Pentevrian and brioverian in the North armorican massif : characteristics and geodynamic evolution

Bernard Auvray

"PENTEVRIAN AND BRIOVERIAN IN THE NORTH ARMORICAN MASSIF : CHARACTERISTICS AND GEODYNAMIC EVOLUTION".

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Abstract :

The North Armorican Massif is one of the rare areas within the Hercynian belt of Western Europe where the Precambrian basement outcrops. Within this basement, two main cycles may be distinguish (1) The Pentevrian or Icartian (2.2 - 1.8 Ga) composed of metamorphic rocks mainly derived from magmatic protoliths. (2) The Brioverian which includes several sedimentary and volcanic units among which stratigraphic correlations are not perfectly established. The numerous plutons emplaced during this period allow a chronology of the main tectonometamorphic events to be established.

Nowadays, the Late Precambrian evolution (660 Ma - 540 Ma) of the North Armorican domain is interpreted as resulting from a subduction geodynamic process, but the vergence of the subduction remains a matter for discussion. Nevertheless, most of the major structures now visible in this domain are related to this Precambrian history.

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The first comprehensive synthesis concerning the Precambrian terrains in the North Armorican Massif has been proposed by Cogné, in 1962, mainly based on the cartographic data of Barrois, Pruvost, Graindor and Cogné himself. As it is possible to observe on fig.1, the Precambrian in this area was subdivided into two main cycles (Cogné 1962).

(1) A highly metamorphosed basement, granodioritic in composition in evidence at Jospinet on the eastern flank of the Baie de St Brieuc and called by Cogné the Pentevrian (Cogné 1959).

(2) This gneissic basement was unconformably overlained by the Brioverian composed of two stages separated by an orogenic phase : at the base, a volcano-sedimentary sequence; at the upper part, and exclusively sedimentary series. The main phase of metamorphism, deformation and granitisation occured at the end of the first stage and was achieved at the end of the second stage with the intrusion of the Mancellian granites.

Fig. 1 →

The first questions concerning the validity of this scheme appeared in 1971 when a new datation of the Erquy volcanic formation, considered as a reference level for the base of the Brioverian, yielded a Lower Paleozoic age of about 480 Ma (Vidal et al. 1971). One of the main consequences of this new radiometric data was to introduce some doubt concerning the existence of Pentevrian at least in the area where it was defined and also to introduce confusion in the Brioverian stratigraphy.

An investigation among the voluminous bibliography concerning the Northern part of the Armorican Massif demonstrates :

(1) That a large amount of various available data have been obtained during the last twenty years.

(2) That the precambrian stratigraphy, especially the Brioverian stratigraphy, has been strongly modified.

(3) That all the authors try to explain the geodynamic evolution during the Precambrian by using a plate tectonic model and more precisely a subduction model. But there is no complete agreement concerning the direction of this subduction.

Consequenlty, it seems now necessary to separate the facts which seem well established from interpretations and hypothesis; this is the main purpose of this paper.

II - MAIN CHARACTERISTICS OF THE PRECAMBRIAN FORMATION IN THE NORTH ARMORICAN DOMAIN :

Let us define the main characteristics of the Precambrian in the North Armorican Massif and first of all the Pentevrian.

(A) The Pentevrian :

The only area where the Pentevrian formations are well-defined is located at the northern margin of the North Armorican Massif, along a line starting from the Tregor area to Cap de la Hague in the Cotentin Peninsula (figure 2).

Fig. 2 → The radiometric data obtained by Adams (1967, 1976), Calvez and Vidal (1978), Auvray et al. (1980), Piton (1985), yield a Lower Proterozoic age ranging from 2,2 by to 1,8 by. The Pentevrian, particularly well exposed in Guernsey and in the Trebeurden area near to Lannion is mainly composed of metavolcanics, metasediments and metagranitoïds. Metavolcanics, varying from basic to acidic types (amphibolites to acidic gneisses) are largely dominant; the only well developed sedimentary sequences being the Jerbourg and Pleinmount metasediments in Guernsey (Roach 1966). Granitoîds, actually transformed into augen-gneisses, are the most typical facies with compositions varying from granodiorite to quartz-monzonite. All the magmatic rocks (including volcanics and plutonites) show a calc-alkaline evolution in the AFM diagram (fig. 3a) and in the Tarney diagram (fig. 3b). All the formations have been metamorphosed in Fig. 3 → the amphibolite facies and in places, it is possible to observe the first stages of a migmatisation. Because of the scattering and small extent of the outcrops, it is impossible to define a large scale metamorphic zoneography and structure in this Lower Proterozoic basement. The ages have been determined on the augen-gneisses and consequently are a minimum age for the volcanics and the sediments intruded by these granitoîds.

Nowhere else in the Armorican Massif has this basement been recognized with certainty, especially in the Jospinet area where it was defined for the first time. At that place, there is no radiometric data and no geological evidence, the main argument (that is the Brioverian age of the volcanic series of Erquy) being highly doubtful.

Finally, concerning the name of this period, it is proposed to use the term Pentevrian as equivalent of Icartian, considering that in its original definition Pentevrian included all the terrains older than the Brioverian.

(B) The Brioverian : Many attempts have been made to establish a comprehensive stratigraphy among the various lithologic units belonging to this stage. Actually, these correlations are not well defined.

At present, with the exception of the Perelle Gneisses in Guernsey which have yielded an age around 700 Ma (Wilson 1986, unpublished data), the oldest age in the Brioverian has been obtained on a granitic pebble of the Cesson Conglomerate and is around 660 Ma (Guerrot et al. 1986). Consequently, this conglomerate, which is considered as the lower part of the Brioverian, has a maximum age of 660 Ma.

Fig. 4 → All over the Baie de St Brieuc area, from the Tregor to St Malo, are exposed numerous lithological units composed of volcanics and sedimentary rocks. The correlations are difficult to establish between these units since they actually belong to tectonic blocks joined side by side during the Cadomian tectogenesis. The most recent syntheses clearly show that there is a tendancy to consider that the variations observed in the different units result from lateral facies variations more than vertical ones. This concept is clearly expressed for instance in the stratigraphic table proposed by Chantraine et al. (1988) and Dissler et al. (1988) (fig.4) and also by Balé (1986) to explain the correlations between the various units outcropping in the South part of the Baie de St Brieuc (fig.5).

Fig. 5 → These units have suffered various degrees of metamorphism from greenshist facies (in the Tregor or Lamballe series) to amphibolite facies in the Lanvollon or Yffiniac formations.

The facts which seem well established are as follows (fig.4) :

(1) The volcanics are very abundant in the northern part of the domain and decrease towards the South-South East in the St Cast, St Malo and Lamballe series.

(2) Among the sedimentary rocks, the black cherts or "phtanites" are considered as a good stratigraphic marker. Consequently, Le Corre (1977) has proposed to use the term "Phtanitic Brioverian" to designate all these units which belong to the Lower Brioverian.

(3) During this first stage of Brioverian, and with the exception of the 660 Ma age of a granodioritic pebble in the Cesson conglomerate, radiometric data are the following :

(a) The 615 Ma age of magmatism in the Tregor area (Graviou 1974).

(b) The 600 Ma age of the basic-ultrabasic sequence of Belle-Isle-en-Terre - Yffiniac (Peucat et al. 1981 ; Guerrot & Peucat this volume).

(4) Except the St Malo - St Cast and Lamballe units, the tectonic and metamorphic evolution ended around 590 Ma, the age of the syntectonic emplacement of the dioritic massifs like that of Coëtmieux - Fort-la-Latte (Vidal et al. 1974 ; Genestier 1984 ; Balé 1986).

(5) Eastwards, in Normandy, appears the same phtanitic Brioverian including large amounts of volcanics (Le Vast, Montsurvent, La Terrette and les Mortes Femmes séries, Dupret 1986 ; Dissler 1987) metamorphosed in the greenschist facies; in this area, the minimum age for the "Phtanitic Brioverian", is given by the emplacement of the Coutances diorite at 585 Ma (Guerrot et al., 1986).

