U/Pb zircon ages and polycyclism of the Gneiss de Brest and the Adjacent formations (Brittany)

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U/Pb Zircon Ages and Polycyclism of the Gneiss de Brest and the Adjacent Formations (Brittany)

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RÉSUMÉ

Ce travail a été entrepris dans le but de suivre l'évolution du système U/Pb dans des zircons d'origine détritique prélevés dans une série de formations lithologiques à caractère polycyclique et à métamorphisme variable affleurant dans le Pays de Léon et récemment étudiées des points de vues géologiques et géochronologiques (L. CHAURIS et J. MICHOT, 1965; L. CHAURIS, 1967; A. C. BISHOP et al., 1968).

Des échantillons ont été récoltés dans les quartzophyllades de l'Elorn, ensemble sédimentaire non métamorphique d'âge briovérien, dans les micaschistes du Conquet, série métamorphique mésozonale élaborée à partir d'un ensemble sedimentaire de même âge et dans les gneiss de Brest, unité considérée comme magmatique par BISHOP et al. (1968), mise en place dans les séries briovériennes il y a 690 m.a. environ. Les deux dernières formations, constituant le flanc sud du dôme métamorphique du Léon, doivent leurs caractéristiques actuelles à la succession des phénomènes qui s'y sont développés durant les orogenèses cadomienne et varisque, la part de chacune étant néanmoins difficilement différenciable sur la base pétrographique ou tectonique.

Les zircons des quartzophyllades forment une population à caractère détritique dont les âges U/Pb sont discordants, une partie de cette population devant être pentévrienne ou plus âgée encore (1 500 m.a.).

Les zircons des roches métamorphiques (micaschistes et gneiss de Brest) ont constitués des systèmes U/Pb ouverts, ayant subi une perte de plomb lors de leur recristallisation partielle liée au développement des orogenèses cadomienne et varisque, cette dernière paraissant, au vu des premiers résultats, comme étant la plus active. Toutefois, l'action sur les roches étudiées du métamorphisme mésozonal n'a pas complètement oblitéré l'origine anté-pentévrienne d'une partie de leurs zircons, origine qui caractérise également ceux des quartzophyllades.

Les premières conclusions qui sont exposées dans cette étude se rapprochent de celles énoncées dans le travail de GRAUERT et ARNOLD (1968) sur la signification des âges discordants des zircons de roches prélevées dans les Alpes suisses, dans une région mésozonale également polycyclique.

I. Introduction

Geochronological and geological studies of the Pays de Léon have been in progress for several years; hence the main events having led to the present structure of the Armorican Massif and in particular of the Gneiss de Brest and its neighbouring formations can now be considered as approximately understood and dated.

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Our present study is thus devoted to the comparison of the U-Pb systems in zircons of detritic origin found in the non metamorphic Quartzophyllades de l'Elorn with those present in the corresponding Brioverian metamorphic formations of the Micaschistes du Conquet and the Gneiss de Brest.

II. Outline of geology

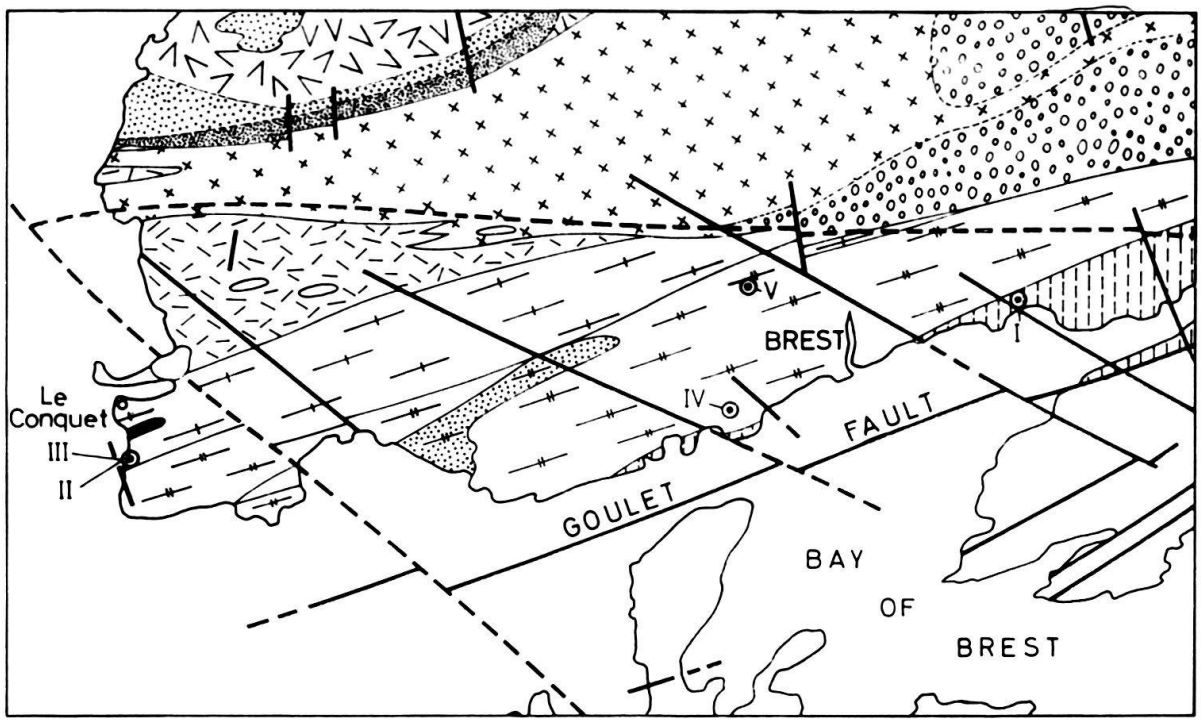
The "Pays de Léon", at the north-western end of the Armorican Massif, appears as an uniformly peneplained region, cut accross a dome of metamorphic terranes stretching from WSW to ENE and intruded by several masses generally of granitic composition. Its tectonic features are oriented along the same direction; they are outlined, on a small scale, by the gneissic structure of the metamorphic units, on a bigger scale, by the stretching of the granitic masses and, locally, by shearing zones limiting different structural blocks.

