- Calcaire oolithique
- Calcaire laguno-lacustre
- Dolomie, calcaire dolomitique
- Dolomie secondaire (sur la couleur de la lithologie originelle)

DÉTRITIQUES
- Silt
- Sable, grès
- Poudingue, brèche, conglomérat

FACIÈS ALPINS PARTICULIERS
- Schistes lustrés
- Radiolarites
- Ophiolites

SYMBOLES LITHOLOGIQUES
- Lignite
- Bitume
- Oncolithe
- Fentes de dessiccation
- Laminite
- Accidents siliceux

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- Gypse, anhydrite
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- Brèche anhydritique
- Oolithes ferrugineuses
- Phosphate
- Glauconie

SYMBOLES BIOLOGIQUES
- Calpionelles
- Dasycladales
- Lituolidés
- Saccocoma
- Ammonites

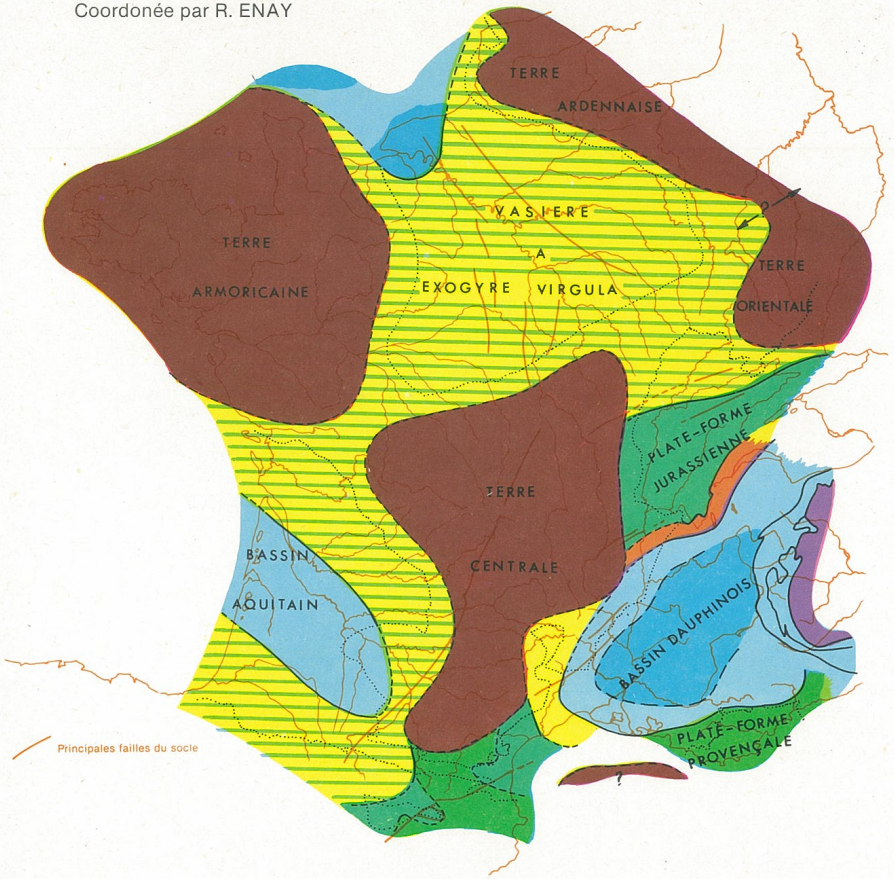
SYMBOLES BIOLOGIQUES
- Lamellibranches
- Spongiaires, bioherme à...
- Polypiers, bioherme à...
- Végétaux terrestres
- Bioturbations

- Glissements sous-marins
- Direction de déplacement du matériel
- Limite des affleurements ou d'érosion du PORTLANDIEN
- Talus sous-marins
- Vallées d'érosion sous-marines

- Massifs anciens
- Principales failles du socle
- Fronts de nappes et chevauchements

Les isopaques du Bassin de Paris sont extraites de la Synthèse géologique du Bassin de Paris (à paraître 1980).