After the Phtanitic cycle, occurs à flysch-type sedimentation with rare volcanic intercalations like the Vassy spilites in Normandy (Dupret et al. 1985). This post-phtanitic cycle is well developed in Normandy (Granville and La Laize series) but is only known in Brittany in the small area of Le Minard near to Paimpol (Denis 1987). The only appreciable metamorphism in this formation is the metamorphism developed at the contact of the Mancellian granites which were emplaced at 540 Ma (Graviou et al. 1988). This age indicates the end of the Cadomian evolution. During this post-phtanitic stage, the St-Malo - Lamballe and Rance series suffered a high temperature - low pressure metamorphism (Brun & Martin 1978) characterized by the appearance of migmatites in the St Malo area, the age of the metamorphism being 540 Ma (Peucat 1982, 1986 ; Peucat & Martin 1985).

The post-phtanitic Brioverian occurs, then, between 590 Ma and 540 Ma. This time range includes the magmatism dated around 550 Ma in the Northern part of the Armorican Massif (Auvray 1975). The ignimbritic volcanics are characteristic of this magmatism and in Normandy, at St Germain Le Gaillard, are directly overlained by the Lower Cambrian formations.

In short, according to the available radiometric data, the Brioverian cycle covers a period of about 120 Ma, the major tectonic events occuring since 590 Ma.

Consequently, the geodynamic models are constrained by the main facts summarized in the table I.

Tabl. I →

III - GEODYNAMIC MODELS - DISCUSSION :

It was at the end of the seventies that the first plate tectonic models were proposed to explain the Precambrian evolution in the North Armorican Massif. Fig.6 shows an example of this modelisation proposed by Auvray (1979) with an oceanic plate plunging under a continental margin constituted by the North Armorican Domain.

Fig. 6 → The models were based on the following main arguments :

(1) The existence of an oceanic domain outlined by a well-marked magnetic anomaly, trending SW-NE in the middle part of the Channel (Lefort 1975, 1977).

(2) The presence of an old sialic basement at the south margin of this oceanic domain.

(3) Emplacement in this continental margin of volcanics and plutonics of calc-alkaline affinity largely developed in the Tregor area (fig. 7).

Fig. 7 → This calc-alkaline affinity was the strongest argument favouring the subduction model, with a subduction plane dipping towards S-SE, the melting of the plate itself or of the above mantle wedge giving rise to the calc-alkaline magmatism.

At the same time, the age 600 Ma for the Belle-Isle-en-Terre Complex of oceanic affinity (Peucat <u>et al.</u> 1981), appeared to confirm the opening of a marginal basin south of the active margin, as was previously proposed by Hirbec (1979) and Auvray (1979).

Since this first proposal, numerous data concerning the characteristics of the sedimentation, the geochemistry of the volcanics, the geochemical and chronological zonations in the plutonism have allowed improvements to the model (see Chantraine <u>et al.</u> 1988, for references). Fig. 8, for instance, shows the regional zonation of the plutonites as given by Graviou and Auvray (1985 ; this volume).

Fig. 8 → More recently, Balé and Brun (1983) and Balé (1986), using structural arguments have demonstrated in the Baie de St Brieuc area :

(1) That it is possible to correlate the Belle-Isle-en-Terre and Yffiniac formations, correlation confirmed by datation, (Guerrot and Peucat, this volume) or the migmatitic belt of St Malo with the migmatitic series of Guingamp as shown on fig. 9.

Fig. 9 → **(2)** That the major Cadomian structures may be interpreted as interactions between imbricate thrust zones towards the S-SW and ductile sinestral wrench zones trending N 50°. This type of deformation has been related to an oblique subduction followed by collision and obduction which developed continuously from 600 Ma until 540 Ma. In fig. 10, it is possible to observe the resulting structures in the Brioverian formations in the St Brieuc area.

Fig. 10 →

The result of this new data, is that in more recent geodynamic models two domains are distinguished (fig. 11) :

(a) in the North, a volcanogenic domain characterized by its calc-alkaline magmatism and its M-type plutonisms with a mean age of emplacement around 600 Ma but in fact scattered between 620 Ma and 580 Ma.

(b) to the South a terrigeneous domain characterized by the lack (except the Vassy spilites in Normandy, fig.4) of volcanism and the nature and age of its plutonism (C-type and 540 Ma in age).

(c) between these two domains, a suture zone represents the closure of the Belle-Isle-en-Terre - Yffiniac back-arc basin.

Fig. 11 →

All this concepts are more or less taken in account in the various models proposed by Dissler et al. (1988) to explain the Precambrian evolution in Normandy (fig. 12) and by Chantraine et al. (1988) (fig. 13) or Graviou et al. (1988) (fig. 14) to explain the same evolution all over the North Armorican Domain. In the three models, the subduction plane is dipping towards the South-East. One of the main difference is the more complicated arc-system in the model of Dissler et al. (1988 ; fig. 12). The existence of a fore-arc, an intra-arc and a back-arc basin results from the various geochemical characteristics of numerous volcanic series (Le Vast, Montsurvent, la Terrette, Les Mortes Femmes series). In fact, some of the chemical data are conflicting and need further determinations; consequently, this arc-model has perhaps to be simplified in the future. Another important difference is that in the model for Normandy (Dissler et al., 1988), the vergence of the deformations is towards the North; it means that all the structures are synthetic, with regard to the direction of the subduction. In opposition, in the models of Chantraine et al. (1988) and Graviou et al. (1988), the vergence of the deformations is systematically towards the South, all the structures being antithetic compared to the subduction dipping.

Fig. 12, 13, 14 →

However, all these models with a subduction plane dipping towards the South become questionable if we consider the structural arguments of Balé and Brun (1983) and Balé (1986) :

(1) In the hypothesis of a subduction dipping towards the South, the systematic antithetic character of the structures, almost in the St Malo and St Brieuc areas, is surprising and has never been observed in modern subduction and collision systems.

(2) If we agree with the translation hypothesis of the Leon block proposed by Balé and Brun (1986) during Paleozoic times (fig. 15), the Channel ocean is not in its original position and must be translated towards the SW, in the prolongation of the Belle-Isle - Yffiniac suture, (see Brun & Balé, this volume, for more details).

Fig. 15 →

Considering these two strong structural arguments and taking into account all the other constraints, it is possible to propose an alternative geodynamic model with a subduction dipping towards the North (fig. 16).

- To the North, a continental domain southern margin of which is represented by the Dòmenean domain but which also includes the Precambrian formations of Wales, South England and South-East Ireland; this Precambrian block (Northern continent in fig. 16) may be a part of the Armorica plate defined by the geophysicists (Van der Voo 1979).

- Then an oceanic domain of limited extension, as is proved by the lack of true ophiolitic assemblage, the non typical oceanic characters of the volcanic series, the marginal type sedimentation and the short time for the closure of this ocean, about 10 Ma.

- Finally, a Southern continent, the Mancellian domain the southern extension of which is ignored in the paper.

After the opening of the ocean before 620 Ma the closure phase begins by a subduction of the oceanic plate under the Northern continent. Then follows the collision around 590 Ma and the underplating of the southern continent under the northern one until 540 Ma. The various stages of this geodynamic evolution are schematically shown in fig. 16.

Fig. 16 →

But this new model is not, again, entirely satisfying, mainly because there is a problem of timing between the opening of the ocean and the subduction process. The subduction has a minimum age of 620 Ma, which corresponds to the age of calc-alkaline magmatism in the Tregor; this means that, at that time, the ocean must has been open, but the only radiometric of the supposed oceanic domain (Belle-Isle - Yffiniac) is at 600 Ma.

Another question concerns the vergence of the deformations (see above); it seems clearly established that, in the Baie de St-Brieuc domain, the vergence is towards the South (Balé and Brun 1983). In contrast, in Normandy, the vergence of the Cadomian deformations has been described as being towards the North. (Dissler et al. 1988; fig. 12). Moreover, Lefort and Bardy (1987), on the base of geophysical arguments yielded by the SWAT-ECORS seismic profiles conclude that the main reflectors dipping towards the South observed in the Channel, are the traces of synthetic deformations related to Cadomian subduction of the Channel Ocean. This is an important problem which needs to be clarified.