The southern side of the Léon metamorphic dome along whose axis outcrop Pentevrian formations, i.e. augen or banded gneisses appearing in the windows of Tréglonou and of Lanhouarneau (L. CHAURIS, 1967), is constituted successively by the Gneiss and Micaschistes de Lesneven, the Micaschistes du Conquet, the Gneiss de Brest and the Quartzophyllades de l'Elorn (Fig. 1).

This complex, limited towards the south by a Paleozoic syncline along which the Bay of Brest and further east the Elorn Valley is developed, is considered to be composed of a sedimentary Brioverian unit presently almost completely metamorphosed, of which, according to BARROIS (1902–1905) and contrary to the opinion of DELATTRE (1952), the Quartzophyllades de l'Elorn represent the non metamorphic part (L. CHAURIS et J. MICHOT, 1965; L. CHAURIS, 1967; A. C. BISHOP et al., 1968).

From a structural point of view, the evolution of the Armorican Massif, better known in its north-eastern part than in the "Pays de Léon", is characterized by a succession of folding episodes related to at least three important orogenies:

- The first one was recognized by COGNÉ (1959) in the northern part of Brittany (Baie de St-Brieuc) and assigned to the Pentevrian; it is approximately 900 m.y. old (F. LEUTWEIN, 1968). Only few outcrops belong to this belt, but their tectonic and metamorphic features prove its importance in the building up of the Breton shield even up to its western end (L. CHAURIS, 1967).
- The second, the Cadomian orogeny (L. BERTRAND, 1944), affects the Brioverian formations, whose oldest sediments, 750 to 780 m.y. old (F. LEUTWEIN, 1968), lie unconformably on the basement. This orogeny, extending between 650 to 570 m.y. was terminated by the emplacement of a series of intrusions of granitic character belonging to the "Mancellia Pluton" (approximately 550 m.y.) (F. LEUTWEIN, 1968; A. C. BISHOP et al., 1968).
- Finally the Variscan orogeny, whose last stages also coïncide with the emplacement of granitic masses (330–280 m.y.: S. DEUTSCH et L. CHAURIS, 1965; F. LEUTWEIN, 1968; A. C. BISHOP et al., 1968), reworks the Cadomian chain along roughly similar directions. At the same time it folds the Paleozoic cover which in the region of Brest is nowadays in contact with its basement along an important shearing plane extending in the Elorn Valley and in the "Goulet de Brest".



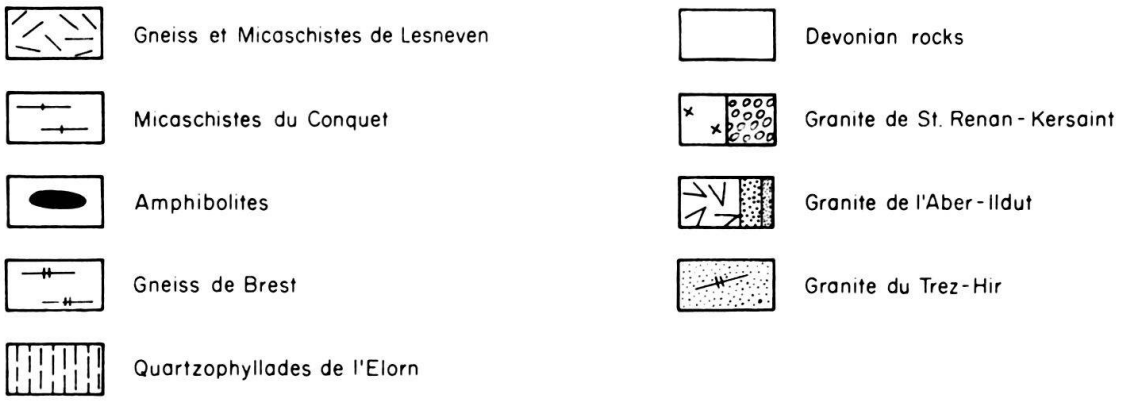


Fig. 1. Geological sketch of the southwestern part of the "Pays de Léon" (after L. CHAURIS). I, II, III, IV, V: Rock samples investigated

Region of Brest – Le Conquet

The recent studies of the region between Brest and Le Conquet (L. CHAURIS et J. MICHOT, 1965; J. MICHOT et J. LAVREAU, 1965; L. CHAURIS, 1967; A. C. BISHOP et al., 1968) have shown that the different formations are formed by Brioverian sediments which have undergone, to different degrees, the effects of the two last orogenies. From south, near the Bay of Brest, to north these formations disclose an increasing metamorphism (Fig. 1).

- The Quartzophyllades de l'Elorn constitute a banded epizonal formation; they are locally finely layered, essentially psammito-pelitic in composition and enclose numerous arkosic beds.
- The Gneiss de Brest is considered by BISHOP et al. (1968) as formed from a magmatic intrusion of granodioritic composition emplaced into the Brioverian sediments and

transformed into a gneissic formation of mesozonal facies by a later metamorphic episode.