41. Kimméridgien supérieur
Coordonée par R. ENAY



LÉGENDE

- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATEES
  - De haute énergie
  - De basse énergie
  - Vasière de plate-forme carbonatée
  - Milieu protégé
  - Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques

Milieux ouverts

- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux
- Détritiques
- Pentes, talus (haut / bas)
- Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique supérieur

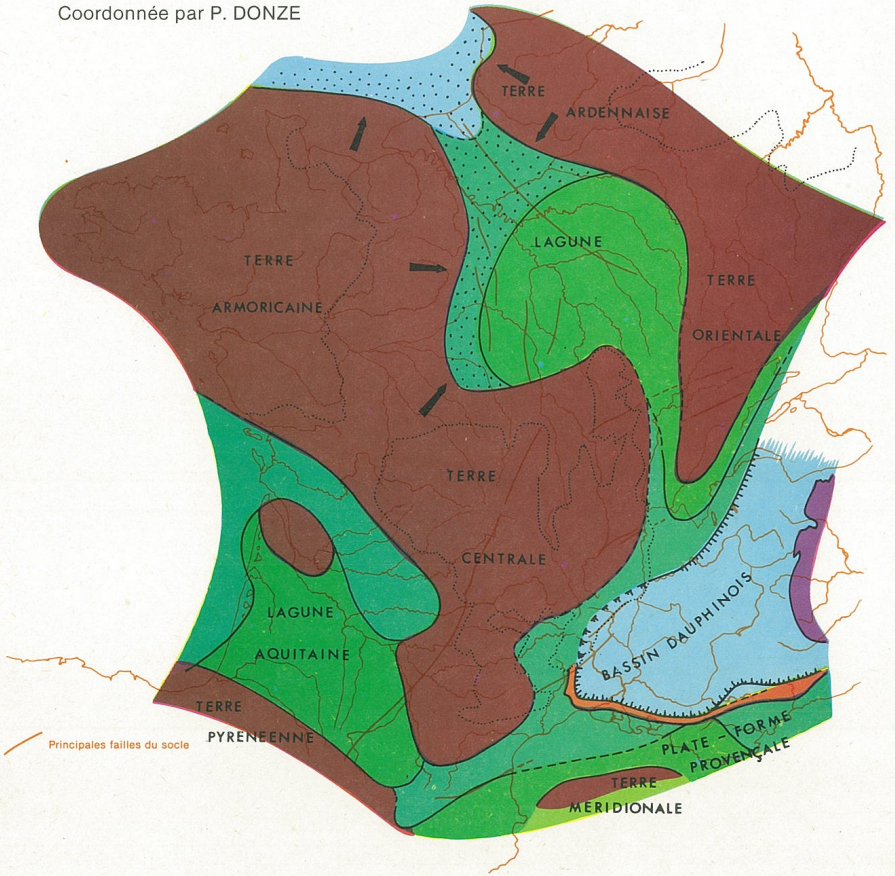
Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
Les domaines de sédimentation occupent leur emplacement actuel à l'exception des Préalpes non représentées.

SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

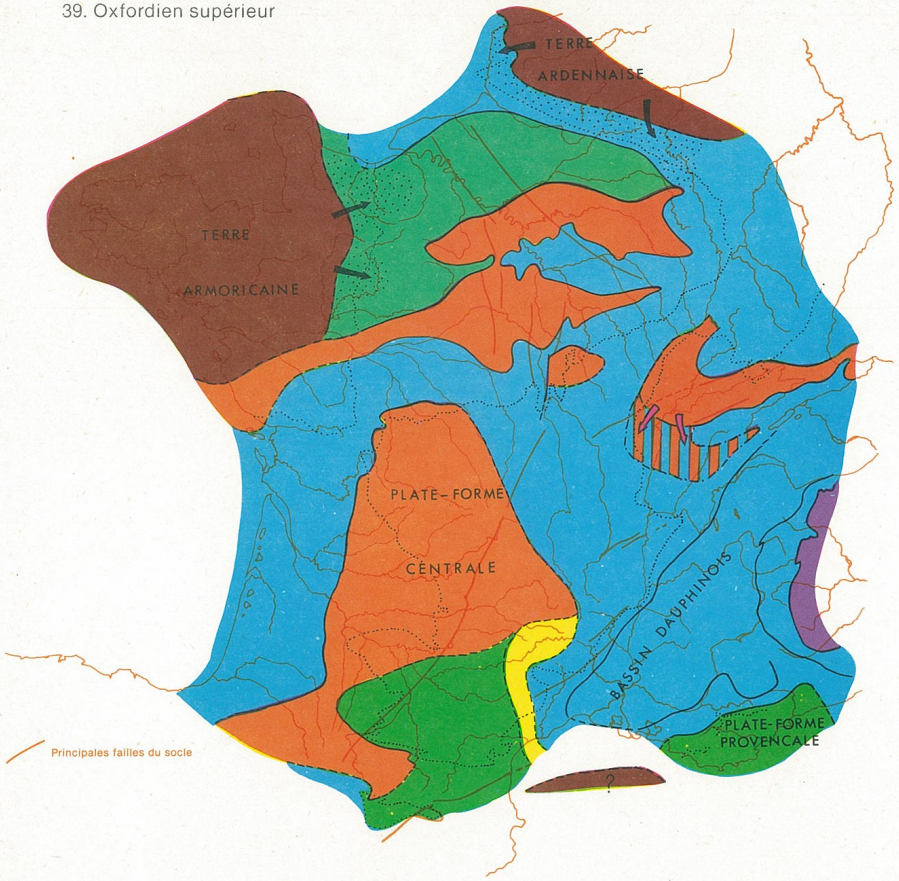
KIMMERIDGIEN SUPÉRIEUR
PORTLANDIEN SUPÉRIEUR

CARTES INTERPRÉTATIVES

42. Portlandien supérieur
Coordonnée par P. DONZE



39. Oxfordien supérieur



LÉGENDE

- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATEES
- De haute énergie
- De basse énergie
- Vasière de plate-forme carbonatée
- Milieu protégé
- Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques
- Milieux ouverts
- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux
- Détritiques
- Pentes, talus (haut / bas)
- Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique supérieur
- Oscillations des limites de la plate-forme

Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
Les domaines de sédimentation occupent leur emplacement actuel à l'exception des Préalpes non représentées.

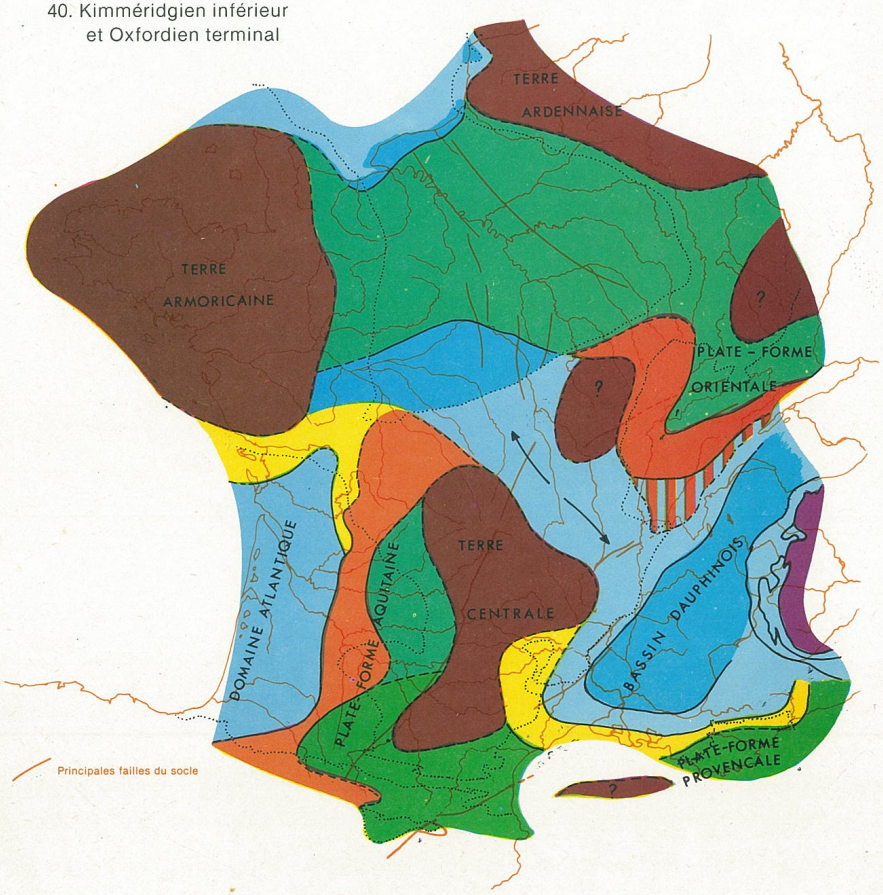
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