Fig. 17 → The non-existance of the Channel ocean which is a consequence of the Balé and Brun hypothesis, does not have a dramatic effect on south dipping subduction models because it is always possible to find another ocean, for instance, the Celtic or Longmyndian ocean as has been previously proposed by Cogné and Wright in 1980 (fig. 17). In that hypothesis, Wales, South England, Southeastern Ireland and North Armorican Massif compose a single continental margin (Northern continent, fig. 17); this would explain the similar geological and geochronological characters of these regions (Shackleton 1975 ; Dunning 1975 ; Max 1975 ; Cogné and Wright 1980 ; Thorpe et al. 1984) . The Belle-Isle - Yffiniac-Coutances suture zone becomes again the trace of a marginal basin developed during the subduction. But remains the structural problem of synthetic deformations; to my knowledge, no characteristic Cadomian structure with a northward vergence has been described in the northern margin of this Northern continent, perhaps mainly because of the strong influence of Caledonian and Hercynian tectonics in that area.

In conclusion, the problem of the vergence of the subduction is not solved for the moment. The main fact enhanced in this revue is that there is a great paradox between the large amount of various geological information acquired concerning the Precambrian domain in the North Armorican Massif and the difficulties encountered in integrating all these data in a global evolution. This is partly because, today, we observe only some fragments of a puzzle; and also perhaps, because the scale of observation is very limited and does not correspond to the continental scale required to apply global tectonic models.

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Figure Captions

Fig. 1 - Precambrian stratigraphy in the North Armorican domain according to Cogné (1962).

Fig. 2 - Location (stars) of the outcrops of the Lower Proterozoic formations at the northern margin of the North Armorican Massif (after Auvray 1979) **(1)** Moulin de la Rive, **(2)** Trébeurden, **(3)** Port-Béni, **(4)** Guernsey, **(5)** Sark, **(6)** Alderney, **(7)** La Hague.

Fig. 3 - Calc-alkaline affinity of igneous rocks (volcanics and plutonites) constituing the Pentevrian or Icartian basement in the Tregor area (North Brittany). **(a)** AFM diagram, **(b)** Tarney's diagram (1976) (after Auvray 1979).

Fig. 4 - Stratigraphic correlations in the Brioverian formations of the North Armorican Massif (after Chantraine et al. 1988 and Dissler et al. 1987). **(1)** Port-Béni, **(2)** Tréguier, **(3)** Trédrez, **(4)** Paimpol, **(5)** La Roche Derrien, **(6)** Le Minard, **(7)** Le Moulin de la Rive - Trébeurden, **(8)** Locquirec, **(9)** L'Armorique, **(10)** St-Michel-en-Grêves, **(11)** Yffiniac, **(12)** Cesson, **(13)** Lanvollon, **(14)** Binic, **(15)** St Malo, **(16)** Lamballe, **(17)** La Rance, **(18)** La Hague, **(19)** Le Vast, Monsurvent, La Terrette, Les Mortes Femmes, **(20)** Phtanitic Brioverian of Normandy, **(21)** Granville and La laize, **(22)** Vassy.

Fig. 5 - Correlations between the various Brioverian lithological units outcropping in the Baie de St Brieuc (from Balé 1986).

Fig. 6 - Subduction geodynamic model proposed by Auvray (1979) for the Brioverian evolution in the North Armorican domain.

Fig. 7 - Calc-alkaline character of the brioverian magmatism in the Tregor area, North Brittany (after Auvray 1979).

Fig. 8 - Geochemical and chronological zonation within the brioverian magmatism (from 620 Ma to 540 Ma) in the North Armorican Massif (after Graviou & Auvray 1985 ; Graviou & Auvray, this volume). **M** = mantle type magmatic rocks; **C** = crustal type magmatic rocks and migmatites.

Fig. 9 - Geological sketch-map of the Baie de St Brieuc area according to Balé & Brun 1983 and Balé 1986 : **(1)** Metamorphic and migmatitic series of Guingamp and St Malo, **(2)** Belle-Isle-en-Terre and Yffiniac basic-ultrabasic formations.

Fig. 10 - Tectonic interpretation of the western part of the Baie de St Brieuc area proposed by Balé & Brun 1983. There is a general overthrusting of all the lithological units towards the S-SW.

Fig. 11 - During the Brioverian evolution, two domains separated by a suture zone are distinguished in the North Armorican Massif : a volcanologic domain to the North, a terrigeneous domain to the South (after Chantraine et al. 1988).

Fig. 12 - Geodynamic model proposed by Dissler et al. 1988. **(1)** Pentevrian basement, **(2)** Active volcanism, **(3)** Remnant volcanism, **(4)** Early Cadomian Granitoids, **(5)** Dioritic intrusions (Coutances type), **(6)** Late Cadomian Gabbroic intrusions, **(7)** Late Cadomian Granitoids, **(8)** Phtanites (black-sherts) formations, **(9)** Upper Brioverian sediments.

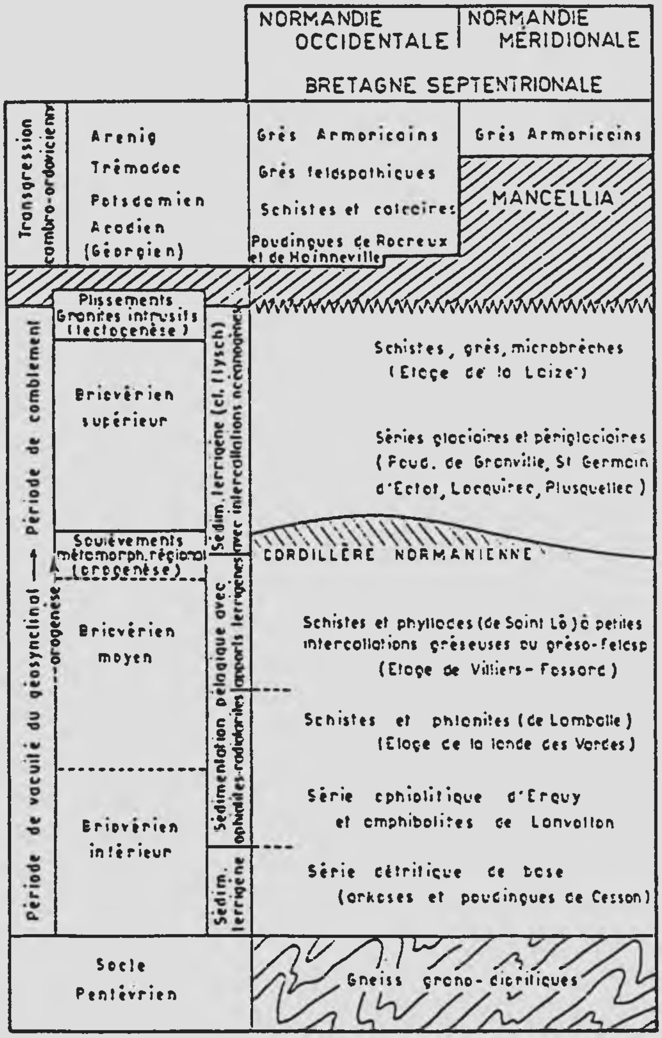
Fig. 13 - Geodynamic model proposed by Chantraine et al. 1988.

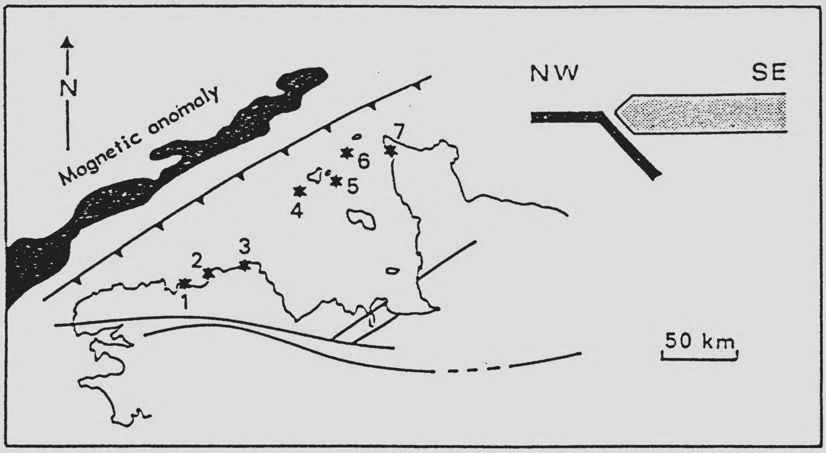
Fig. 14 - Geodynamic model proposed by Graviou et al. 1988. T = Tregor massif ; **LP** = Lannion-Paimpol volcanics, **MF** = Les Mortes Femmes volcanics; **M** = Montsurvent volcanics; **Te** = La Terrette volcanics; **BI** = Belle-Isle-en-Terre series; **BS** = Baie de St Brieuc series; **SQ** = St Quay diorite massif; **C-FI** = Coëtmieux - Fort-La-Latte diorite massif; **SM** = St Malo migmatite belt.