- The mesozonal Micaschistes du Conquet with garnet and staurolite appear as a characteristic formation of the regional metamorphism.

The two last formations grade progressively one to another. Their original contacts, if the Gneiss de Brest is really a premetamorphic intrusion, have probably been more or less shaded off all along the metamorphic evolution.

At the opposite, the contact between the Gneiss de Brest and the Quartzophyllades de l'Elorn in its western part is regularly outlined by a dislocation zone dipping steeply to the south; along this zone, the rocks show a mylonitic structure associated in the Gneiss de Brest with an epizonal diaphtoresis.

The reworking of the structures, even aside from the contact zone itself, has probably lowered the age of certain minerals, especially the biotite. Measurements on this mineral on a sample from Pont Cabioch yielded an apparent age of 300 ± 15 m.y. (S. DEUTSCH and L. CHAURIS, 1965) which thus seems to indicate that this shearing zone as well as the closer one recently described by CHAURIS (1969) may be related to the Variscan deformations. Nevertheless, the real influence of the Variscan orogeny is rather difficult to appreciate either by a petrographic or a tectonic study.

III. Radiometric studies

As emphasized above, the radiometric studies have been developed with the purpose of controlling the behaviour of zircons in rocks of intricate and different geological evolutions. We have collected one sample of the Quartzophyllades de l'Elorn (I) (Kerisbihan); two samples of the Micaschistes du Conquet (Porsliogan), one corresponding to a staurolite-bearing micaschist (II), the other to a biotite-plagioclase gneiss (III); one sample of the southern facies of the Gneiss de Brest (IV) (Hildy) differing from that already analysed and originating from its northern facies (V) (Pont Cabioch) (Fig. 1).

The general lithological characters of these rocks together with their petrographical aspects are given in the appendix.

Morphology of the zircons

The zircon concentrates extracted from the rocks show heterogeneous populations in which four types of zircons can be roughly distinguished (Figs. 2, 3 and 4).

1. Euhedral zircons, mostly light coloured, sometimes zoned, elongated and terminated by acute pyramids (faces 331).
2. Stubby zircons, dark coloured, with flattened pyramids (faces 111), some of them showing in the center a more or less well-shaped nucleus.
3. Dark almond-shaped zircons limited by many small faces.
4. Rounded, mostly dark zircons.

The Quartzophyllades de l'Elorn contain mainly rounded zircons, very few belonging to the other types.

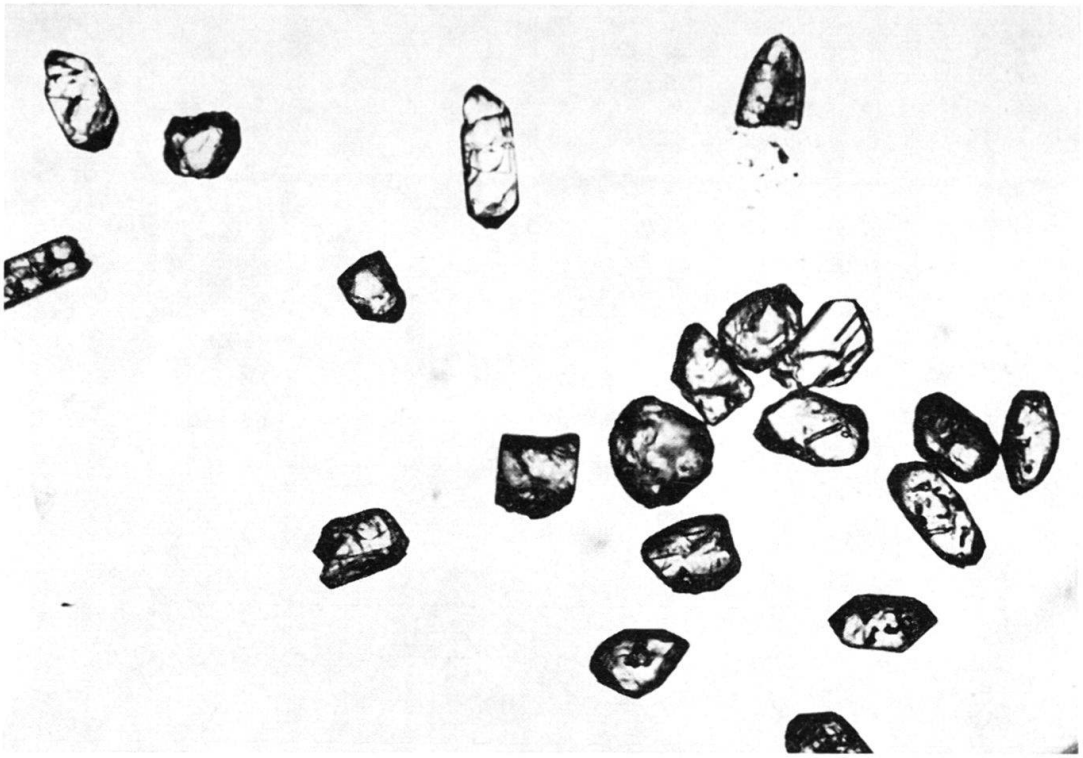


Fig. 2. Zircons from the Quartzophyllades de l'Elorn.

The Micaschistes du Conquet and the associated gneissic rock contain mainly stubby zircons, few rounded (less in the gneissic facies than in the micaschists proper) and few almond-shaped zircons.

