

DEVONIAN SANDSTONES FROM THE LIEVIN SHAFT N° 8, AVION (PAS-DE-CALAIS, FRANCE) : HISTORICAL CONTEXT AND ADDITIONAL VERTEBRATE REMAINS

Grès dévoniens du puits n° 8 de Liévin à Avion (Pas-de-Calais, France) : contexte historique et nouveaux restes de vertébrés

by Alain BLIECK (*) & André STYZA (**)

Abstract. – The Liévin shaft n° 8 of the Nord – Pas-de-Calais coal basin worked as a ventilation shaft from 1948 to 1982. Collections of Early Devonian vertebrates, made both *in situ* during boring of the shaft, and later on its slag heap, included mostly pteraspigid heterostracans, plus a few remains of cyathaspidiforms, osteostracans, as well as thelodont and acanthodian scales. In 1982, vertebrates were collected on its slag heap. They came from the subsurface Lochkovian, lower Pernes Formation. They include Heterostraci (Traquairaspididae indet., *Rhinopteraspis crouchi*, Pteraspidae indet.), Osteostraci (*Cephalaspis* sp.) and ‘actinolepid’ Arthrodira (*Kujdanowiaspis?* sp.). These are dated of the *R. crouchi* Biozone, and correlated to the ‘middle’ Lochkovian. As in the Liévin shaft n° 6, it corresponds to the highest diversity for the latest Silurian-Early Devonian sequence of vertebrates in Artois (northern France). This peak is known worldwide.

Résumé. – Le puits n° 8 de Liévin dans le bassin houiller du Nord – Pas-de-Calais a fonctionné comme puits d’aération de 1948 à 1982. Des récoltes de vertébrés du Dévonien inférieur, faites tant pendant le fonçage du puits qu’ultérieurement sur son terril, ont fourni principalement des hétérostracés ptéraspidés, et quelques restes de cyathaspidiformes, d’ostéostracés ainsi que des écailles de thélodontes et d’acanthodiens. En 1982, des vertébrés ont été récoltés sur son terril. Ils provenaient de la partie inférieure de la Formation de Pernes, d’âge lochkovien. Ils comprennent des Heterostraci (Traquairaspididae indet., *Rhinopteraspis crouchi*, Pteraspidae indet.), des Osteostraci (*Cephalaspis* sp.) et des Arthrodira ‘actinolépides’ (*Kujdanowiaspis?* sp.). Ils sont datés de la Biozone à *R. crouchi* et corrélés au Lochkovien ‘moyen’. De même que dans le puits n° 6 de Liévin, cette biozone correspond à la biodiversité la plus grande pour toute la série de vertébrés du Silurien terminal-Dévonien inférieur de l’Artois (nord de la France). Ce pic est connu à l’échelle mondiale.

Key words. – Pernes Formation, Lochkovian, Heterostraci, Osteostraci, Placodermi Arthrodira, peak of biodiversity, history of geology.

Mots clés. – Formation de Pernes, Lochkovien, Heterostraci, Osteostraci, Placodermi Arthrodira, pic de biodiversité, histoire de la géologie.

I. — INTRODUCTION

The vertebrates that have been found during the boring of coal mine shafts of the Nord – Pas-de-Calais basin have been published in several papers, a review of which is given by Blicek & Janvier (1989, for the Silurian-Devonian), Blicek *et al.* (1995a for the Silurian to Carboniferous; 1995b for the Silurian-Devonian), and in the catalogue of collections of the Natural History Museum of Lille (Blicek *et al.*, 1999). Two more recent papers have either mentioned or described other Devonian and Carboniferous vertebrates of the region: Mistiaen *et al.* (2002: Frasnian of the Boulonnais Palaeozoic inlier), and Derycke-Khatir (2005: microremains of the Devonian to Carboniferous carbonate formations from the Channel to the Meuse river); but, none of the latter is concerned with Devonian material from the

ancient shafts of the Nord – Pas-de-Calais coal basin. The last active shaft was closed in 1990, so that new findings can only come from surface collection made on the series of slag heaps left by the coal mining activity. Here we report on a small collection of Early Devonian vertebrate remains made by one of us (A.S.) on the slag heap of Liévin shaft n° 8 (Avion, Pas-de-Calais). The material is described after a short historical account of the shaft activity, and historical review of the vertebrate remains. This kind of material being rare, it is worth being described and illustrated. It gives additional information on the biodiversity of Early Devonian vertebrates in northern France, and particularly of the ‘middle’ Lochkovian diversity peak observed worldwide for vertebrates.

(*) Université de Lille – Sciences et Technologies, UFR Sciences de la Terre (SN5), UMR 8217 Géosystèmes du CNRS, F-59655 Villeneuve d’Ascq cedex; alain.blicek@univ-lille1.fr

(**) 29 bis rue de la Lys, 59280 Armentières; astyza@free.fr



Fig. 1. — Sealed memorial plate of the Liévin shaft n° 8 in Avion (Pas-de-Calais), after APPHIM (2014). Abbreviation: CDF- Charbonnages de France.