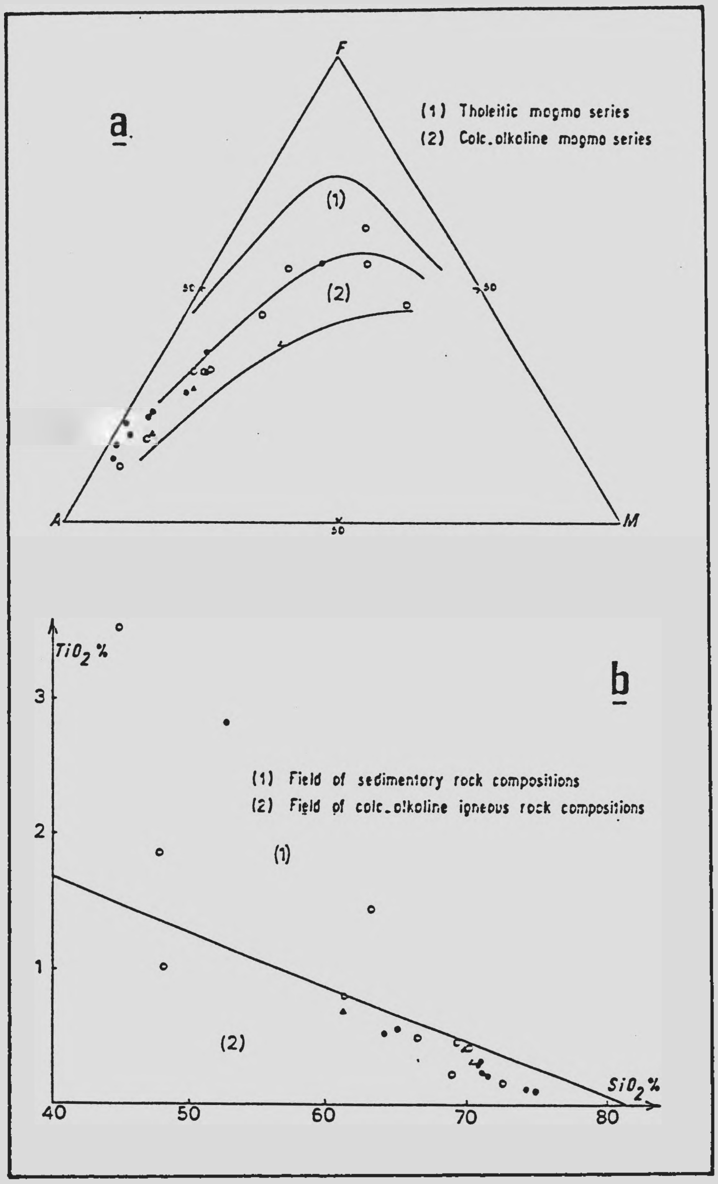
Fig. 15 - Translation of the Leon block from South to North during the Devonian (from Balé & Brun 1986).

Fig. 16 - Geodynamic evolution of the North Armorican Massif explained by a subduction process with a subduction plane dipping towards N-NW.

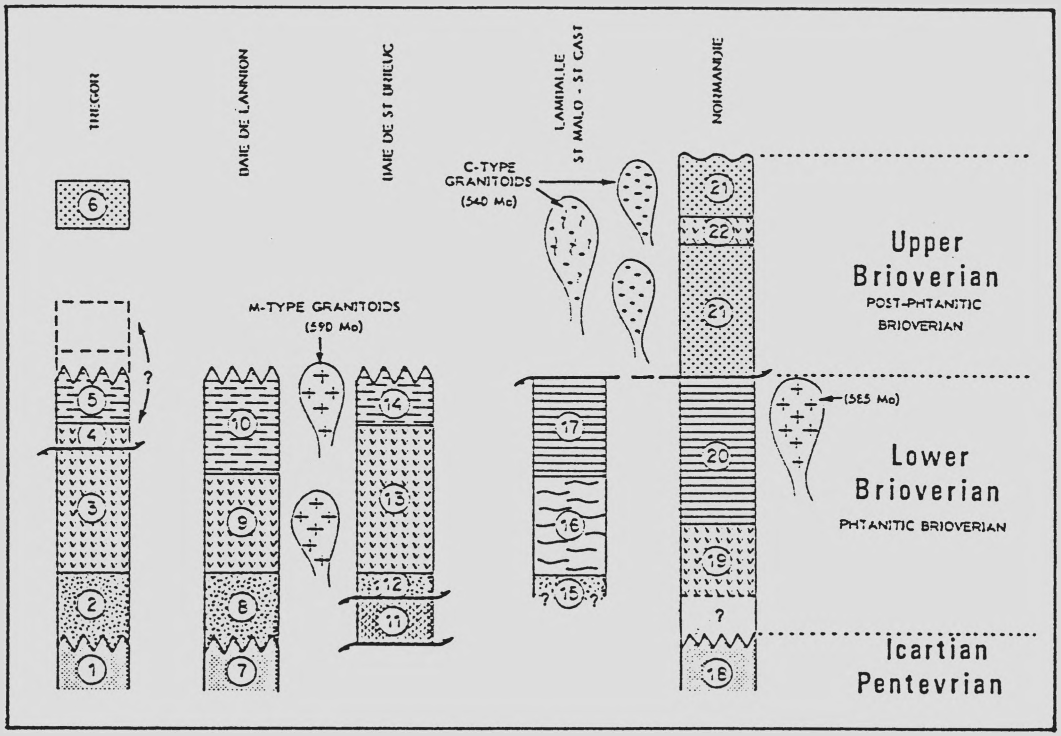
Fig. 17 - Subduction model proposed by Cogné & Wright 1980, to explain the Brioverian evolution. The closure of the Celtic Ocean induced a subduction towards S-SE under the Pentevrian micro-plate (Wales, South England, Southern Ireland and North Armorican Massif).


NORMANDIE OCCIDENTALE
NORMANDIE MERIDIONALE
BRETAGNE SEPTENTRIONALE
Transgression cambro-ordovicienne
Arenig
Trémadoc
Potsdamien
Acadien
(Géorgien)
Grès Armoricains
Grès feldspathiques
Schistes et calcaires
Poudingues de Rocreux et de Hoinneville
Grès Armoricains
MANCELLIA
Plissements
Granites intrusifs
(tectogenèse)
Période de vacuité du géosynclinal → Période de comblement
Briovérien supérieur
Sédim. terrigène (cf. flysch) avec intercallations nécanogènes
Schistes, grès, microbrèches
(Etage de la Laize)
Séries glaciaires et périglaciaires
(Poud. de Granville, St Germain d'Ectot, Locquirec, Plusquellec)
Soulèvements
métamorph. régional
(orogenèse)
CORDILLÈRE NORMANIENNE
orogenèse
Briovérien moyen
Sédimentation pélagique avec ophiolites-radiolarites
apports terrigènes
Schistes et phyllades (de Saint Lô) à petites intercallations gréseuses ou gréso-felesp
(Etage de Villiers-Fossard)
Schistes et phtanites (de Lamballe)
(Etage de la lande des Vardes)
Série ophiolitique d'Erquy et amphibolites de Lanvollon
Briovérien inférieur
Sédim. terrigène
Série détritique de base
(arkoses et poudingues de Cesson)
Socle Pentévrien
Gneiss grano-dioritiques