The two samples of the Gneiss de Brest are characterized by a great proportion of elongated zircons (one third of the total in Hildy), the majority of their population consisting however of stubby or almond-shaped ones.

The elongated zircons are similar to those found in the granites of Vire and St-Renan; they do not exist in the metamorphic rocks studied here nor for instance in the Gneiss de Pont-Ar-Rest located more to the north. Thus they seem to be in connection with the magmatic origin of the rock in which they are found. This is in favour of the assumption that the Gneiss de Brest is related to a magmatic event.

U/Pb results on zircons and monazites

The results of the U/Pb measurements on zircons and monazites of the four rocks, together with a few Rb/Sr measurements on micas are given in Table 1.

The zircons of three of these rocks have been subdivided into fractions of different radioactivity which were analysed separately.

The U and Pb contents have been determined by isotope dilution (L. T. ALDRICH et al., 1956; S. DEUTSCH et al, 1965).

The isotopic ratios have been measured on a Nier-type mass spectrometer equipped with a single filament thermoionic source for solid samples. The apparent U/Pb ages are shown on a Concordia diagram (Fig. 5).

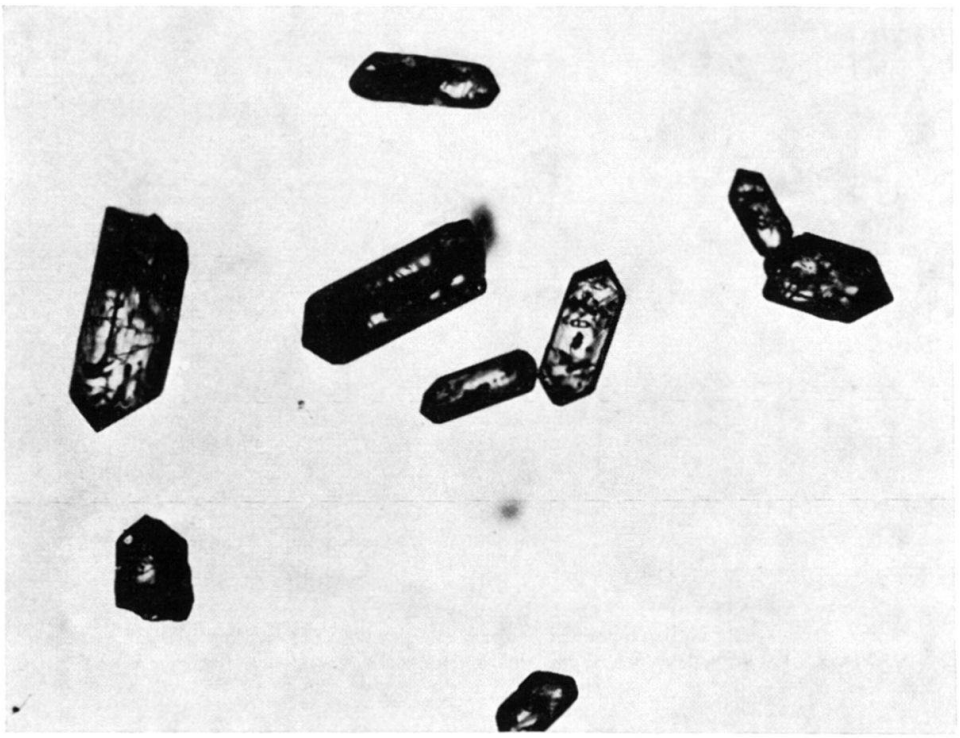


Fig. 3. Zircons from the Micaschistes du Conquet.

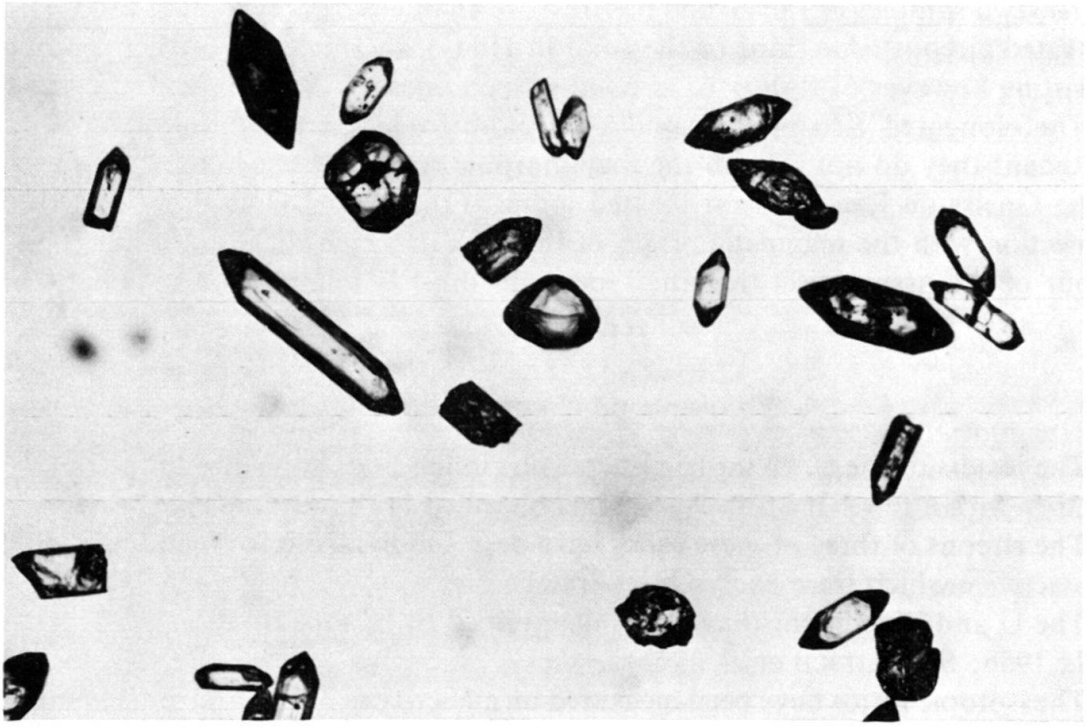


Fig. 4. Zircons from the Gneiss de Brest.