OXFORDIEN SUPÉRIEUR
KIMMERIDGIEN INFÉRIEUR

CARTES INTERPRÉTATIVES

Coordonnées par R. ENAY

40. Kimméridgien inférieur
et Oxfordien terminal



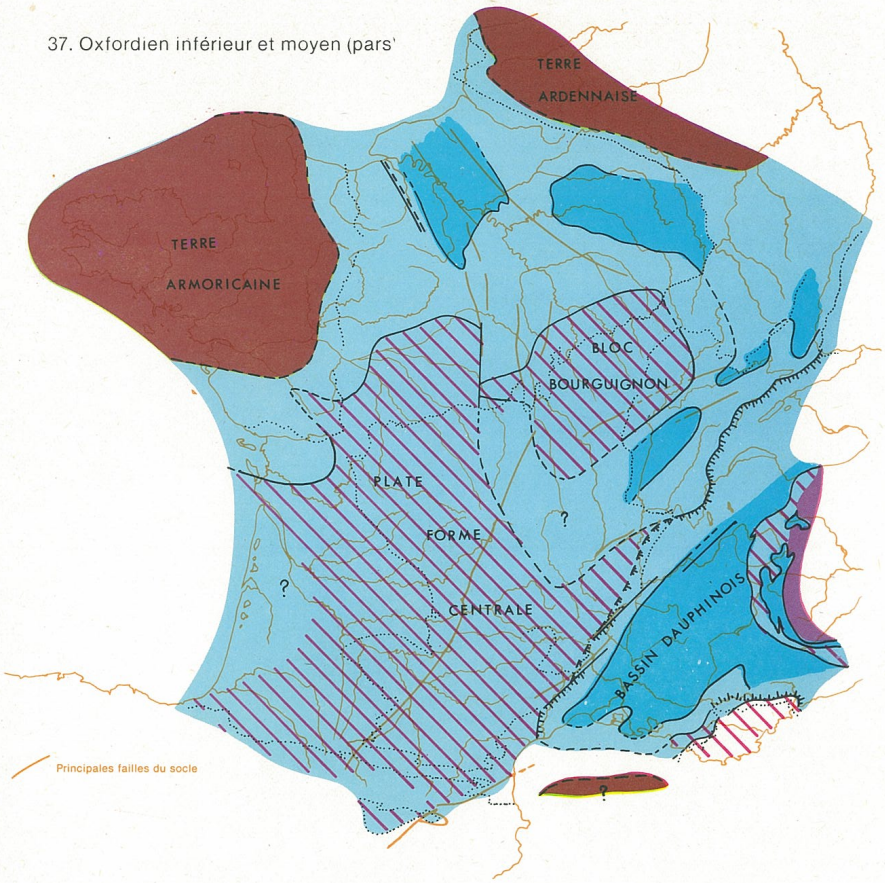
SYNTHÈSE PALÉOGÉOGRAPHIQUE DU JURASSIQUE FRANÇAIS
PAR LE GROUPE FRANÇAIS D'ÉTUDE DU JURASSIQUE