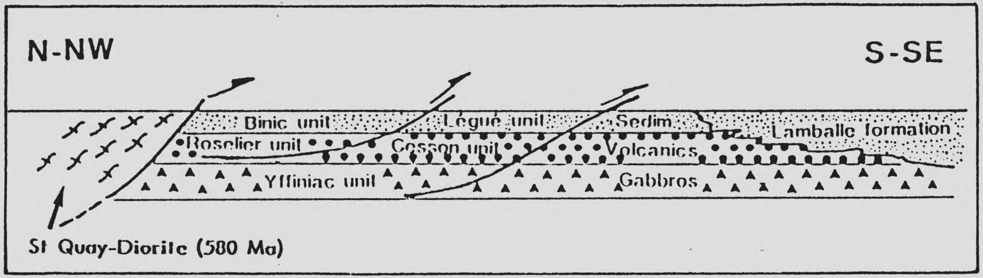

N
Magnetic anomaly
NW
SE
1
2
3
4
5
6
7
50 km



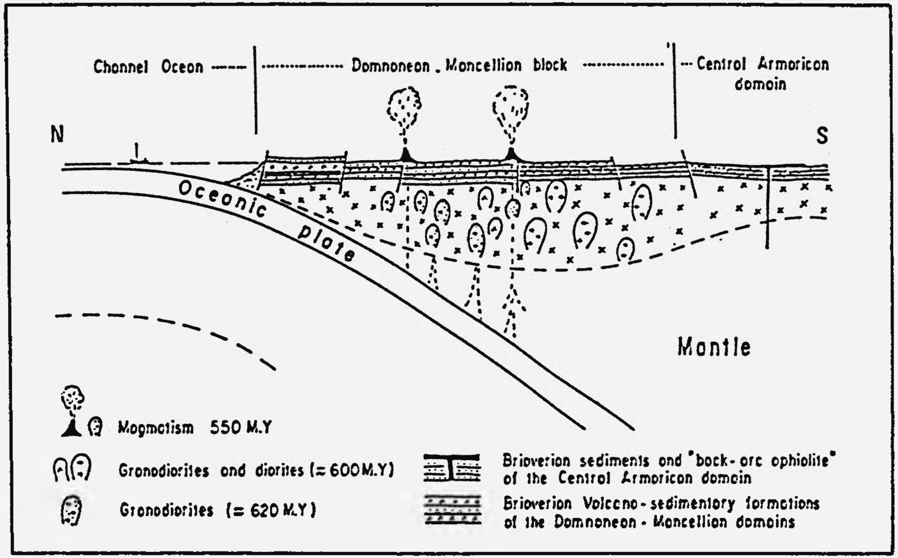
a
F
A
M
(1) Tholeitic magma series
(2) Calc.alkaline magma series
(1)
(2)
50
50
50
b
TiO_2 %
SiO_2 %
(1) Field of sedimentary rock compositions
(2) Field of calc.alkaline igneous rock compositions
(1)
(2)
3
2
1
40
50
60
70
80



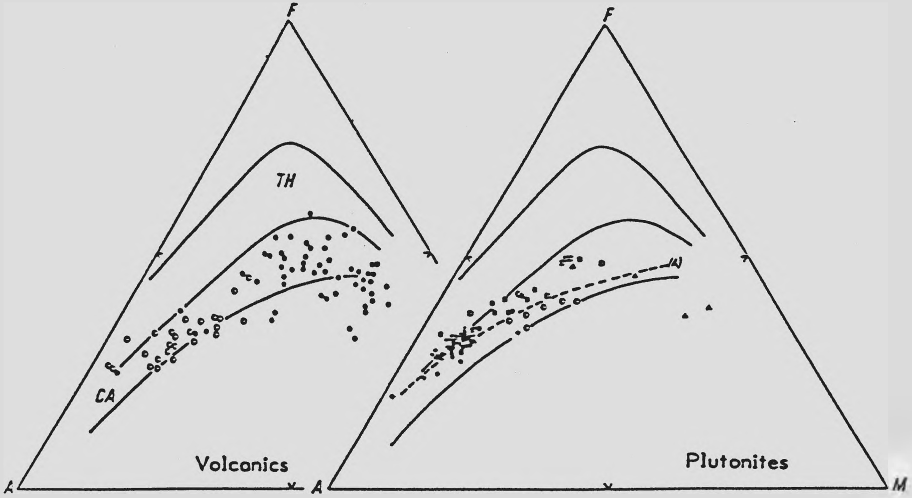
TREGOR
BAIE DE LANNION
BAIE DE ST BRIEUC
LAMBALLE
ST MALO - ST CAST
NORMANDIE
C-TYPE GRANITOIDS (540 Ma)
M-TYPE GRANITOIDS (590 Ma)
(585 Ma)
Upper Brioverian
POST-PHTANITIC BRIOVERIAN
Lower Brioverian
PHTANITIC BRIOVERIAN
Icartian
Pentevrian

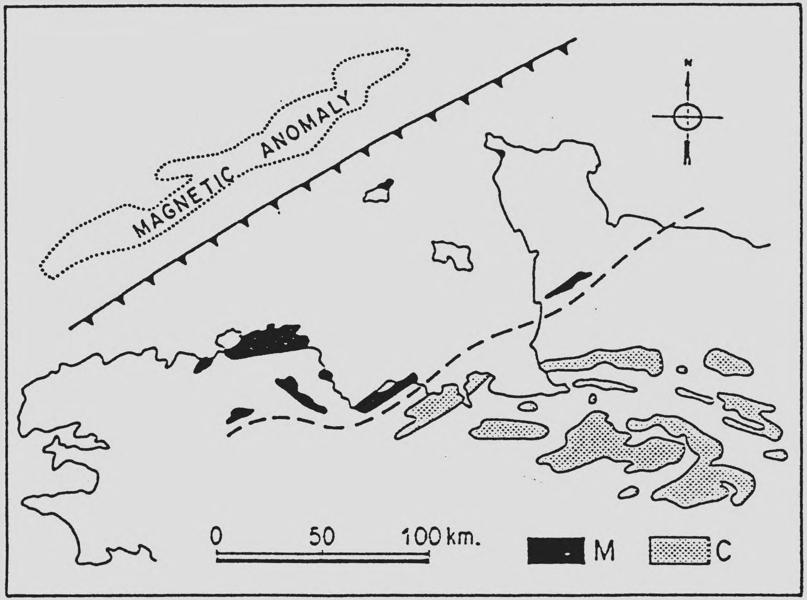


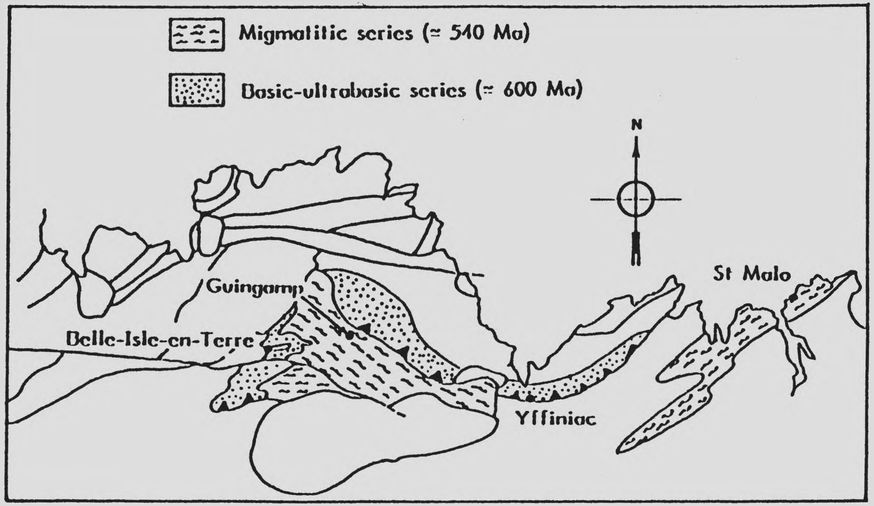
N-NW
S-SE
Binic unit
Légué unit
Sedim.
Lamballe formation
Roselier unit
Cesson unit
Volcanics
Yffiniac unit
Gabbros
St Quay-Diorite (580 Ma)