On the left side of the graph, the apparent Rb/Sr ages are reported for the micas of the same rocks. The four main events in this region dated by previous studies, are also shown. These are:

1. 690 ± 40 m.y. (Rb/Sr on total rock) which would be the intrusion age of the granodiorite from which the Gneiss de Brest was formed according to BISHOP et al. (1968).
2. 565 ± 40 m.y. (Rb/Sr on total rock); age of the Renard granite.

According to the same authors these first two ages bracket the Cadomian orogeny.

3. 340 ± 20 m.y.; total rock Rb/Sr age of the granites of Kersaint, Quintin and Tregana (A. C. BISHOP et al., 1968; S. DEUTSCH and L. CHAURIS, 1965), age on zircon from the granite of Kersaint – St-Renan, representing a first magmatic stage following the Variscan metamorphism.
4. 280 ± 20 m.y.; zircon age of the granite of Aber-Ildut; Rb/Sr age on total rock from the granites of Aber-Ildut, Tregastel, Ploumanach (same authors), which represents a second younger magmatic stage.

Table 1. U/Pb and Rb/Sr mineral ages of the Gneiss de Brest and the adjacent formations

Sample	Mineral fraction	U ppm	Pb rad ppm	Age m.y. Pb-207/Pb-206	Pb-206/U-238	Pb-207/U-235	Rb/Sr Biotite
V							
Gneiss de Brest (Pont Cabioch)	zircon	327	24.8	460 ± 70	459 ± 15	458 ± 30	280 ± 15
IV							
Gneiss de Brest	zircon a	515	47.3	900 ± 75	584 ± 10	654 ± 30	396 ± 12
(Hildy)	b	553	56.5	943 ± 35	650 ± 15	719 ± 20	
III							
Micaschistes	zircon a	997	57.9	590 ± 70	358 ± 7	392 ± 20	285 ± 15
du Conquet	b	718	38.7	390 ± 35	329 ± 16	338 ± 10	
(Biotite-Plagioclase Gneiss)	monazite	2 241	589	1144 ± 65	654 ± 15	775 ± 25	
II							
Micaschistes	zircon	612	64.3	1162 ± 170	651 ± 15	778 ± 60	300 ± 15
du Conquet	monazite	5 360	751	484 ± 35	394 ± 7	408 ± 12	
I							
Quartzophyllades de l'Elorn	zircon a	364	53.3	1520 ± 40	850 ± 20	1058 ± 25	460 ± 60 (muscovite)
	b	391	55.7	1484 ± 45	833 ± 20	1033 ± 30	

Interpretation of the U/Pb apparent ages

The zircons of the rocks studied show discordant ages. All the representative points fall in a triangle (Fig. 5) whose apexes correspond to the 690 m.y. and 300 m.y. points on the Concordia, and to the zircons of the Quartzophyllades de l'Elorn (I).

