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DEPARTMENT OF ENERGY, MINES AND RESOURCES

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT 141

REPORT OF A LECTURE TOUR IN FRANCE AND VISITS TO DEVONIAN SECTIONS IN FRANCE AND SPAIN

HELEN R. BELYEA

OTTAWA
1970

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National Research Council of Canada program of Exchange Scientists with France, Travel Grant.

The travel grant was used for giving a series of lectures in France on the Devonian geology of Western Canada and in visiting Devonian outcrops in Asturias and the Cantabrian Mountains on a trip organized by the Compagnie Française des Pétroles and led by a Spanish geologist. Originally, the tour was to last from November 16 to December 14, 1969. Owing, however, to the great interest shown in the lectures by the French companies and universities, the time limit was extended and the tour lasted from October 29 to December 17. Comments on the Devonian of Asturias are included in an Appendix.

I was fortunate in having the itinerary for my tour suggested by geologists of the French Petroleum Company of Canada and Elf Oil Exploration and Production, Canada, Ltd. in Calgary. Moreover, Dr. Burollet of the Compagnie Française des Pétroles in Paris came to Calgary on his semi-annual visit in March of this year and helped me plan my complete itinerary from his knowledge of which universities would be interested in Devonian sedimentation and carbonates in Western Canada.

Following the field trip in Asturias I first visited the University of Montpellier at the request of Professor Avias. The Laboratoire de Géologie at that university has moved recently to a new building, part of a new modern, well designed campus on the outskirts of the city. The collections were not completely unpacked nor the Museum set up. Between 20 and 30 students attended my lecture on the Devonian of Western Canada.

Foreseeing a demand for geologists in the field of water resources Professor Avias has set up a course in this field. One student was sufficiently interested in the possibility of employment in Canada in this field to come to my hotel for advice.

During my stay in Montpellier I was taken on a field excursion to the Montagne Noire to examine a Devonian sequence. There, the Lower Devonian Siegenian rests unconformably on Gothlandian. Siegenian, possibly Gedinnian (reefal facies), Eifelian, Givetian, Frasnian and Famennian stages have been identified and, except for the Famennian the Devonian consists of limestones and dolomites. The most interesting facies is the "calcaires griottes" (Famennian?) which consists of light grey limestone inclusions in a reddish, probably argillaceous, limestone matrix. The origin of this facies is problematical, but the rocks are generally considered to represent a deep water facies.

I arrived in Paris on November 16 and was given space at the office of the Compagnie Française des Pétroles in Puteaux. Monsieur Fediaevsky of that company was delegated to assist me in any way necessary and to ascertain that the equipment for my lectures was in order. The program in Paris was as follows:

On November 18 I gave a one hour lecture on Le Dévonien du Canada Occidental to the Institut Français du Pétrole.

On November 20 a one day meeting was held at L'association des Sédimentologistes Français. At this meeting I gave a one hour presentation of thin sections and photographs of thin sections illustrating the various microfacies of Devonian carbonates in Western Canada. The presentation aroused considerable interest and was followed by a question period and discussion lasting at least a half hour. As a result of this session I was invited to visit quarries in Brittany near Nantes to examine interesting Devonian facies.

Following the formal presentation of papers in the afternoon I was taken to the University of Orsay (near Paris) by Monsieurs Marquis and Fediaevsky to present a talk to the students on "Transgressions sur un haut-fond". We were welcomed by Professor Brunn who informed me that the students had been on strike and that this was an undergraduate class attending their first lecture in Geology of that year. He asked that I present my lecture in a simplified form so I revised it extemporaneously to explain the type of uplift present, the sequence of transgressions and times of uplift, stressing the methods of reasoning whereby conclusions in this as in other geological problems, may be reached. The class, about 40 students, was definitely attentive and interested and a few questions were asked although the hour was late.

The Department of Geology at this University is new, beautifully located on a wooded hillside, but in a rather dreary, unimaginative, completely utilitarian-type of building rather poorly finished.

On November 21 an official lecture was given to the Société des Paléontologistes at the Museum National d'Histoire Naturelle on the Ecology of Organisms in the Devonian reefs and banks of Western Canada. This lecture was attended by a small but interested audience.