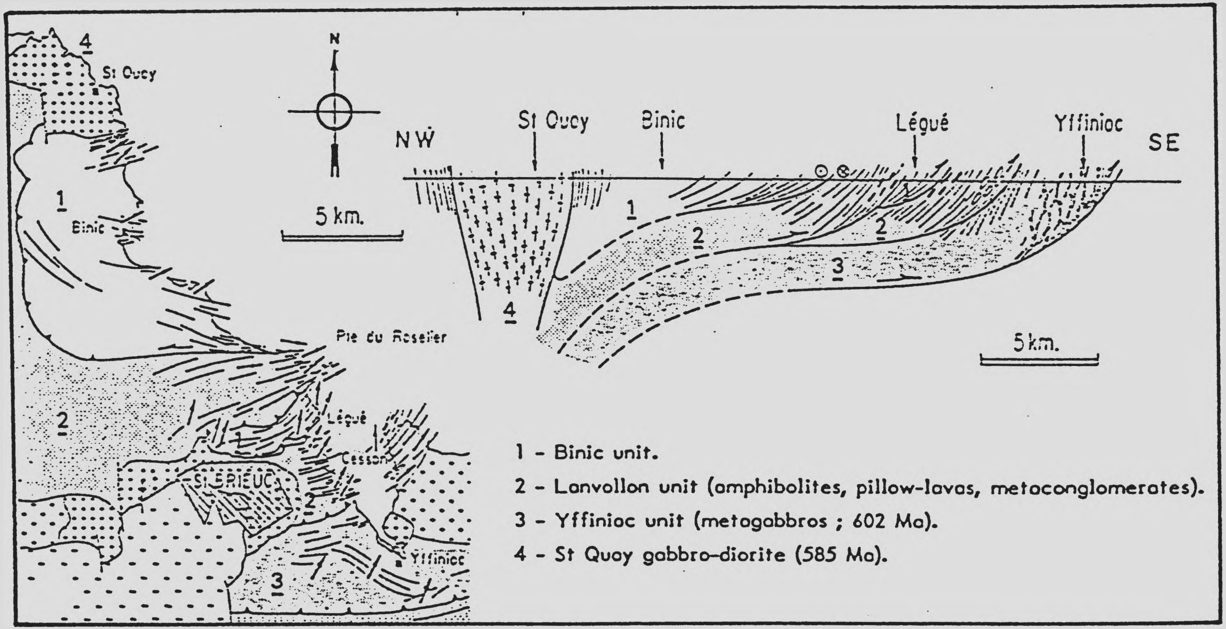


Chonnel Oceon
Domnoneon . Moncellion block
Centrol Armoricon domoin
N
S
Oceonic plote
Montle
Mogmotism 550 M.Y
Gronodiorites ond diorites (≃ 600 M.Y)
Gronodiorites (≃ 620 M.Y)
Brioverion sediments ond "bock-orc ophiolite" of the Centrol Armoricon domoin
Brioverion Volccno-sedimentory formotions of the Domnoneon - Moncellion domoins

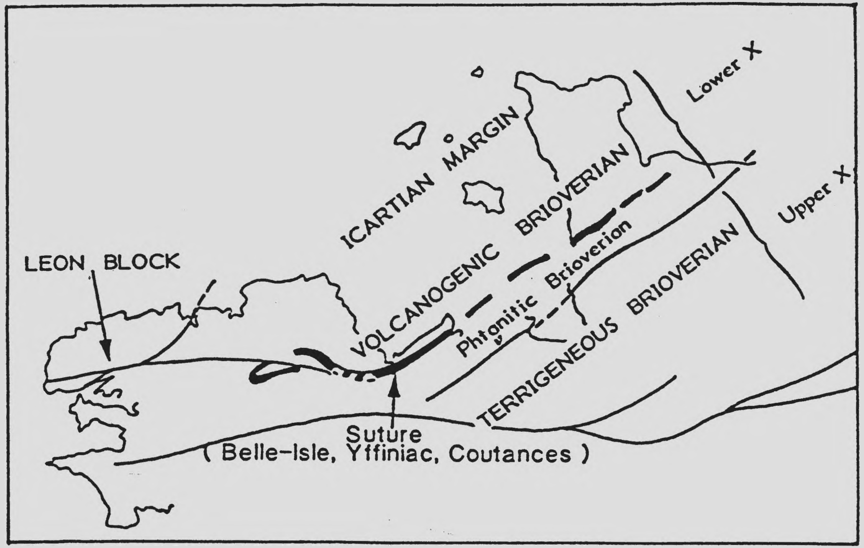

F
TH
CA
Volcanics
A
F
Plutonites
A
M


MAGNETIC ANOMALY
N
0
50
100 km.
M
C

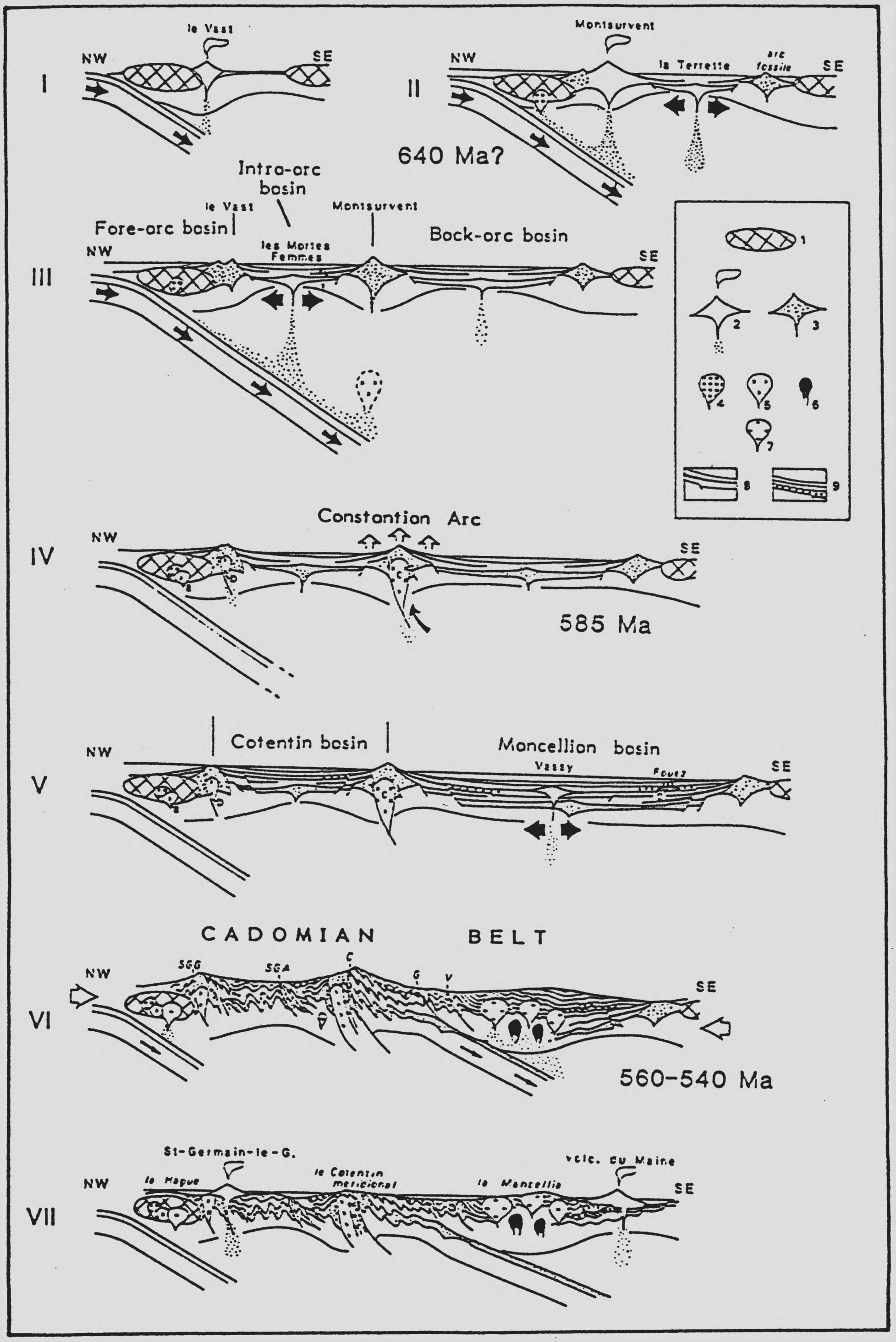

Migmatitic series (≃ 540 Ma)
Basic-ultrabasic series (≃ 600 Ma)
N
Guingamp
Belle-Isle-en-Terre
St Malo
Yffiniac