Fig. 1. — Plaque de renseignements (ou dalle de puits) du puits de la fosse n° 8 de Liévin à Avion (Pas-de-Calais) d'après APPHIM (2014). Abréviation : CDF- Charbonnages de France.

II. — HISTORICAL ACCOUNT OF THE LIEVIN SHAFT N° 8

Boring of the shaft n° 8 of the Liévin Concession (« Groupe de Liévin ») began in 1948. Alexis Bouroz was then head of the geological survey of the Nord – Pas-de-Calais coal basin (Houillères du Bassin du Nord et du Pas-de-Calais or HBNPC). Pierre Dollé was the geologist following the boring in order to establish the geological section of the shaft (Dollé, 1950, p. 185). The Liévin shaft n° 8 was an air shaft for ventilation of the eastern part of the area covered by the Liévin mines 4 and 7 where important firedamp release was known (Petit,

1951). In 1952, the Liévin Concession merged with the Lens Concession to constitute the Lens-Liévin Concession (« Groupe de Lens-Liévin »). It was during that year that the n° 8 shaft began to be worked after having been connected to the mines 4-4bis and 7-7bis by mean of galleries (« bowettes » in the local underground coalminers' vocabulary). The diameter of the shaft was 6,50 m, its depth 910 m, and it worked as a ventilation shaft. The wooden pit-head frame (tower) was replaced by the metallic tower from the shaft n° 19 of the mine 11-19 of the Lens Concession at Loos-en-Gohelle. In 1982, shaft n° 8 became useless and consequently it was filled in. Its tower was destroyed the same year. A memorial plate has been placed at the original location of the shaft – but with the year 1981 (Fig. 1). P. Dollé established the stratigraphical log of the shaft, that has been described in the HBNPC report n° 63632 on May 8th, 1949 (B.R.G.M., 1949).

III. — HISTORY OF THE DEVONIAN VERTEBRATE COLLECTIONS OF THE LIEVIN SHAFT N° 8

Dollé (1949) was the first to have reported and described Devonian vertebrate remains from the Liévin shaft n° 8. He gave an oral communication to the Société géologique du Nord (SGN) on January 21, 1950, and published his discovery in the *Annales* (Dollé, 1950). During boring of the shaft, the Devonian was encountered at a depth of 145 m when red and green shaly sandstones were found. At – 165 m, a series of white quartzitic beds lying above a 1 m-thick sandstone bed overlying alternating green and red sandstones and schists was found. Dark green remains identified as « *Pteraspis* » by Prof. J. Piveteau of the Paris (Sorbonne) University were collected in the latter sandstones (Dollé, 1950, p. 187). The deposit (litho- and bio-facies) is similar to the Pernes quarry locality in the Artois hills as reported by Dollé (1903) and Leriche (1903). Dollé (1950, p. 202) identified three co-occurring species, viz. « *Pteraspis Crouchi* Lankester », « *Pteraspis rostrata* Agassiz » and « *Pteraspis cf. dunensis* Roemer » [sic]. The following year, on January 28, 1951, a field trip of the SGN was organized on the slag heap of Liévin shaft n° 8. Petit (1951) mentioned the occurrence of the pteraspids at two different levels, i.e. – 163 m and – 334 m, in the Devonian series that lies tectonically above the Carboniferous series due to the Midi Fault (Grande Faille du Midi), the main regional overthrust encountered here at – 562 m (Petit, 1951, p. 48) (Fig. 2).

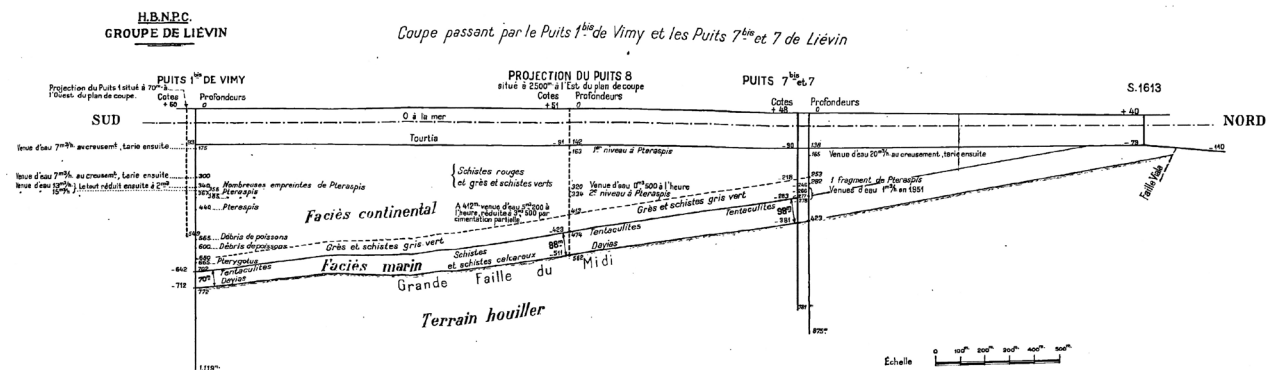


Fig. 2. — Lateral projection of location of the Liévin shaft n° 8 on a geological section from Vimy 1bis shaft to Liévin 7 and 7bis shafts (Petit, 1951, pl. I). Note both pteraspid-bearing layers '1er niveau à Pteraspis' at – 163 m, et '2e niveau à Pteraspis' at – 334 m.