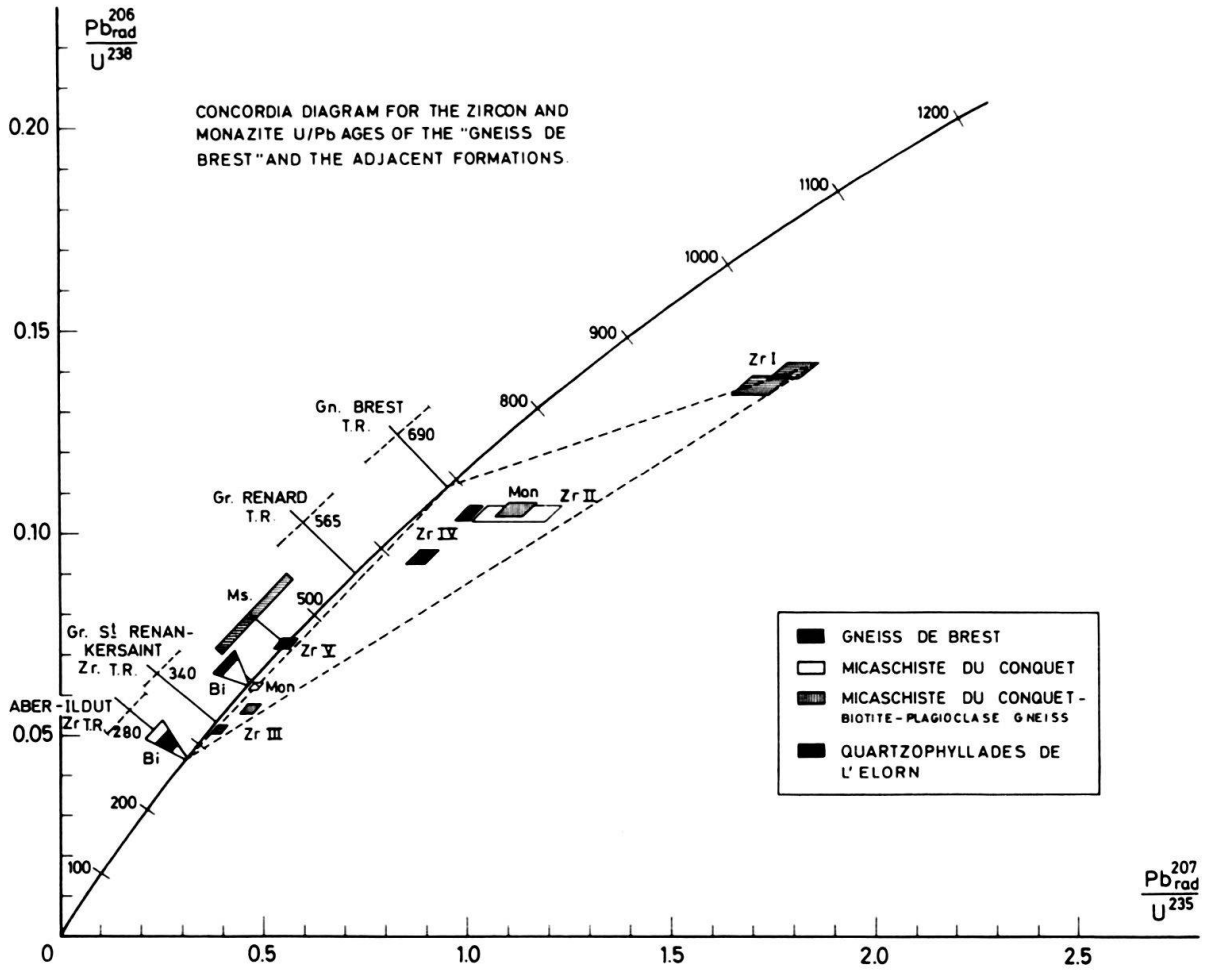


Fig. 5. Concordia diagram for the zircon and the monazite U/Pb ages of the Gneiss de Brest and adjacent formations. ZrI–ZrV: Zircon samples of the rocks investigated. On the left side of the graph are reported the apparent Rb/Sr ages of the micas from the same rocks as well as selected ages obtained in previous studies referred to in the text. Bi = Biotite; Gn = Gneiss; Gr = Granite; Mon = Monazite; Ms = Muscovite; T.R. = Total rock.

The populations of the zircons of these rocks are heterogeneous; they are indeed, totally or partially, of sedimentary origin. The observed age discordances of the different zircon fractions of any given rock cannot consequently be explained by one or several events affecting a unique U/Pb system of a given age. Hence the proposed interpretation is based on the following hypothesis.

The Quartzophyllades de l'Elorn are considered to be of Brioverian age. The same age is attributed to the original geosynclinal sediments which now form the Micaschistes du Conquet, as well as to the granodioritic intrusion which are strongly contaminated by the same material and now appear under the Gneiss de Brest facies. It can therefore be assumed that the detritic zircons of these last rocks had approximately the same characteristics as those found in the Quartzophyllades. The apparent

U/Pb ages of the different fractions extracted from the metamorphic rocks (II, III) could thus be explained by diverse alterations which occured during Cadomian and Variscan times. Indeed, the assumption of episodic lead losses at these times instead of losses by continuous diffusion is admitted because of the proximity on Concordia at 350 and 650 m.y. of some representative points of the micaschists and of the gneiss. The similar apparent ages (>800 m.y.) of the two zircon fractions from the Quartzophyllades de l'Elorn (I) are the highest measured. By assuming a recent lead loss from a homogeneous population, these zircons would be dated from the Pb 207/206 values at approximately 1 500 m.y. Any other and more probable assumption, considering the population as consisting of a mixture of zircons of different ages, will lead to the following interpretation of the discordant ages: a fraction, at least, of the zircons of the Quartzophyllades is older than 1 500 m.y.

The positions of the representative points of the zircons of the micaschists series (II, III), when compared to those of the Quartzophyllades (I), are closer to Concordia, first in the vicinity of the 650 m.y. point, secondly towards 300–350 m.y. This is particularly conspicuous for the zircons of the biotite-plagioclase gneiss facies (III), a fraction of which is nearly concordant around 330 m.y. The display of these points is in agreement with the previous hypothesis in which a modification is considered to result from the influence of the superposed Cadomian and Variscan orogenies.

Nevertheless the mesozonal metamorphism did not obliterate completely their Ante-Cadomian origin, and particularly the age greater than 1 500 m.y. of part of their population.

A similar interpretation is valid for the points representing the zircons of the Gneiss de Brest (IV). When compared with those from the other rocks, these points fall closest to the apex at 690 m.y. of the triangle drawn on the graph. Considering the Rb/Sr total rock age of 690 m.y. measured by BISHOP et al. (1968), it can be concluded that one of the events which contributed at that time to the formation of the Gneiss de Brest had no counterpart in the micaschists. This event might correspond to the emplacement of the granodioritic magma which, according to our English colleagues, is the origin of this gneiss, an important fraction of zircons being formed at that time. Nevertheless, the Pb^{207}/Pb^{206} ages of two fractions of the zircons being significantly higher than 690 m.y., it may be assumed that part of the population is inherited and detritic, and therefore related to the assimilation of the sediments in which the granodioritic magma has intruded (sedimentary remnants can be seen macroscopically and microscopically; see appendix). Moreover, the distribution of the representative points towards 350 m.y. can be considered as the response of the U-Pb systems to the Variscan orogeny.