The next day, November 22, I took part in an excursion with Mlle. Brice of the Université Libre de Lille to Boulonnais area where beds of Lower Devonian to Upper Devonian age are exposed in quarries. The most interesting were those of Middle Devonian (Givetian) age of the Carrière du Griset. The lower part consists of poorly fossiliferous, bedded carbonates and intercalated beds containing massive and lamellar-shaped corals, some rolled, others in growth position. In one case, at least, both types are present in the same bed. It should be noted that massive and lamellar-shaped corals, especially Alveolites and Hexagonaria play a far more important role than stromatoporoids and take on shapes similar to those taken by stromatoporoids in

Western Canada. Also, small Thamnopora-type corals are present and seem to occupy the niche of Amphipora in Western Canada. One wedge-shaped bed exposed along a cross-cut of quarry wall contains abundant rolled and overturned massive corals (Alveolites, Hexagonaria) and possibly stromatoporoids. This bed seems to be a talus slope derived from a reef either completely destroyed during or immediately following growth, or from a reef removed by quarrying or still behind the quarry wall. It should be noted, although it may have no significance, that the abundant coral growth seems to follow along small post-Devonian faults.

The upper part of the Givetian consists of rhythmic alternations of dark grey limestones containing scattered corals locally developing into structures interpreted as reefs, and overlain by dark grey, argillaceous limestones and shales grading to reddish, calcareous shales and limestones. One organic structure has a crinoid limestone base that is concave upward; the lower part of this concave crinoidal bed is filled with limestone containing abundant Alveolites fragments, whereas the upper part contains large colonies of corals or stromatoporoids. The structure is truncated and onlapped by thin-bedded, dark grey, argillaceous limestone and shale containing lamellar forms. The explanation of this structure is difficult but it may be related to small faults since a massive bed under the structure and the crinoid bed are cut by small faults. These have displacements of one foot or less that have formed a small graben a few feet across. The graben was filled with limestone debris and the colonial organisms grew in the protected area over the graben, later to be destroyed by deepening of water and onlap of shaly limestone and shales. An analogy may be made with reef growth along lineaments associated with apparent small displacement of beds at various times along the flanks of the Tathlina uplift.

The uppermost carbonate of this sequence contains Stringocephalus. Above this the beds consist of red, argillaceous carbonate and shale, in part brecciated, overlain by grey shales containing a Frasnian fauna. The breccia and red beds suggest evaporitic conditions possibly accompanied by a hiatus.

A Frasnian reef facies occurs in the Carrière de la Parisienne a short distance from the Carrière du Griset but only the lower part is preserved. It is yellowish where weathered and contains massive colonial corals and possibly stromatoporoids which suggest reef "in situ". The quarried-out strata were undoubtedly limestone.

The Université Libre de Lille, Laboratoire de Géologie, was visited with Mlle. Brice during the morning of November 24. The fossil collections are kept in a museum in the basement, selected examples being brought up for student use as needed.

In the afternoon I was taken to the Université de Lille, of which Professor Ch. Delattre is head of the Laboratoire de Géologie Régionale. This is a new campus on the outskirts of the city. The buildings are low modern blocks, simple but suited to the flat landscape. The library is the only outstanding building.

My lecture on the Devonian of Western Canada was given to the Geological Association of northern France and students of the University. The audience, of all age groups, was interested and asked numerous questions. Following the lecture I returned to Paris.

On November 25 I travelled from Paris to Caen where, at the Université de Caen, I had a brief meeting with le Professeur Dangeard who is about to retire. Le Professeur Pareyn is head of the Institut de Géologie et de Paléontologie and Monsieur Poncet, a research fellow with no teaching responsibilities, was designated to meet me and take me on a field excursion the following day. Le Professeur Pareyn asked me to give a talk comprising parts of my lectures on the Devonian of Western Canada for general background and the main part of my lecture on Devonian banks and reefs. This required some re-organization of slides but was accomplished quite easily. The student audience was one of the best I encountered and asked many intelligent questions. Several students there are working on carbonate problems.