Fig. 2. — Projection du puits n° 8 de Liévin sur une coupe passant par le puits n° 1bis de Vimy et les puits n° 7bis et 7 de Liévin (Petit, 1951, pl. I). Notez les deux niveaux à pteraspides « 1er niveau à Pteraspis » à – 163 m, et « 2e niveau à Pteraspis » à – 334 m.

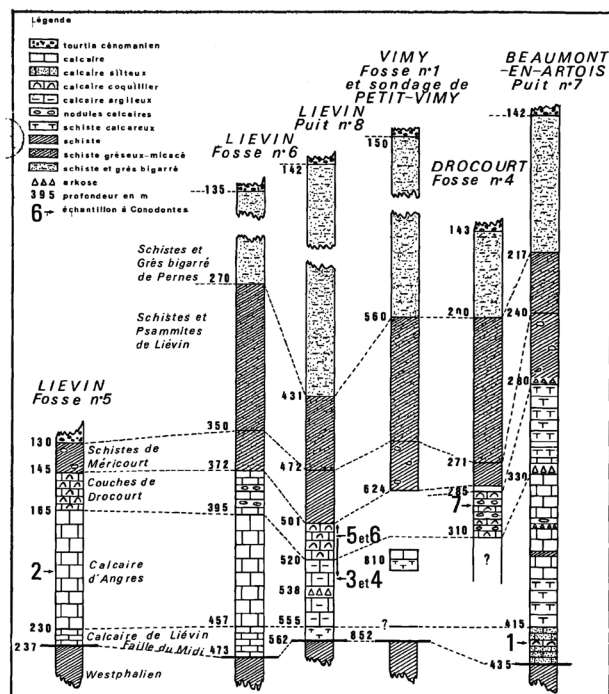


Fig. 3. — Lithostratigraphical correlation between the Silurian-Devonian series of coal mine shafts in the Artois (Bultynck, 1977, fig. 1). The small bold numbers indicate depth in meters. The bigger numbers 1 to 7 correspond to conodont-bearing samples.

Fig. 3. — Corrélation lithostratigraphique entre les séries siluro-dévonniennes de puits de mine de l'Artois (Bultynck, 1977, fig. 1). Les petits nombres en gras indiquent la profondeur en mètres. Les grands nombres de 1 à 7 correspondent aux échantillons à conodontes.

White (1956, p. 2) cited Dollé's (1950) discovery, and considered that all his figured specimens belong to *P. crouchi* (with neither *P. dunensis* nor *P. rostrata*). A year later, in an unpublished memoir, Dollé (1957) attributed his material to a series of species, i.e. « *P. dubari* nov. sp. » [nomen nudum], *P. crouchi*, *P. rostrata*, and « *P. lafonti* » [sic; about this « species », see comments in Blicek & Janvier, 1989, p. 139; and Blicek *et al.*, 1999, p. 91]. Dollé & Legrand (1966) gave a precise location of the three pteraspid-bearing layers of Liévin shaft n° 8, that is at – 163 m (*P. crouchi* and *P. dunensis*), – 165 m (*P. rostrata*) and – 334 m (*P. dubardi* [sic]). In the same paper, they concluded to the marine environment for the beds where the pteraspids occur, due to the co-occurrence of marine algae (Dollé & Legrand, 1966, p. 145: « Ce fait, d'importance capitale, ne permet plus de considérer les ostracodermes comme poissons d'eau douce »; and p. 147: « Il faut donc conclure que les poissons associés à ces algues ont la même origine marine »). Bultynck (1977), while studying the stratigraphical range of conodonts in the subsurface Liévin Series – in relation to the Silurian-Devonian boundary problem, gave a precise correlation between coal mine shafts, including Liévin shaft n° 8 (Bultynck, 1977, fig. 1) where the pteraspid-bearing « Schistes et Grès bigarrés de Pernes » are 289 m thick (between – 142 m and – 431 m), and dated as Lochkovian (« Gedinnien ») (Fig. 3).

On March 29, 1978, a visit to the slag heap of Liévin shaft n° 8 was organised by A. Blicek (then at the Muséum National d'Histoire Naturelle - MNHN, Paris), P. Dollé (one of the last mining engineers of the HBNPC), Wang Nian-Zhong (from the

Academia Sinica, Beijing, then on visit at the MNHN) and D. Goujet (MNHN). Several fossils were collected on the heap, including pteraspid remains (specimens MNHN n° LIE 101 and 101a) attributed to *Belgicaspis crouchi* (Lankester, 1868) — formerly *Pteraspis crouchi* — by Goujet & Blicek (1979, p. 265), thus in agreement with White's (1956) opinion that only *B. crouchi* occurs in Liévin shaft n° 8. At the end of the same year, on November 10, 1978, one of us (A.B.) made a visit to Mr. Jacques Chalard, the last coal mine engineer to have been employed — see his biography by Laveine & Cuvelier (2011) — in the HBNPC geological service in Douai (Nord). Additional material from the Liévin shaft n° 8 was thus given to the MNHN collections, viz. specimens n° LIE 110 to 124. Some of these specimens are attributed to *Rhinopteraspis crouchi* (LIE 117, rostral plate; formerly *Belgicaspis crouchi* — see Blicek, 1980) and *Pteraspis rostrata* (LIE 118/119, dorsal disc; this being one of the rare specimens from the Devonian of Artois to be attributed with certainty to *P. rostrata*: Blicek, 1980, p. 39; figured in Blicek, 1982, pl. 1: 3), thus contradicting White's (1956) opinion. The faunal list of the « Schistes et Grès de Pernes » in the Liévin shaft n° 8 was reviewed by Blicek (1982, p. 11-12) as follows:

- Heterostraci: *Rhinopteraspis crouchi*, *Pteraspis rostrata* (specimen LIE 118/119 — see above), Cyathaspidiformes gen. et sp. indet.;

- Osteostraci: *Securiaspis* sp., the only osteostracan remain to have been found here, originally determined as *Pteraspis rostrata* by Dollé (1950, fig. 7 and pl. VII: 7) and attributed to *Securiaspis* by P. Janvier (in Goujet & Blicek, 1979, p. 270 and fig. 6 A1);

- Thelodonti indet. and Acanthodii indet. isolated scales (unfigured; the thelodont and acanthodian scales figured by Goujet & Blicek, 1979, come from the Liévin shaft n° 6).

This is summarized by Blicek & Goujet (1986, fig. 37 on p. 207) who listed this faunal assemblage in the lower part of the Pernes Formation of the Liévin Group as redefined by Rachebœuf (1986 — that is the former « Schistes et Grès de Pernes » or « Schistes et grès bigarrés de Pernes » [Blicek & Goujet, 1986, also listed an acanthodian scale assemblage in the Noulette Formation, at the base of the Liévin Group]). The lower Pernes Formation fish assemblage of the Liévin shaft n° 8 corresponds to the *Crouchi* Zone of Great Britain (Blicek & Goujet, 1986, fig. 40). It has been renamed the *Rhinopteraspis crouchi* Biozone (« Biozone à *Rhinopteraspis crouchi* ») by Blicek & Janvier (1989, p. 30 and fig. 12) and correlated to the *micronatus-newportensis* (MN) spore Zone (upper part of the lower Lochkovian to lower part of the upper Lochkovian; Blicek & Janvier, 1989, fig. 11; Blicek *et al.*, 1995 a-b).

IV. — ADDITIONAL VERTEBRATE REMAINS FROM THE LIEVIN SHAFT N° 8

1) Origin, preservation and age of the material

One of us (A.S.), while a young boy living in the city of Avion (Pas-de-Calais), began in 1974 to explore a small, rather flat, approximately 5 m high slag heap, located at the boundary between the cities of Avion and Méricourt. This was the Liévin shaft n° 8, that had been bored for ventilation of part of the Liévin Concession mines. Contrary to many slag heaps of the Nord – Pas-de-Calais coal basin, this heap did not deliver fossil fern remains, but many invertebrates including trilobites. In 1982, when the shaft became useless, it was filled in by mean

of its heap. During this activity the central part of the slag heap appeared, and showed the green, red and variegated sandstones and schists, typical of the Pernes Formation. These rocks yielded the vertebrate remains reported here. A preliminary determination was made by the senior author (A.B.) in 1983. A sample with many fragmented specimens was deposited in the Natural History Museum of Lille where they are catalogued under n° 801910 (1 to 26) and determined as Heterostraci indet. (Blieck *et al.*, 1999, p. 97). Here we describe still unreported remains of heterostracans, osteostracans and placoderms. The lithofacies is mostly made of light grey medium-grained sandstones and reddish and greenish fine-grained sandstones, similar to the matrix of previously described material from the lower Pernes Formation (« Schistes et Grès de Pernes »). The light grey sandstones include many small micaceous flakes and rare pyrite cubes. The preservation of the material is also similar to the material already deposited in both the MNHN (e.g. Goujet & Blieck, 1979) and the Natural History Museum of Lille (Blieck *et al.*, 1999), i.e. all specimens are made of dark grey to black bone, where the outer ornamentation (or microsculpture) is rather well preserved (dentine ridges or tubercles). All specimens have been mechanically prepared, by use of sharp needles and a compressed air tool. They are deposited in the geological collection of the Natural History Museum of Lille under abbreviation MGL (standing for the former « Musée Gosselet de Lille »). The age of this material is given here above in section III, i.e. *Rhinopteraspis crouchi* Biozone, upper part of the lower Lochkovian to lower part of the upper Lochkovian (Blieck & Janvier, 1989, fig. 11; Blieck *et al.*, 1995 a-b).

2) Systematics

Preliminary note on nomenclature and classification. The authorship of higher chordate taxa follows Nielsen's (2012) nomenclature in order to correct Blieck *et al.*'s (1999) one. The classification of Traquairaspidiformes (Heterostraci) follows Mark-Kurik *et al.* (2013), that of Pteraspidiiformes (Heterostraci) follows Pernègre & Elliott (2008), that of Osteostraci follows Sansom (2009; see also Scott & Wilson, 2012), and that of 'Actinolepida' (Placodermi) follows Dupret *et al.* (2007; see also Denison, 1978 for higher taxa). Authors of taxa names are indicated in capital letters followed by year of authorship. The corresponding bibliographical references are not listed here in the bibliography section, they are found in the papers of Nielsen (2012), Mark-Kurik *et al.* (2013), Pernègre & Elliott (2008), Sansom (2009), Dupret *et al.* (2007) and Denison (1978) respectively. All other cited papers are in the bibliography section.