OXFORDIEN INFÉRIEUR ET MOYEN

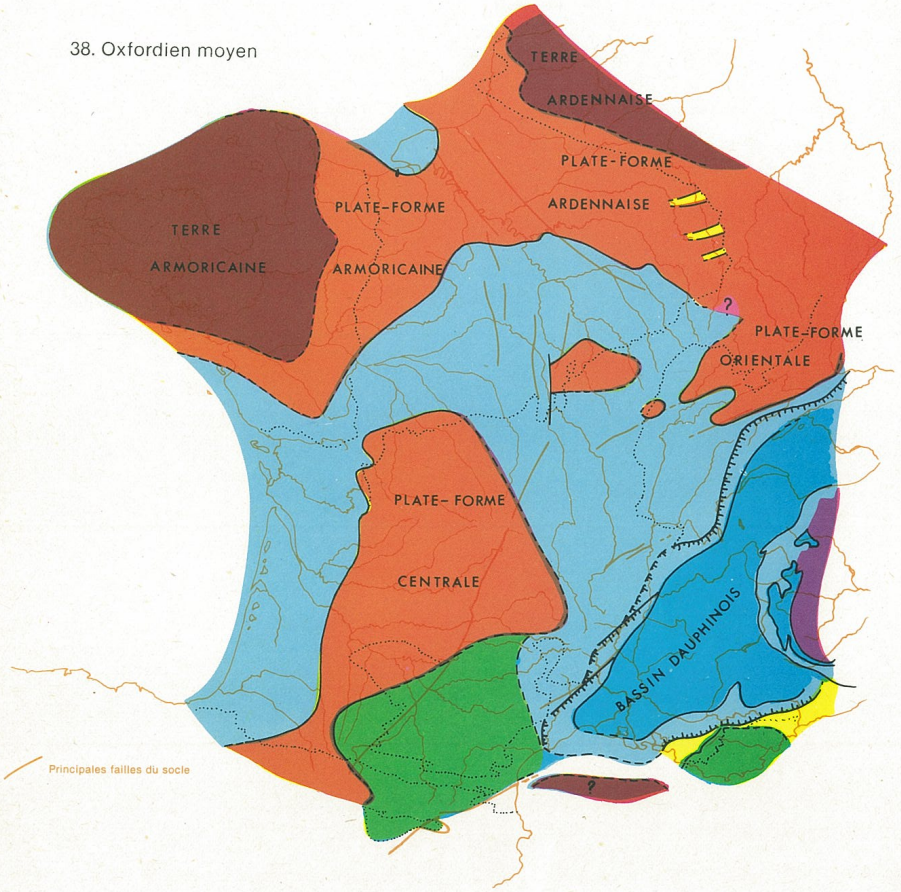
CARTES INTERPRÉTATIVES

Coordonnées par R. ENAY

37. Oxfordien inférieur et moyen (pars')



38. Oxfordien moyen



LÉGENDE

- Domaine océanique
- Bassin plus (1) ou moins (2) subsident
- PLATES-FORMES CARBONATEES
  - De haute énergie
  - De basse énergie
  - Vasière de plate-forme carbonatée
  - Milieu protégé
  - Milieu confiné
- Domaine émergé probable
- Zones à tendance positive : séries réduites, absence de dépôt ou érosions intra-jurassiques

Milieux ouverts

- Transgression
- Régression (couleur du domaine correspondant)
- Sens de progradation des corps sédimentaires
- Apports continentaux
- Détritiques
- haut bas Pentes, talus
- Glissements
- Failles actives reconnues ou probables
- Flexure (trait interrompu du côté subsident)
- Voie de communication et d'échange
- Limites d'affleurement ou d'érosion du Jurassique supérieur

Les régions à structure complexe, Alpes en particulier, ne font l'objet d'aucune interprétation rétrotectonique.
Les domaines de sédimentation occupent leur emplacement actuel à l'exception des Préalpes non représentées.

SYNTHESE PALEOGEOGRAPHIQUE DU JURASSIQUE FRANÇAIS

PAR LE GROUPE FRANÇAIS D'ETUDE DU JURASSIQUE

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