On November 26 le Docteur Poncet took me to the Cotentin to examine the Lower Devonian reefs on which he has done a detailed study of facies by means of thin sections taken from 1- to 2-foot intervals across the reef and flanking beds. The platform is a coarse grainstone containing thin coquinas of brachiopods; crinoids also are abundant. The reefs, about 5 feet high, are a complex of massive stromatoporoids and corals with crinoid stems intermixed; the top of the reef contains abundant crinoids. A thin layer of shale overlies the reef and forms the base for a mass of fragile branching stromatoporoids, in places overlain by brachiopod-crinoid packstone. The change from the massive forms of the reef to the more fragile branching forms suggests deepening of water resulting in the quiet conditions necessary for preservation of the branching forms. The fore-reef beds dip off the reef at about 20 degrees. They contain coarse stromatoporoid detritus. In a nearby quarry, where dipping reef-flank beds are exposed, massive stromatoporoids are covered by lentils of platy, argillaceous limestone and shale, greenish yellow in colour. Lamellar stromatoporoids are also present. The matrix is coarse-grained and contains abundant crinoids. The stratigraphically higher beds contain large fragments of branching Stachyodes. No reef is exposed, but it may have been removed by quarrying. The most remarkable fact about the reefs and associated beds is the complete lack of recrystallization. It is difficult to explain, but may be the result of continued subsidence at the time of reef growth.

The following day, November 27, I proceeded south to Pau to visit the Société National du Pétrole d'Aquitaine. This company has the largest gas field in France located at Lacq, a few kilometers from Pau. The plant headquarters has a small display, open to the public, showing the geology and steps involved in drilling and processing gas, the production of sulphur, the general geology of the area, etc. The whole display is done with considerable artistry. A town, built to house the workers, comprises high rise apartments, what we call "town-houses" as well as a few individual houses, and a shopping centre, theatre etc. Gas heat is central.

SNPA had planned a field trip to the Pyrenees but the weather turned cold and outcrops were snow-covered. Within the SNPA organization Monsieur Radier is Chief of the Exploration Division and Monsieur Borocco is Chief Geologist in charge of operations in Canada. M. Borocco was in charge of my program. I visited all departments of the research establishment of which Monsieur Kilbicki is head and was given short lectures on the work carried out in physical chemistry (Mlle. Roumazeilles), geochemistry (M. Artru), drilling techniques (M. Barreyte), Paleontology (Le Febre, Oertli, Peniguel). I had meetings with the group of sedimentologists accompanied by discussion of thin sections, both theirs and mine. Monsieur Elloy is head of that section of the research establishment.

In addition to the discussions on sedimentology I presented all three of my lectures; Devonian of Western Canada, Devonian reefs and banks, and Transgression over a basement high.

From Pau I went to visit the Elf Research establishment in Boussens. Monsieur Housse, the Director, resides in Paris and Monsieur Bujnicourt was ill with flu. Monsieur Presta and Mlle. Fischer greeted me and showed me through the establishment. They asked for a combination of two lectures - The Devonian of Western Canada and Devonian banks and reefs. In addition I spent an afternoon discussing thin sections and sedimentary petrology with the sedimentology staff and a group of geologists from the North African operations who were being trained in sedimentology.

On December 5 I went from Boussens to Nantes. Professors Cavet and Lardeux of the University of Nantes with Monsieurs Bodeur and Debreuil, graduate students, took me to visit two quarries in the Lower Devonian of Brittany, north and northeast of Nantes.

The first quarry contained facies which resembled facies developed in Canada. A bed with abundant Amphipora and a few rounded massive stromatoporoids is overlain by an Amphipora - stromatoporoid bank. The overlying massive, barren limestone beds are interbedded with others containing small stromatoporoids, beds with Amphipora and lamellar stromatoporoids and beds with ostracods, gastropods and small brachiopods. A small reef, in which corals are the chief colonial organism, occurs above the bedded sequence. Thin-bedded limestones drape the reef and are overlain by sandstone and shale. This quarry seems to be a reef complex. It resembles more closely the Canadian Devonian than any Devonian I have seen in Europe, particularly the Amphipora beds.

A second quarry, seen in pouring rain, contained a most interesting sequence of bedded, black limestones some of which contained large rounded stromatoporoids. A small stromatoporoid biostrome occurs near the apparent base of the section. (It has not yet been determined whether the sequence is normal or overturned. M. Lardeux is now studying the Tentaculites in an effort to solve the problem). The bedded limestones form a rhythmically repeated sequence. Prominent in each sequence are beds of breccia

in which flat-pebble shaped fragments of limestone are separated by white crystalline sparry calcite; these short sparry calcite "inclusions" being oriented in all directions from horizontal to vertical. No explanation for this phenomenon has been suggested.

From Nantes, on December 9, I proceeded to Bordeaux to visit the sedimentological laboratory of the Compagnie Française des Pétroles and the Université de Bordeaux.