Phylum CHORDATA HAECKEL 1874
 Subphylum VERTEBRATA LAMARCK 1801
 †Class PTERASPIDOMORPHI GOODRICH 1909
 Subclass HETEROSTRACI LANKESTER 1868
 Order TRAQUAIRASPIDIFORMES TARLO 1962
 Family TRAQUAIRASPIDIDAE KIAER 1932
Traquairaspididae gen. et sp. indet.
 (Pl. I, fig. A-B)

Material. Specimens MGL n° 9571-2 and 9571-3 (fragments of dermal plate with denticulated, oak-leaf-like tubercles, Pl. I: A-B).

Description and comparison. Both specimens MGL n° 9571-2 and 9571-3 are on two separate blocks of grey sandstone that appear to have been connected. So, both specimens are probably

parts of the same fragmentary plate. The whole specimen is 24 mm long x 13 mm wide. It bears 35 black, shiny tubercles with denticulated edges. Most of them are oak-leaf-like-shaped (Pl. I: A-B). They are 1 to 2,5 mm long, and regularly spaced. They do not correspond to separate tesserae, but rather to the superficial ornamentation (microsculpture) of a single dermal plate. This morphology is typical for what is classically attributed to traquairaspid heterostracans. It can be compared to the fragmentary traquairaspid material recently described from the Lochkovian of Chukotka, in Arctic far-eastern Russia (Mark-Kurik *et al.*, 2013, figs 4 and 5); however, contrary to this Russian Arctic material, MGL n° 9571-2 and 9571-3 show no smaller intermediate tubercles between the bigger ones, a morphology that is classically met with in Devonian material from the Arctic regions (see particularly Dineley & Loeffler, 1976). The ornamentation of MGL n° 9571-2 and 9571-3 is similar to the material from the Lower Devonian of the Anglo-Welsh region, such as *Phialaspis symondsi* (see Tarrant, 1991, pl. 1: 6 and pl. 5: 2-3).

Order PTERASPIDIFORMES BERG 1937

Clade PTERASPIDOIDEI [*sensu* Pernègre & Elliott, 2008 ;
 PTERASPIDINA *sensu* Janvier, 1996]

Family PTERASPIDIDAE CLAYPOLE 1885 [*sensu* Pernègre
 & Elliott, 2008]

Genus *Rhinopteraspis* JAEKEL 1919

Rhinopteraspis crouchi (LANKESTER 1868)

(Pl. I, fig. C-E)

Material. Specimens MGL n° 9570-1 (dorsal face of a rostral plate, Pl. I: C), 9570-2 (fragment of a probable rostral plate), 9571-1 (ventral face of a rostral plate in part, Pl. I: D), 9572 (tip of the dorsal face of a small rostral plate, Pl. I: E), and 9577 (fragment of the rear part of a rostral plate).

Description and comparison. These rostral plates are typical for *Rhinopteraspis crouchi*. The most complete one, viz. specimen MGL n° 9570-1 (Pl. I: C), corresponds to the dorsal face of a rostrum that is more than 33 mm long, and 16 mm wide at its rear part. This size falls within the variability of the species (Goujet & Blieck, 1979, p. 265; Blieck, 1980, table I). It bears 5-6 dentine ridges per mm (*ibid.*). These ridges are organized into chevron-like groups that cut across each other as has been described for other *R. crouchi* rostra from England and northern France (White, 1973, figs. 24-25 and 33: « *Pteraspis (Belgicaspis) crouchi* LANK. »; Goujet & Blieck, 1979, fig. 3B and pl. XXIII: 2a, 2b, 6 and 7: « *Belgicaspis crouchi* (Lankester) »; reconstructed by Blieck, 1980, fig. 5: *Rhinopteraspis crouchi* (Lankester)). The specimen MGL n° 9570-2 is an 11 mm long x 9 mm wide fragment of the posterior margin of the dorsal face of a rostrum. The specimen MGL n° 9571-1 represents part of the worn ventral face of a rostrum whose tip and most posterior part are lacking (Pl. I: D). It is 23 mm long and 10 mm wide at its rear part. It is very similar to some slender rostral plates figured by White (1973, fig. 25). The specimen MGL n° 9572 is the most anterior part of the dorsal face of a rostrum (Pl. I: E) that is very similar to one of the specimens figured by White (1973, e.g. fig. 23). MGL n° 9577 is the left portion of the rear part of a rostral plate which shows five chevron-like groups of dentine ridges, with 6 ridges per mm.

Pteraspidae gen. et sp. indet.
(Pl. I, fig. F-G)

Material. Specimens MGL n° 9573 (ridge scale, Pl. I: F), 9574 (probable posterior end of a cornual plate), 9575 (probable anterior end of a branchial plate), 9576 (fragment of a dorsal shield with right posterior part of the dorsal disc and base of the dorsal spine), and 9578 (a big cornual plate, Pl. I: G).