The zircons from the Gneiss sample of Pont Cabioch (V) (S. DEUTSCH and L. CHAURIS, 1965) which are only slightly discordant and whose representative point falls on the 690–300 m.y. side of the triangle, could have crystallized 690 m.y. ago and suffered drastic lead loss around 300 m.y.

This geochronological interpretation of the results obtained on the zircons of the different rocks is confirmed by the study of their morphology and by the distribution of the different types encountered in the three populations. Indeed, the Gneiss de Brest (IV, V) contains a great proportion of elongated zircons which appear to be related to

its partially magmatic origin. Moreover, the gneissic facies of the micaschists (III) contain mainly stubby euhedral zircons, a feature which might be related to a more pronounced reworking during the Variscan orogeny. The micaschist proper (II), whose zircons yielded the highest apparent ages, is characterized by a higher abundance of almond-shaped and rounded zircons.

The U/Pb age of monazites of the two rocks from the micaschists series are also discordant. The monazite of the micaschists (II) has probably crystallized during the Cadomian orogeny and, according to its U/Pb ratios, has lost part of its radiogenic lead during the Variscan metamorphism. The monazite of the gneissic facies (III) must be at least partially detritic with later recrystallization or episodic lead loss, in order to give the high Pb 207/U 235 and Pb 207/Pb 206 ratios. If this lead loss as might be assumed, happened around 300 m.y. ago, the detritic monazite fraction must have at least an age of 1500 m.y.

Rb/Sr measurements on the biotite of the Gneiss de Brest and the Micaschistes du Conquet yield apparent ages younger than those obtained by the U/Pb method on zircons and monazites.

These apparent ages of approximately 300 m.y. are the result of a rejuvenation due to the last events of the Variscan orogeny. In fact, they are similar to the ages of the last magmatic phases in the region and seem to reflect the regional heating and the accompanying tectonic events (L. CHAURIS, 1969). The apparent age of the biotite of the Gneiss de Brest sampled at Hildy (296 $\pm$ 12 m.y.) being older than those of the biotites of the other rocks shows that this rejuvenation was not homogeneous through all the metamorphic series. An interpretation of the apparent age of the muscovite of the Quartzophyllades de l'Elorn is impossible with only one measurement; indeed this mineral consists of a mixture of crystals, some of them being detritic, others recrystallized and reoriented.

IV. Conclusion

U/Pb age measurements have been carried out mainly on zircons separated from rocks belonging to the north-western part of the Armorican Massif, in the area between Brest and Le Conquet. All the rocks studied originate from Brioverian sedimentary series, the Quartzophyllades de l'Elorn being an unmetamorphosed formation and the Micaschistes du Conquet their mesozonal metamorphic equivalent.

The Gneiss de Brest is considered to be formed partially by a pre-Cadomian (690 m.y.) granodiorite intrusive into the Brioverian sedimentary series and reworked by a later metamorphism. The Variscan action on this complex is not apparent from the petrographic or tectonic points of view.

The interpretation of the discordant U/Pb ages obtained on the different fractions of zircons can be summarized as follows considering the morphology of the crystals:

The zircons of the Quartzophyllades are characterized by very discordant U/Pb ages, higher than 830 m.y., part of them having an age older than 1 500 m.y. They most probably originate from the erosion of a shield which is at least of Pentevrian age.

The zircons of the Micaschistes du Conquet and of the Gneiss de Brest have U/Pb ages less discordant and significantly younger than those of the Quartzophyllades. The effects (episodic lead loss) of the Cadomian and Variscan orogenies are conspicuous on their zircons, as well as on the monazites of the Micaschistes.

A comparison between the U/Pb ages of the zircons of the Micaschistes du Conquet and of the Gneiss de Brest show the latter to be closer to 690 m.y. This fact and the 690 m.y. Rb/Sr age measured by BISHOP et al. (1968) on the gneiss are considered to be an argument for a magmatic origin for that rock. This is also confirmed by the zircon population which is heterogeneous and composed of newly formed as well as inherited zircons from the assimilated country rocks.

An important fraction of the zircons from the Micaschistes du Conquet are limited by well developed faces (stubby and almond-shaped zircons). It thus appears that the various metamorphic events responsible for the transformation of these rocks as well as for the rejuvenation of the zircons led to an undoubtable recrystallization of these minerals.

The nearly concordant 330 m.y. ages of some fractions of zircons clearly show that the Variscan orogenic phase strongly reworked the preexisting Cadomian complex. This fact already suspected particularly by the interpretation of the apparent Rb/Sr ages on biotites is further demonstrated by this study. The magnitude of the Variscan influence is thus confirmed.

A more detailed geochronological study in the region of Brest-Le Conquet would however be necessary to achieve a complete understanding of the U/Pb ages of zircons in this polycyclic region. Moreover, the analogy of the present results with those of GRAUERT and ARNOLD (1968) on the meaning of the discordant ages of zircons in the Swiss Alps is worthwhile mentioning.

APPENDIX

Petrography of the rocks containing the analysed zircons

The Quartzophyllades de l'Elorn

The Quartzophyllades de l'Elorn (Quarry of Kerisbihan and Portzic light-house) are constituted by fine-grained arenitic or arkosic layers of a sericite-chlorite network texture, sometimes carrying abundant plagioclase (grain-size approximately between 20 to 60 microns), alternating with very fine-grained quartziferous pelitic layers, locally arkosic in character, spangled all over with small randomly distributed phenoclasts of muscovite.

These latter often form clusters of two or three flakes enclosed in a fine orientated micaceous matrix containing in some places very thin biotitic flakes. Close to the contact with the Gneiss de Brest the granularity of the rocks seems to increase slightly; very often, intercalations of inequigranular arkose locally grading to a microconglomeratic facies are observed.