The Compagnie Française des Pétroles has a policy of systematically examining thin sections of core from all areas in which they are interested in order to obtain an understanding of the microfacies. It is hoped that such a study will enable them to predict facies and porosity favourable for hydrocarbon accumulation. M. Sacal is in charge of the laboratory, M. Fediaevsky is their reef and carbonate specialist, and M. Bousquet, their Carboniferous specialist.

I presented a combined lecture on the Devonian of Western Canada and Devonian reefs and banks to this group as well as taking part in a discussion of thin sections.

The Faculté des Sciences, Domaine Universitaire de Talence, Bordeaux, is a new campus on the outskirts of the city. The auditorium, which serves the Campus, is large but not well equipped for projection of 35 mm slides.

On December 11 I travelled from Bordeaux to Grenoble. The Department of Geology at the Université de Grenoble is in the Institut Dolomieu, a new well-designed building on a hill overlooking the city. They have a small but good museum containing an excellent collection of minerals. Dolomieu's desk, chair and small library are preserved in the board room. M. Barbier, a specialist in applied geology particularly dam sites, is Chef du Laboratoire. He was away during my visit and I was looked after by M. Debelmas, alpine structural geologist, by M. Perriaux, carbonate specialist and by M. Vialon, an igneous petrographer. I gave a combined lecture on the Devonian of Western Canada and Devonian Reefs and Banks.

The professors at this University are very concerned over employment for the students and are particularly interested in the possibility of employment in Canada. The students are encouraged to learn English. This group seemed unaware of the possibilities for employment in Quebec or that persons of nationalities other than Canadian or American would be employed by English-speaking oil companies. In reply to a request I gave a summary account of the geological institutions in Canada which might employ geologists including government and industry, but restricted my remarks to the federal and provincial organizations and the oil industry. I was asked to deliver the talk in both English and French and to stress the importance of understanding and speaking English for employment by industry in Canada.

On December 14 I left Grenoble and travelled to Nancy to visit the École National Supérieure de Géologie Appliquée et de Prospection Minière. Many of the staff were ill with flu but I was given a tour of the laboratories. These are oriented toward the mineral industry. They have been visited by S. C. Robinson who has undoubtedly submitted a report on them.

In Nancy I gave a combined lecture on the Devonian of Western Canada and Banks and Reefs. They were most interested in dolomitization in Pine Point area and similar occurrences in the Middle Devonian in northern Alberta, British Columbia and southern Northwest Territories. As a result, they also received a summary of my paper on "Transgressions sur un haut-fond". It was a small audience but one of the most interested groups I met and a long question period followed the formal presentation.

I returned to Paris on December 16 and to Canada the following day.

I should point out that a person undertaking a lecture tour throughout France must be able to understand and speak French. Most professors, I believe, read English but few attempted to speak to me in English. In fact, except when conversing with a few persons who wanted to practice their English, I spoke French all the time. French is necessary in many hotels in the smaller non-tourist cities and, even in many of the larger centres, it is convenient to speak French rather than request assistance when dealing with under members of hotel staffs, taxi drivers, etc. I noticed that in all of my lectures, even to the Sedimentological and Paleontological Societies, questions were asked in French.

Considerable interest was expressed in the possibility of employment in Canada for graduates in geology. France has an excess of students graduating relative to the number of positions available and some of the younger men are willing to migrate. I pointed out that there are possibilities at the present time in Quebec, that the petroleum industry is a fluctuating market for personnel, and that graduates without experience cannot expect highly paid jobs at the present time. I also pointed out the necessity to speak English in the oil industry.

This tour of France was very demanding in time and effort but was rewarding and certainly worthwhile from the point of view of liaison between France and Canada. I was welcomed everywhere and treated with the utmost hospitality and kindness. The oil companies were understandably interested in everything I had to say on the Devonian of Western Canada but the university professors and students were equally interested. Most lectures were followed by question periods which demonstrated the enthusiasm of the students and professors.

APPENDIX

Field Trip in Asturias and Cantabrian Mountains

This trip was made in company with Madame and Monsieur Marquis and Monsieur Fediaevsky of Compagnie Française des Pétroles. The Devonian of these areas and the included faunas have been discussed by Llado, de Villalta, Cabanas, Pelaez Pruneda and Vilas in Le Dévonien de L'Espagne, International Symposium on the Devonian System, vol. 1, pp. 171-187, 1967. We were given a somewhat more detailed discussion of the stratigraphy and were taken to examine the outcrops along the coast of Asturias and in roadside outcrops 25 kms inland. Comments supplementary to the discussion in the above mentioned paper will be made here. Such comments will refer mostly to reef and associated facies and the forms of the contained organisms, particularly where these contrast with organisms that play a similar role in reefs in Western Canada.