Description and comparison. Specimens MGL n° 9573, 9575 and 9576 may belong to *Rhinopteraspis crouchi*, but they are too incomplete to be attributed with certainty to this species. MGL n° 9573 is a partly worn ridge scale; it is 11 mm long and 5 mm wide (Pl. I: F). This scale is more vaulted externally and longer than the ridge scale of « *Belgicaspis crouchi* » published by Goujet & Blicek (1979, pl. XXIII: 4) which is only 5,7 mm long. The specimen MGL n° 9574 represents the posterior, sharp tip of a probable cornual plate; it is too developed to be the cornual plate of *R. crouchi* which is small and narrow, with no developed tip (White, 1973, figs. 39-41). The specimen MGL n° 9575, a probable anterior end of a branchial plate, looks like the branchial plates of *R. crouchi* figured by White (1973, figs 37-40). The specimen MGL n° 9576 is a fragment of a dorsal shield with the right posterior part of the dorsal disc and base of the dorsal spine. It shows 5 to 6 dentine ridges per mm, as in *R. crouchi*, but such an isolated fragment can not be attributed with certainty. The specimen MGL n° 9578 is a big cornual plate, 32 mm long and 15 mm wide at its base (Pl. I: G). Its surface is worn, nearly all of the external dentine layer of the plate having been removed, except for a small portion near to its posterior tip where a group of five dentine ridges is visible. This cornual plate originally bore 6 to 7 dentine ridges per mm. MGL n° 9578 is suggestive of two other big cornual plates from the Pernes Formation, viz. « Pteraspidae gen. et sp. indet. forme A » and « Pteraspidae gen. et sp. indet. forme B » of Goujet & Blicek (1979, figs 3D and 3E, from the Liévin shaft n° 6) (these plates look like both *Parapteraspis jackana* and *Larnovaspis stensioei sensu* Blicek, 1984, from the Lochkovian of Podolia, Ukraine [see Blicek *et al.*, 1995b, p. 453]). MGL n° 9578 is of nearly the same size as « Pteraspidae gen. et sp. indet. forme A » which is slightly curved (contrary to MGL n° 9578) and bears 14 ridges per mm (vs. 6-7 for MGL n° 9578). MGL n° 9578 is smaller than « Pteraspidae gen. et sp. indet. forme B » which is about 50 mm long (Goujet & Blicek, 1979, p. 267-268).

†Class OSTEOSTRACI LANKESTER 1868
Subclass CORNUATA JANVIER 1981

[Order and family undesignated]

Genus *Cephalaspis* AGASSIZ 1835 (*fide* Afanassieva, 2004)

Cephalaspis sp.
(Pl. I, fig. H)

Material. Specimen MGL n° 9579 (fragment of the external margin of a cephalic shield, Pl. I: H).

Description and comparison. This specimen is 15 mm long x 6 mm wide. It is covered with minute, rounded and closely packed tubercles. Some of them are slightly star-shaped, elongated and irregularly arranged into rows (left part of Pl. I: H). This morphology may be compared to another fragment of osteostracan collected from the lower Pernes Formation in the Liévin shaft n° 6 (Goujet & Blicek, 1979, fig. 6B). However, MGL n° 9579 shows a single natural margin (top on Pl. I: H) which probably corresponds to the outer margin of a cephalic shield, contrary to *Cephalaspis* sp. indet. of Goujet & Blicek (1979, fig. 6B) which is from a broken cornual process and bears more elongated tubercles on its outer part.

Superclass GNATHOSTOMATA GEGENBAUR 1874
†Class PLACODERMI McCOY 1848

Order ARTHRODIRA WOODWARD 1891

Suborder 'ACTINOLEPIDOIDEI' MILES 1973

Infraorder 'ACTINOLEPIDA' MILES 1973

Superfamily KUJDANOWIASPIDOIDEA BERG 1955
(*sensu* Dupret *et al.*, 2007)

Family KUJDANOWIASPIDIDAE BERG 1955

Genus *Kujdanowiaspis* STENSIÖ 1942

Kujdanowiaspis? sp.

(Pl. I, fig. I-L)

Material. Specimens MGL n° 9571-4 (separate tuberculated fragmentary plate), 9580-1 (fragment of a rather big plate with spaced tubercles, Pl. I: I), 9580-2 (fragment of a smaller plate with smaller and tightly organized tubercles, Pl. I: J), 9580-3 (fragmentary spinal plate, Pl. I: K), and 9581 (fragmentary possible spinal plate, Pl. I: L).