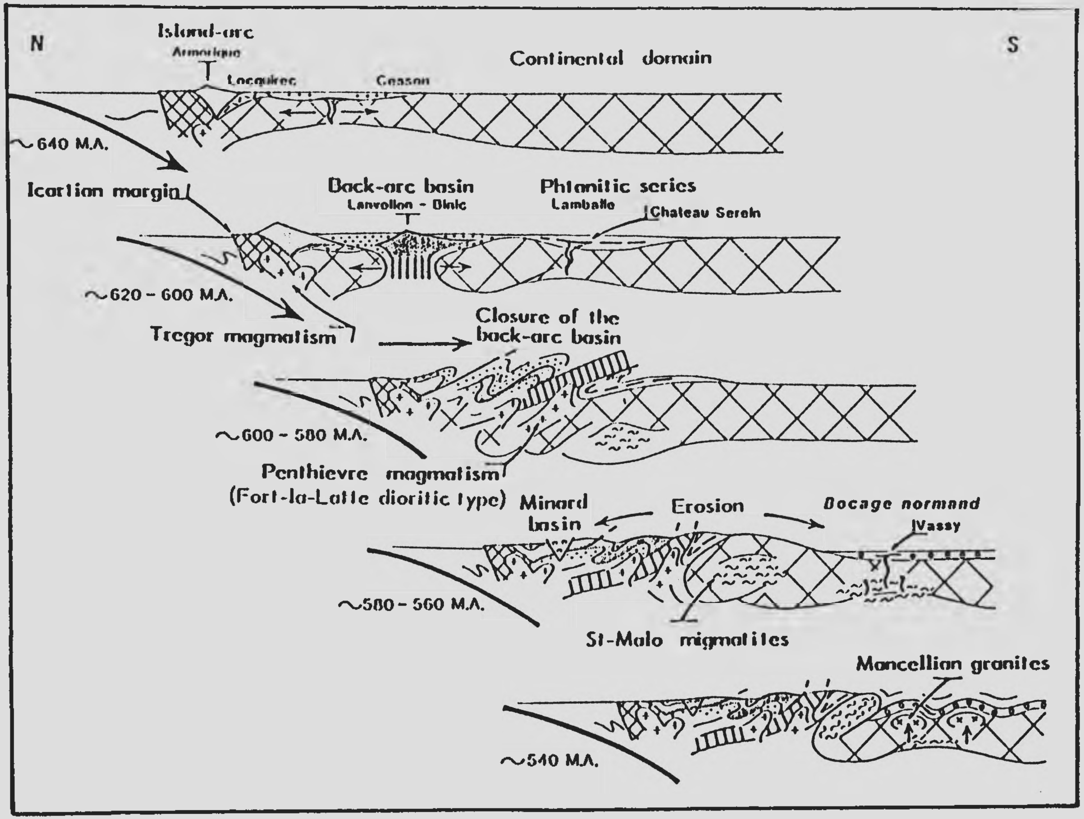


4
St Quay
1
Binic
Pte du Roselier
2
Légué
Cesson
ST BRIEUC
2
Yffiniac
3
N
5 km.
NW
St Quay
Binic
Légué
Yffiniac
SE
1
2
2
3
4
5 km.
1 - Binic unit.
2 - Lanvollon unit (amphibolites, pillow-lavas, metaconglomerates).
3 - Yffiniac unit (metagabbros ; 602 Ma).
4 - St Quay gabbro-diorite (585 Ma).

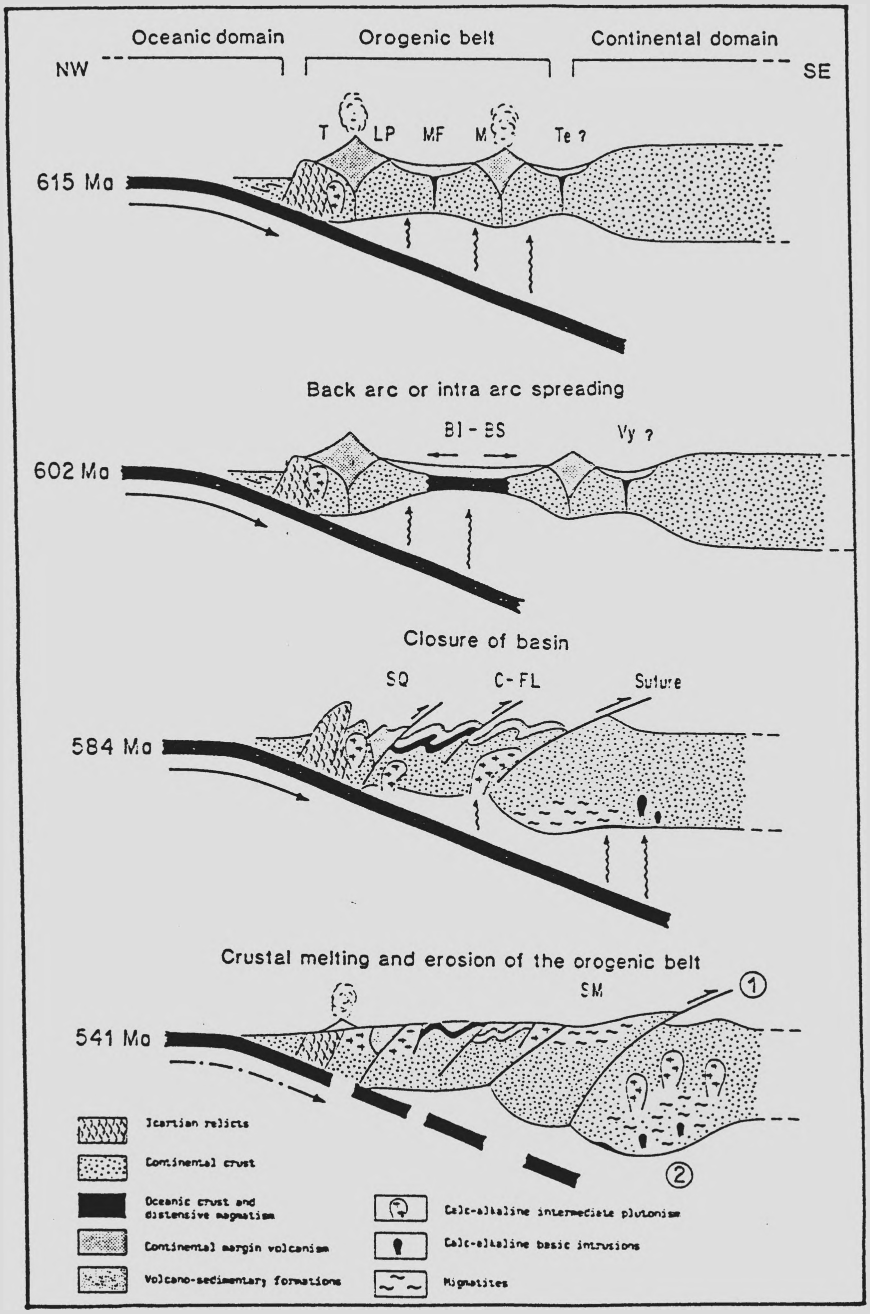


Lower X
ICARTIAN MARGIN
VOLCANOGENIC BRIOVERIAN
Upper X
LEON BLOCK
Phtanitic Brioverian
TERRIGENEOUS BRIOVERIAN
Suture
(Belle-Isle, Yffiniac, Coutances)

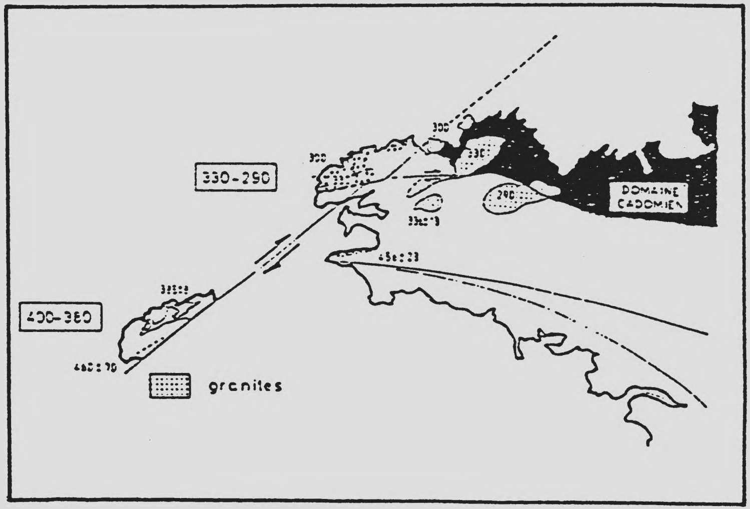

I
le Vast
NW
SE
II
Montsurvent
la Terrette
arc fossile
640 Ma?
Intra-arc basin
le Vast
Montsurvent
Fore-arc basin
les Mortes Femmes
Back-arc basin
III
IV
Constantion Arc
585 Ma
V
Cotentin basin
Mancellian basin
Vassy
VI
CADOMIAN BELT
560-540 Ma
VII
St-Germain-le-G.
la Hague
le Cotentin meridional
la Mancellia
volc. du Maine