In Asturias, the Devonian is preserved in tightly folded synclines; in the Cantabrian Mountains in a folded belt in which resistant strata form bare ridges and cliffs, and the less resistant are grass-covered.

The Silurian-Devonian boundary lies within a sequence of interbedded reddish weathering sandstones and shales - Grès de Furada.

Asturias

Calcaire de Niéva (Gedinnian to Siegenian) western exposures seen along the coast consist of brownish weathering, slightly dolomitic limestones containing massive, scattered stromatoporoids and Thamnopora-type corals that seem to occur in the ecological niche that, in Western Canada is occupied by Amphipora. No actual reefs were seen. Beds of the same age seen 27 kilometers inland form a roadside section about 25 feet thick. The section, from the base upward, changes from structures interpreted as algal laminites to yellowish weathering breccias suggestive of solution breccias, to reddish, finely crystalline dolomite that grades up to interbedded dolomite (thin beds) and red and green dolomitic shale. Interpretation - open marine, possibly reef facies to the west and evaporitic to the east.

Schistes et Calcaires de Ferroñes - calcareous shales, in part sandy, and dark grey limestones with ochre-weathering dolomite inclusions or concretions; chert, dark grey, replaces dolomite, probably a tectonic effect. Pleurodictyum problematicum is present in one outcrop. Inland, Ferroñes is similar and contains large brachiopods (Spirifer pellicoides), and small crinoids. There are some laminated beds and the section is faulted.

Calcairc de Arnao - the top limestones (Siegenian to Emsian) contain lentils of reddish weathering shales and large crinoids (1 cm diameter), branching Encrinus lilliformis, bryozoans, and corals. The block containing this fauna and facies is down-faulted. What were said to be overlying beds contain tabulate corals and lamellar stromatoporoids and corals typical of the black, thin-bedded limestone facies throughout the Devonian of this area. Abundant small branching corals (lasagne en coraux) are present.

Calcaire de Moniello - These beds, Emsian to Couvinian in age, consist of thin-bedded, dark grey, argillaceous limestone with discontinuous limestone beds and "augen" similar to the "off-reef" shaly limestones with limestone "augen" in the Mt. Hawk and Ireton Formations. The fauna is composed of small crinoids, Calceola, and a few zones containing abundant lamellar stromatoporoids. Inland, roadside outcrops contain more abundant small stromatoporoids, disphyllid-type corals, and branching crinoids. Near the top is an interesting stromatoporoid-crinoidal facies in which massive beds contain abundant crinoids, disphyllid corals and a few massive globular and lamellar stromatoporoids. Near the top of the Moniello, and exposed in a quarry, is a reef facies overlain by massive crinoid banks. Blocks in the quarry consist of wackestone or grainstone containing globular stromatoporoids, Thamnopora-type corals, algal-coated grains.

Grès de Naranco, Couvinian to Givetian in age, consists of reddish sand-stone. The boundary with the Frasnian is uncertain. These strata overlie crinoid beds of the Moniello in the road section.

Calcaire de Candás - visited near Syndicate holiday resort. There, bedded limestones and reefs (Frasnian) overlie sandstones of Givetian age and are overlain by sandstones, Grès de Candás, that may represent uppermost Frasnian and Famennian. The Grès de Candás are reddish sandstones and are overlain by calcaire griotte that contain carboniferous goniatites.

The Calcaires de Candás, at this locality (below Syndicate summer resort) consist of dark grey limestone with lighter grey limestone nodules that contain numerous disphyllid corals. In one place a massive stromatoporoid occurs in a disphyllid bed suggesting conditions favorable for reef growth.

The Frasnian reef facies occurs on the northwest flank of the syncline. The whole sequence is present from platform, through reef growth in situ to reef debris beds. The overlying and what are probably inter-reef beds are argillaceous limestone and shale with lamellar stromatoporoids and corals. The series of small reefs is overlain and draped by shaly limestones and shales containing abundant crinoids. Small erosion surfaces in and below the crinoid beds suggest channelling.