Description and comparison. This kind of fragmentary, tuberculated arthrodire material is difficult to determine at lower than generic rank. The specimen MGL n° 9571-4 is a fragment of a small plate with rounded worn tubercles. It was broken during preparation and is not described further. The 'best preserved' specimen is MGL n° 9580-1 which corresponds to a fragment of dermal plate with closely and regularly organized tubercles (Pl. I: I). The specimen shows a single natural edge (on top of Pl. I: I), both other edges being broken. Its tubercles are regularly spaced, rounded, and large (1 to 1,5 mm wide). They are suggestive of the ornamentation of *Kujdanowiaspis* or *Erikaspis* (see Dupret *et al.*, 2007; Dupret, 2010; a quick "determination key" based on overall size of the animal and type of tuberculation being given in Dupret & Blicek, 2009). The ornamentation of MGL n° 9580-1 looks like that of *Erikaspis zychi*, in particular of its larger plates such as the anterolateral plate with its large rounded tubercles (Dupret *et al.*, 2007, fig. 10E). However, on *E. zychi*, the ornamentation is variable, being composed of tubercles « less dense (i.e., more widely spaced) on large plates (e.g., median dorsal, nuchal, paranuchal) than on small ones (e.g., preorbital) » (Dupret *et al.*, 2007, p. 268). MGL n° 9580-1 is also suggestive of the ornamentation of *Kujdanowiaspis podolica* as, e.g., its anterolateral plate (Dupret, 2010, fig. 20B). However, the ornamentation of the *Kujdanowiaspis* species is variable, having « finer and more dense tubercles in *K. buczacziensis*; those of *K. podolica* [being] a bit larger and more widely spaced » (Dupret, 2010, p. 12) — apart from the size, *K. buczacziensis* being nearly twice the size of *K. podolica*. So, it is nearly impossible to distinguish both genera, *Kujdanowiaspis* and *Erikaspis*, on a fragmentary element such as MGL n° 9580-1. Additionally, the ornamentation of MGL n° 9580-1 is definitely not that of *K. buczacziensis*, with is very fine, with almost no space in between tubercles. It recalls the *Erikaspis* type of ornamentation (space between and size of tubercles). A clue might be also in the fact that *K. buczacziensis* is only known in the Pragian of Podolia, but absent in the Lochkovian of Spain (Dupret *et al.*, 2011). Nevertheless, a few anterolateral plates from the lower Pernes Formation of the Liévin shaft n° 6 were described as *Kujdanowiaspis* sp. by Goujet & Blicek (1979, fig. 7 A-B); and the specimen MGL n° 9580-1, whose preserved natural edge is ca. 17 mm long (Pl. I: I), might well correspond to the upper (dorsal) edge of such a left anterolateral plate. So, we provisionally determine MGL n° 9580-1 as *Kujdanowiaspis*? sp.

The specimen MGL n° 9580-2 is a fragment of a smaller plate with small and tightly organized tubercles (Pl. I: J). It recalls the ornamentation of some dermal elements of *Kujdanowiaspis podolica* (see Dupret & Blicek, 2009; Dupret, 2010). Indeed, some of the dermal elements of *Kujdanowiaspis podolica*, such as the plastron (anterior ventral part of the thoracic armour), show a rather fine tuberculation as well. So, MGL n° 9580-2 may be of the same species as MGL n° 9580-1, and we also identify it as *Kujdanowiaspis*? sp.

The same block that bears MGL n° 9580-1 and 9580-2, also shows a fragmentary spinal plate MGL n° 9580-3, with prominent rounded tubercles on what is probably its external (lateral) margin (top of Pl. I: K) — as can be seen on other actinolepid arthrodiros (e.g. on *Heightingtonaspis*: Denison, 1978, fig. 33A). It does not show the spinelets which are typically present on the mesial (inner) side of the spinal plates of *Kujdanowiaspis* (e.g. Dupret, 2010, fig. 2F). However, these spinelets are mostly absent from the fossil material, and our specimen is incomplete. So, MGL n° 9580-3 may be the spinal plate of the same species as MGL n° 9580-1 and 9580-2, and eventually from the same individual. The specimen MGL n° 9581 is a possible fragmentary spinal plate from the same taxon, with a group of prominent tubercles on its external margin (top right of Pl. I: L).

V. — CONCLUSION

The history of the Liévin shaft n° 8 in the Nord – Pas-de-Calais coal basin began with its boring in 1948, and its opening as a ventilation shaft in 1952. It has been stopped and filled in with its slag heap in 1982. It was during this process that Early Devonian (Lochkovian) sandstones of the lower Pernes Formation appeared (formerly known as « Schistes et Grès de Pernes »). They yielded a small collection of vertebrate remains that we identify as Traquairaspididae gen. et sp. indet., *Rhinopteraspis crouchi*, Pteraspidae gen. et sp. indet., *Cephalaspis* sp. and *Kujdanowiaspis*? sp. This material increases the list of taxa found in the lower Pernes Formation of the Liévin shaft n° 8: MGL n° 9571-2 and 9571-3 are attributed to an undetermined traquairaspid which had not been found in this shaft yet (Blicek & Goujet, 1986); MGL n° 9578 represents a pteraspide species with big cornual plates, different from the ones described in previous papers (e.g. in Goujet & Blicek, 1979; Blicek & Janvier, 1989); MGL n° 9579 is probably from a basal cornuate osteostracan attributed to *Cephalaspis* sp., that is a second osteostracan for the Liévin shaft n° 8 (see Goujet & Blicek, 1979); specimens of *Kujdanowiaspis*? sp. are represented

by possible anterolateral and spinal plates, this genus is new for the Liévin shaft n° 8. So that the list of vertebrate taxa of the lower Pernes Formation of the Liévin shaft n° 8 is as follows (after Blicek & Goujet, 1986, and the present work):

- Thelodonti: Thelodonti indet.
- Heterostraci: Traquairaspididae gen. et sp. indet., *Pteraspis rostrata*, *Rhinopteraspis crouchi*, Pteraspidae gen. et sp. indet., Cyathaspidiformes indet.
- Osteostraci: *Securiaspis* sp., *Cephalaspis* sp.
- Placodermi: *Kujdanowiaspis*? sp.
- Acanthodii: Acanthodii indet.