From a textural point of view the Quartzophyllades de l'Elorn are characterized by a well developed schistosity generally parallel to the bedding. In some samples, thin sections show a second cleavage, less conspicuous and cutting accross the first one.

Near the contact zone between the Gneiss de Brest and the Quartzophyllades, the structure becomes more and more mylonitic; detritic quartz and plagioclase grains, as well as the phenoclasts of muscovite progressively acquire a strongly undulating extinction.

The Gneiss de Brest

This gneiss appears as a medium-grained rock, of "augen" type, with a pronounced oriented structure. It contains very often small nodules of polycrystalline quartz and thin lenticular aggregates composed of phyllitic material, both being oriented parallel to its structure.

Under the microscope, it shows honeycomb type texture and a well defined gneissic structure, locally mylonitic in character. It is constituted by phenoclasts, sometimes very coarse-grained, of

plagioclase (oligoclase 12–15% an), potash feldspar (rare) and quartz, concentrated in lenticular aggregates parallel to each other and separated by narrow strings in which are associated biotite, in the form of more or less deformed flakes, muscovite, apatite, zircon, sphene (or leucoxene), tourmaline and opaque minerals.

The plagioclase occurs as isometric grains of different sizes, up to 1 cm, rarely euhedral, deformed or even broken, slightly zoned and surrounded at the contact of the potash feldspar by a rim of albite or small myrmekitic fringers. The potash feldspar is generally albitised and shows the characteristic checkboard aspect.

It is cut by numerous cracks cemented by very fine-grained quartz, sometimes mixed with small plagioclases and myrmekites. The quartz in minute grains (50–150 microns) forms thin elongated aggregates of mosaic texture surrounding in places a few coarser elements of a clearly cataclastic nature. These aggregates, often associated with the biotitic strings constitute a cement which surrounds the phenoclastic grains.

Biotite of a sagenitic type appears as brown reddish flakes from 1 to a few mm long. It is often deformed and broken into a series of little pieces which either form a belt around the main section or are dispersed in the quartzitic matrix and associated with muscovite which constitutes an important part of the honeycomb texture. The biotitic strings are dotted with fine grains of leucoxene and contain the accessory minerals.

Very often, the rock includes polycrystalline quarzitic lenses and phyllitic clusters in which muscovite and biotite are associated.

Locally the Gneiss de Brest shows facies variations from the type described above. In particular, in its northern part (Quarry Pont-Cabioch) the mylonitic structure is slightly blurred out. Quartz is still cataclastic, but the plagioclase, sometimes rather small grains, has a typical granoblastic texture. With biotite are associated garnet and a green-bluish amphibole, locally retromorphosed in epidote + biotite, the colour of the latter changing from brown to green towards the periphery of the crystal. In its southern facies, near the contact with the Quartzophyllades de l'Elorn, the mylonitic structure becomes more pronounced, the feldspars more and more broken and saussuritized, the biotite chloritized and the muscovite more and more abundant.

Finally, over a thickness of several tens of meters, the contact zone is underlined by an "augen" mylonite (amygdalo-schiste) in which a fine granulated matrix of quartz and plagioclase associated to a muscovite-chlorite network embeds countless tiny fragments of feldspar and quartz (Quarry of Kerisbihan, Portzic light-house).

If one assumes that the Gneiss de Brest originated from a magmatic intrusion of granodioritic type (A. C. Bishop et al., 1968), a hypothesis which is in principle quite reasonable, its association, on a microscopic as well as macroscopic scale, with quartzic elements (polycrystalline lenses), phyllitic aggregates, sometimes very abundant, and with lenses of slates and quartzites, proves beyond doubt, that this magmatic rock is heavily contamined by a material of sedimentary character, the same material in which it has been emplaced.

As mentioned before this heterogeneous nature as well as the presence of interlayered beds with Gneiss de Brest features in the Quartzophyllades de l'Elorn led to the previous conclusion that both series originate from comparable sedimentary sequences (L. Chauris and J. Michot, 1965; J. Michot and J. Lavreau, 1965).

The Micaschistes and Schistes Cristallins du Conquet

The micaschists series which forms the cliffs in the area of Le Conquet is composed of a variety of rocks in which the proportion of the different constituants varies rather largely. Nevertheless, they are essentially biotite-muscovite schists, locally muscovite-chlorite schists, more or less quartzic, appearing as alternating masses, sometimes very thick, very often enclosing garnet, staurolite and locally sillimanite (generally completely epigenized). Some intercalations, in thin layers, are constituted by a biotite- and plagioclase-bearing gneiss; others, more important, are represented by beds or lenses of amphibolites and, in some places, by lenticular dioritic masses.

Under the microscope, the quartzic biotite-muscovite schist is composed of thin lenses of granoblastic texture in which are associated plagioclase and quartz (150 to 300 microns) enclosed in thin zones of lepidoblastic texture essentially made up of biotites and muscovites oriented parallel to each

other and surrounding small grains of plagioclase. These zones, grading sometimes to an association of muscovite and chlorite, contain in some places staurolite and garnet.

The biotite and plagioclase bearing gneiss consists of a mosaïc of plagioclase and quartz grains, more or less isometric (100 to 500 microns) among which biotitic flakes are dispersed; these latter are locally concentrated and form a few undulating strings in which muscovite appears.

The accessory minerals are tourmaline, zircon, apatite and an opaque mineral. The oriented structure is always very conspicuous.

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