The reef platform is essentially a biostrome containing large lamellar corals (Phillipsastrea?), stromatoporoids, bryozoans and disphyllid corals in situ, whereas, the massive reef contains massive stromatoporoids and colonial coral heads, including some large lamellar forms, in a matrix containing abundant disphyllid corals. The upper part of the reef complex contains massive forms in situ and smaller fragments of colonial organisms. Reef breccia forms the uppermost part of the mound.

Another small Frasnian reef has been exhumed as a headland but, because of the topography, only the base was examined. At the base is a reddish, crinoidal zone overlain by beds rich in disphyllid corals and a few lamellar stromatoporoids. The overlying massive zone consists of large lamellar stromatoproids, as much as 2 feet in length, separated by layered beds containing abundant disphyllids.

Calcaires de Candás inland - There, the reef facies forms a cliff where it is exposed along a narrow road.

A cursory examination of the section shows the sequence from top to bottom to be as follows:

Tournaisian, light grey limestone resting directly on Frasnian disphyllid bed.

Zone with disphyllids - small to large.

Reef: Elongate, lamellar corals (?Hexagonaria ?Tabulophyllum), massive stromatoporoids and disphyllids; shale and limestone interbedded, corals; bedded limestone and shale with "cabbage" stromatoporoids; massive reefs with stromatoporoids; massive, barren beds; beds with small globular stromatoporoids; massive, barren carbonates; shales; limestone, massive-bedded, large lamellar forms and massive "cabbage" stromatoporoids both occurring in one bed, many fragments are disturbed and broken; limestone with brachiopods; reddish sandstones.

Cantabrian Mountains

On November 7 we proceeded to Villamanin at the top of the pass in the Cantabrian Mountains on the highway between Oviedo, Asturias and Leon, Leon, for a 2-day field trip with Senor Vilas of the University of Madrid.

At that locality the uppermost Silurian and Gedinnian consists of ferruginous sandstones and interbedded shales some of which contain faunas (le Grès de San Pédro). The boundary between the Silurian and Devonian is not precise. Graptolites of Ludlow age have been found and the next higher fauna documented is a brachiopod fauna comparable to that found in the Schiste de Mondrepuit and which is of upper Gedinnian age.