This faunal list is characteristic of the *Rhinopteraspis crouchi* Biozone (*sensu* Blicek & Janvier, 1989), and probably of its lower part (see Ball & Dineley, 1961, p. 202-203; Dineley & Metcalf, 1999, p. 109-144). This *R. crouchi* Biozone is correlated to the 'middle' Lochkovian (Blicek, 1984, fig. 74; Blicek & Janvier, 1989, fig. 11). It corresponds to the richest diversity of vertebrates in the Lower Devonian of the Artois region, at the base of the *R. crouchi* Biozone (Blicek *et al.*, 1995b, p. 452-453), particularly in the Liévin shaft n° 6 where 11 different taxa have been reported (Blicek & Goujet, 1986, fig. 37). The Liévin shaft n° 8, with 10 different taxa in the same *R. crouchi* Biozone, shows the same richness as the Liévin shaft n° 6 [There are in fact certainly more than ten species in shaft n° 8 because what is here named Pteraspidae gen. et sp. indet. corresponds to several different species]. Even if the fossil record in this siliciclastic series of Artois is incomplete, it does coincide with a 'middle' Lochkovian peak of biodiversity for early vertebrates, also encountered with in Spitsbergen and other places (Blicek, 1984; Blicek *et al.*, 1987, 1995b). It may be correlated to the presence of *Kujdanowiaspis podolica* + *Erikaspis zychi* (and absence of *K. buczaciensis*) if similar to what occurs in Podolia (Dupret & Blicek, 2009). It has been hypothesized that this high diversity event is correlated to a high stand of sea level (Blicek *et al.*, 1995b, p. 455), the mid-Lochkovian time corresponding also to a high sea water temperature episode (Joachimski *et al.*, 2009, fig. 7).

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EXPLICATIONS DE LA PLANCHE I

EXPLANATIONS OF PLATE I

Plate I. — Vertebrates of the 'middle' Lochkovian, lower Pernes Formation (formerly known as « Schistes et Grès de Pernes »), slag heap of the Liévin shaft n° 8, Avion (Pas-de-Calais, France). **A-B-** Traquairaspididae gen. et sp. indet., fragments of a dermal plate, specimens MGL n° 9571-3 (A) and 9571-2 (B); **C-E-** *Rhinopteraspis crouchi*, dorsal face of a rostral plate, specimen MGL n° 9570-1 (C), part of ventral face of a rostral plate, specimen MGL n° 9571-1 (D), and tip of the dorsal face of a rostral plate, specimen MGL n° 9572 (E); **F-G-** Pteraspidae gen. et sp. indet., ridge scale, specimen MGL n° 9573 (F), and cornual plate, specimen MGL n° 9578 (G); **H-** *Cephalaspis* sp., fragment of external margin of a cephalic shield, specimen MGL n° 9579; **I-L-** *Kujdanowiaspis?* sp., fragment of plate (anterolateral?), specimen MGL n° 9580-1 (I), fragment of plate, specimen MGL n° 9580-2 (J), fragmentary spinal plate, specimen MGL n° 9580-3 (K), and possible fragmentary spinal plate, specimen MGL n° 9581 (L).

Planche I. — Vertébrés de la partie inférieure de la Formation de Pernes (originellement « Schistes et Grès de Pernes ») du terril du puits 8 de Liévin, à Avion (Pas-de-Calais, France; Lochkovien 'moyen'). **A-B-** Traquairaspididae gen. et sp. indet., fragments de plaque dermique, spécimens MGL n° 9571-3 (A) et 9571-2 (B); **C-E-** *Rhinopteraspis crouchi*, face dorsale de plaque rostrale, spécimen MGL n° 9570-1 (C), face ventrale incomplète de plaque rostrale, spécimen MGL n° 9571-1 (D), et pointe de la face dorsale d'une plaque rostrale, spécimen MGL n° 9572 (E); **F-G-** Pteraspidae gen. et sp. indet., écaille faitière du tronc, spécimen MGL n° 9573 (F), et plaque cornuale, spécimen MGL n° 9578 (G); **H-** *Cephalaspis* sp., fragment du bord externe d'un bouclier céphalique, spécimen MGL n° 9579; **I-L-** *Kujdanowiaspis?* sp., fragment de plaque (antérolatérale ?), spécimen MGL n° 9580-1 (I), fragment de plaque, spécimen MGL n° 9580-2 (J), plaque spinale incomplète, spécimen MGL n° 9580-3 (K), et fragment d'une possible plaque spinale, spécimen MGL n° 9581 (L).