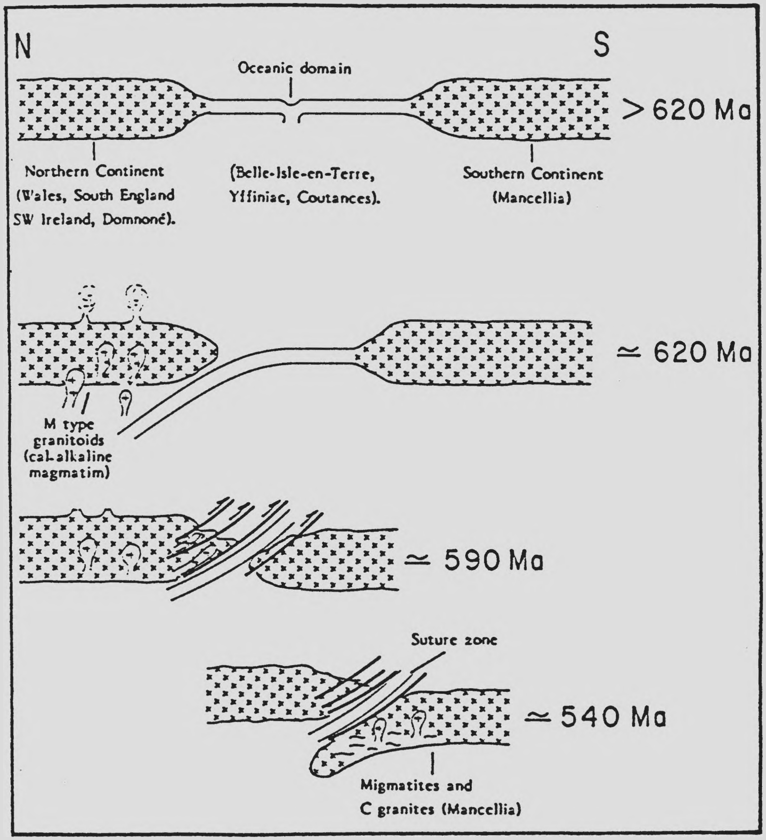


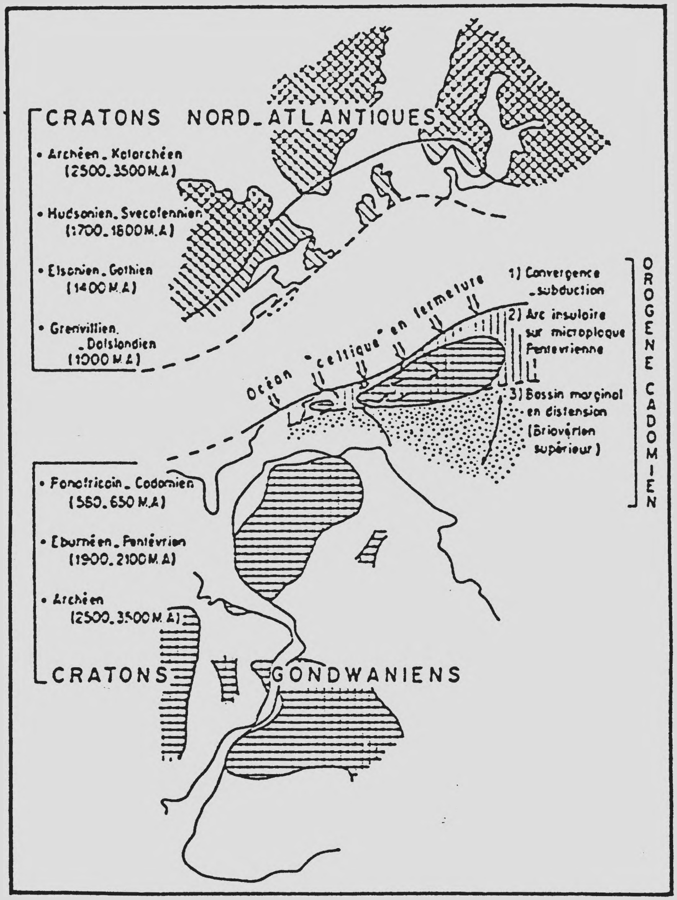
N
S
Island-arc
Armorique
Locquirec
Gesson
Continental domain
~640 M.A.
Icartian margin
Back-arc basin
Lanvollon - Binic
Phtanitic series
Lamballe
Chateau Serein
~620 - 600 M.A.
Tregor magmatism
Closure of the back-arc basin
~600 - 580 M.A.
Penthievre magmatism
(Fort-la-Latte dioritic type)
Minard basin
Erosion
Bocage normand
Vassy
~580 - 560 M.A.
St-Malo migmatites
Mancellian granites
~540 M.A.



Oceanic domain
Orogenic belt
Continental domain
NW
SE
T
LP
MF
M
Te ?
615 Ma
Back arc or intra arc spreading
Bl - BS
Vy ?
602 Ma
Closure of basin
SQ
C - FL
Suture
584 Ma
Crustal melting and erosion of the orogenic belt
SM
①
541 Ma
②
Icartian relicts
Continental crust
Oceanic crust and distensive magmatism
Continental margin volcanism
Volcano-sedimentary formations
Calc-alkaline intermediate plutonism
Calc-alkaline basic intrusions
Migmatites


330-290
300
300
330
290
DOMAINE
CADOMIEN
400-380
granites


N
S
Oceanic domain
> 620 Ma
Northern Continent
(Wales, South England
SW Ireland, Domnoné).
(Belle-Isle-en-Terre,
Yffiniac, Coutances).
Southern Continent
(Mancellia)
≃ 620 Ma
M type
granitoids
(cal-alkaline
magmatim)
≃ 590 Ma
Suture zone
≃ 540 Ma
Migmatites and
C granites (Mancellia)


CRATONS NORD_ATLANTIQUES
• Archéen_Kalarchéen (2500_3500 M.A)
• Hudsonien_Svecofennien (1700_1800 M.A)
• Elsonien_Gothien (1400 M.A)
• Grenvillien_Dalslandien (1000 M.A)
Océan "celtique" en fermeture
1) Convergence _subduction
2) Arc insulaire sur microplaque Pentevrienne
3) Bassin marginal en distension (Briovérien supérieur)
OROGENE CADOMIEN
• Panafricain_Cadomien (550_650 M.A)
• Eburnéen_Pentévrien (1900_2100 M.A)
• Archéen (2500_3500 M.A)
CRATONS GONDWANIENS

MAIN CHARACTERISTICS OF PRECAMBRIAN IN THE NORTH ARMORICAN MASSIF

1° - Occurence of a gneissic basement - Lower Proterozoic age (2.0 - 1.8 Ga) - in the northern part of the area.

2° - Development, between 660 Ma. (perhaps 700 Ma) and 540 Ma. of a two-stage Brioverian cycle :

(a) - The phtanitic stage (650 Ma - 590 Ma) with large amounts of volcanics at the base and sedimentary rocks (black cherts = phtanites) towards the upper part.
Emplacement of plutonic rocks of calc-alkaline affinities all during this stage.

(b) - The post-phtanitic stage (590 Ma - 540 Ma) characterized by flysch type sedimentation with rare basic volcanics (Normandy).

3° - Metamorphism and deformation occur during ≈ 60 Ma (600 Ma to 540 Ma)
They mainly, but irregularly, affect the formations which belong to the phtanitic stage.

4° - Finally, the Precambrian evolution ends with the emplacement at about 550 Ma - 540 Ma.
of magmatic rocks : mainly volcanics in the North (ignimbrites)
and plutonites in the South-East (Mancellian granites).

Table 1