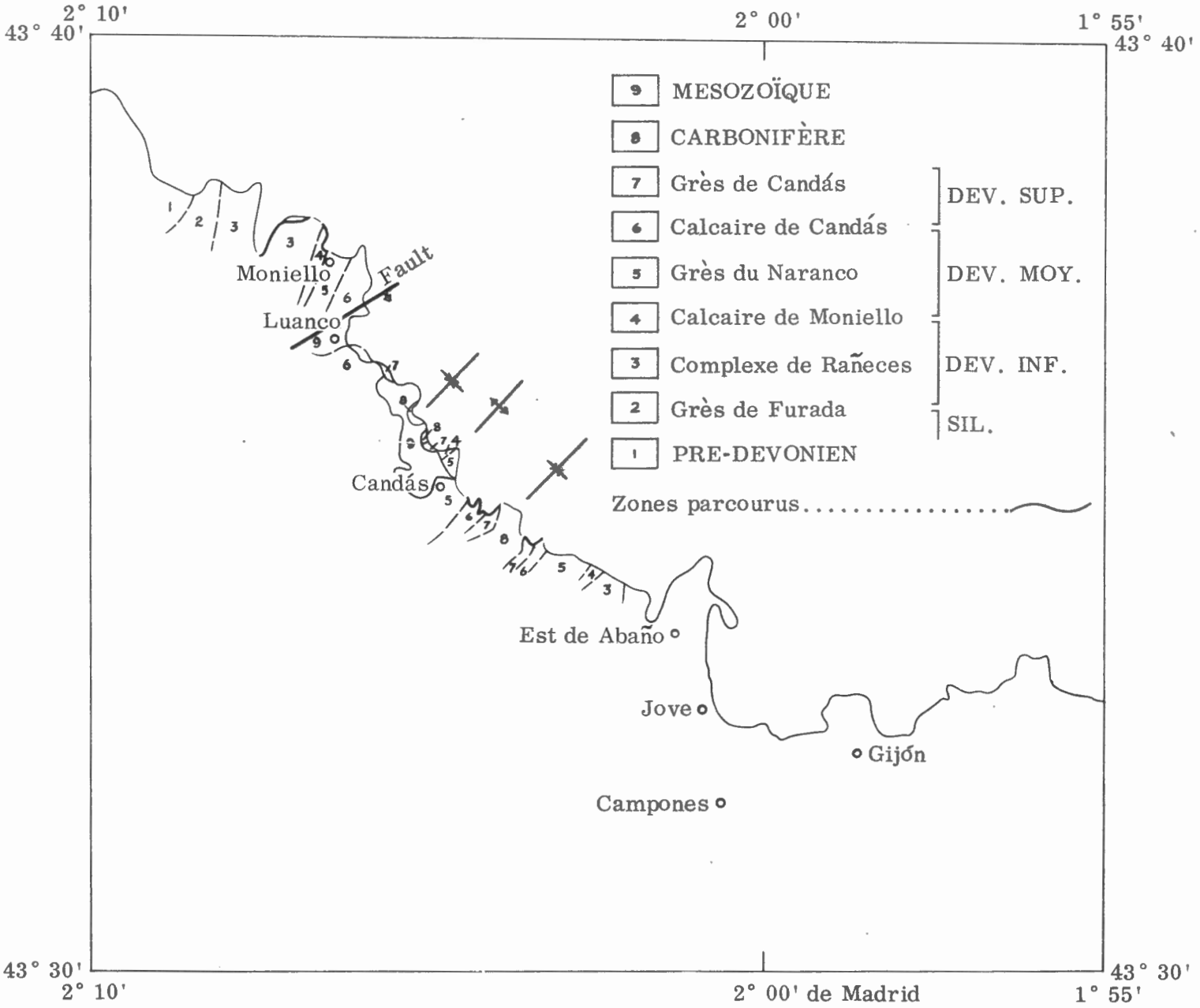
The overlying beds, calcareous shales and limestones of La Vid, range from upper Gedinnian to within the Emsian. La Vid section examined consisted of grey and reddish sandstones and siltstones at the base overlain by finely laminated dolomites. Succeeding cycles of sedimentation consist roughly of red beds, fine-grained dolomites with interbedded shale, laminated dolomites resembling algal laminite, in one cycle with mud cracks; interbedded dolomite, dark limestone and shale. Breccias, resembling solution breccias in at least one cycle, overlie and cut down into the laminite beds, the contact between the two being quite irregular and suggestive of erosion. The limestone - shale sequence overlying the breccias is wavy-bedded to nodular and shows slump structures. Crinoids and brachiopods are present. Higher in La Vid are massive crinoid beds containing a few corals. Near the boundary between La Vid and the Santa Lucia beds are large crinoids similar to those seen in Asturias.

The Santa Lucia beds range from low middle Emsian to early Couvinian; these are dolomitic at the base but are overlain by bedded limestones containing abundant crinoids and thin zones containing corals and lamellar stromatoporoids. Brachiopod beds contain Paraspirifer conjugatus.

A long section examined briefly, shows a variety of rock types: limestone containing crinoids and lamellar stromatoporoids; limestone containing scattered massive stromatoporoids and Thamnopora-type corals but with crinoid discs in the matrix and black shale between limestone layers; beds containing gastropods; a bed containing crinoids in the matrix also has massive stromatoporoids up to 8 inches tall in growth position; bedded "nodular" limestones with crinoids, and scattered small globular stromatoporoids and brachiopods; one biostrome? consists of large stromatoporoids separated by black shaly limestone containing small tabulate corals; massive crinoid beds, one of which is crossbedded, another of which grades to dolomite and evaporite. This sequence suggests an environment dominated by turbulent water. It is overlain by dark grey shales that range from Couvinian to Givetian in age.

Givetian carbonates in this area contain biostromes and probably bioherms. Massive corals, stromatoporoids and disphyllid corals occur in outcrop. The Givetian carbonates are overlain by quartz sandstones of Frasnian age.

The Devonian sequence of the area is truncated and overlain in different parts of the area by beds ranging from Famennian sandstones to Carboniferous limestones.


2° 10'
2° 00'
1° 55'
43° 40'
43° 30'
9 MESOZOÏQUE
8 CARBONIFÈRE
7 Grès de Candás
6 Calcaire de Candás
5 Grès du Naranco
4 Calcaire de Moniello
3 Complexe de Rañeces
2 Grès de Furada
1 PRE-DEVONIEN
DEV. SUP.
DEV. MOY.
DEV. INF.
SIL.
Zones parcourus
Moniello
Fault
Luanco
Candás
Est de Abaño
Jove
Gijón
Campones
2° 00' de Madrid