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THE TOARCIAN AND LOWER MIDDLE BAJOCIAN BEDS AND AMMONITES IN THE FERNIE GROUP OF SOUTHEASTERN BRITISH COLUMBIA AND PARTS OF ALBERTA

HANS FREBOLD

Energy, Mines and Resources Canada
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Abstract

Beds with Sonninia *spp. of early Middle Bajocian age and belonging to the lower part of the Rock Creek Member of the Fernie Group have now been found in southeastern British Columbia in an area extending northward for about 100 km (60 miles) from Lodgepole Creek close to the International Boundary. Previously,* Sonninia *was known only from the Fernie Group at one locality in the Lake Minnewanka area north of Banff, Alberta. The bed with* Sonninia *is a calcareous sandstone that has a maximum thickness of 5. 2 m (17 ft) in the southern part of the area and becomes thinner toward the north. It is assigned to the Sowerbyi Zone. No proof of the presence of the next younger Sauzei Zone has been found so far. The bed with* Sonninia *is overlain by younger beds of the Rock Creek Member with ammonites characteristic of the Middle Bajocian Humphriesianum Zone and underlain by 6. 3 m (21 ft) of greyish shale with very poorly preserved ammonites possibly referable to* Sonninia *and/or* Witchellia. *This shale forms the basal part of the Rock Creek Member and is underlain by the "Toarcian paper shale". It is tentatively assigned also to the Sowerbyi Zone of the Middle Bajocian.*

The calcareous sandstone with Sonninia *is probably of the same age as the calcareous sandstones in the Livingstone Range toward the east (i. e. Warren's original Rock Creek Member). Equivalents of the sandstone with* Sonninia *possibly are present also in Montana.*

In the Toarcian strata, the presence of the Lower Toarcian Falcifer Subzone with Hildaites *spp.,* Harpoceratinae *spp., and dactylioceratids and the Middle Toarcian Variabilis Zone with genera of the Phymatoceratinae was established at various localities in southeastern British Columbia and farther north. These two units were previously unknown in the Fernie Group.*

No Lower Bajocian ammonites were found, and Upper Toarcian ammonites, previously said by some authors to be present, were probably misidentified. At present, beds of Late Toarcian and Early Bajocian age may be considered to be absent.

Résumé

Des couches contenant des Sonninia *(espèce) du début du Bajocien moyen et appartenant à la partie inférieure du niveau de Rock Creek du groupe de Fernie ont été découverts dans le sud-est de la Colombie-Britannique, dans une zone qui s'étend vers le nord sur environ 100 kilomètres (60 milles) à partir de Lodgepole Creek, près de la frontière internationale. On ne connaissait auparavant de* Sonninia *que dans les couches du groupe de Fernie qu'on rencontre en un endroit de la région de lac Minnewanka, au nord de Banff (Alberta). La couche contenant les* Sonninia *est recouverte par des couches plus récentes du niveau de Rock Creek, qui contiennent des ammonites caractéristiques de la zone à Humphriesianum du Bajocien moyen. Elle recouvre elle-même une couche de schistes gris de 6, 3 m (21 pieds) d'épaisseur contenant des ammonites très mal conservées qui sont peut-être des* Sonninia *ou des* Witchellia. *Ces schistes constituent la base du niveau de Rock Creek et recouvrent le "Toarcian paper shale". On les attribue également pour le moment à la zone de Sowerbyi du Bajocien moyen.*

Le grès calcaire contenant des Sonninia *a probablement le même âge que les grès calcaires de la chaîne de Livingstone qu'on trouve à l'est (c'est-à-dire le niveau primitif de Rock Creek d'après Warren). Il est possible qu'on rencontre dans le Montana des équivalents du grès à* Sonninia.

Dans les couches du Toarcien, la présence de la sous-zone à falcifers, du Toarcien inférieur, contenant des Hildaites *(espèce), des* Harpoceratinae *(espèce) et des dactylloïdés et la présence de la zone à variabilis du Toarcien moyen contenant des genres des Phymatoceratinae ont été reconnues en divers endroits du sud-est de la Colombie-Britannique, et même plus au nord. Ces deux formations étaient inconnues auparavant dans le groupe de Fernie.*

L'auteur n'a pas trouvé d'ammonites du Bajocien inférieur, et les ammonites du Toarcien supérieur, dont certains auteurs ont dit qu'elles étaient présentes, ont probablement été mal identifiées. Dans l'état actuel de nos connaissances, les couches du Toarcien supérieur et du Bajocien inférieur peuvent-être considérées comme manquantes.

THE TOARCIAN AND LOWER MIDDLE BAJOCIAN BEDS AND AMMONITES IN THE FERNIE GROUP OF SOUTHEASTERN BRITISH COLUMBIA AND PARTS OF ALBERTA

Introduction

The first discovery of Jurassic ammonites from the beds now known as the Fernie Group was made by R. G. McConnell in 1886[1]. They were obtained "from the Rocky Mountains three miles north of the east end of Devils Lake". Devils Lake is known now as Lake Minnewanka. The ammonites were described by Whiteaves (1889) as species of *Schloenbachia,* and dated as Cretaceous. It was later recognized by McLearn (1927, p. 69), Crickmay (1931, p. 35), and the present author (Frebold, 1957, p. 15) that the specimens assigned to *Schloenbachia* by Whiteaves from this locality are in fact Middle Bajocian Sonniniidae. The best specimen obtained by McConnell, the holotype of *Schloenbachia gracilis* Whiteaves, was redescribed and illustrated by the author (op. cit., p. 48) as *Sonninia gracilis* (Whiteaves). The remaining specimens obtained by McConnell, which, presumably, include those referred by Whiteaves to *Schloenbachia borealis* Whiteaves (Whiteaves, 1889, p. 170), were identified by the writer as indeterminable species of *Sonninia* (Frebold, 1957, p. 48, 49). Whiteaves' identification of *"Schloenbachia borealis"* from McConnell's collection is incorrect. The holotype of *Schloenbachia borealis* is from a different locality (Yukon River) and was tentatively assigned to *Grammoceras* (Frebold, 1964, p. 18).

Since McConnell's time, a considerable variety of Jurassic ammonites, ranging in age from Sinemurian to Oxfordian, have been described from the Fernie Group. A summary of the work done until 1957 is included in the comprehensive Memoir on the Fernie Group (Frebold, 1957). Additional discoveries, made since then, have been described by the writer and others (Frebold *et al.*, 1959; Frebold, 1962, 1963, 1966, 1967, 1969; Westermann, 1964). But, until now, the *Sonninia* fauna has been known only from McConnell's collection. Because McConnell's work was of a reconnaissance nature, exact details regarding the locality and stratigraphic position of the fauna are not known. So, although the fact that early Middle Bajocian fossils occurred within the Fernie Group was proved by this old collection, their position in the rock succession has remained unknown.

In this paper, new discoveries of *Sonninia* from the Fernie Group are described and the stratigraphic position of the fauna, indicating the Sowerbyi Zone (lower Middle Bajocian), is established for the first time. Also recorded in this paper are new data on the Toarcian strata in the Fernie Group. They comprise new occurrences of the Variabilis Zone (Middle Toarcian) and of the Falicifer Subzone (Lower Toarcian). Lower Bajocian strata are unknown and the presence of Upper Toarcian strata previously suggested to be present, is very doubtful.

[1] Whiteaves (1889, p. 163) wrote that McConnell collected the specimens in 1887, but this is evidently a mistake.

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FIELD WORK AND ACKNOWLEDGMENTS

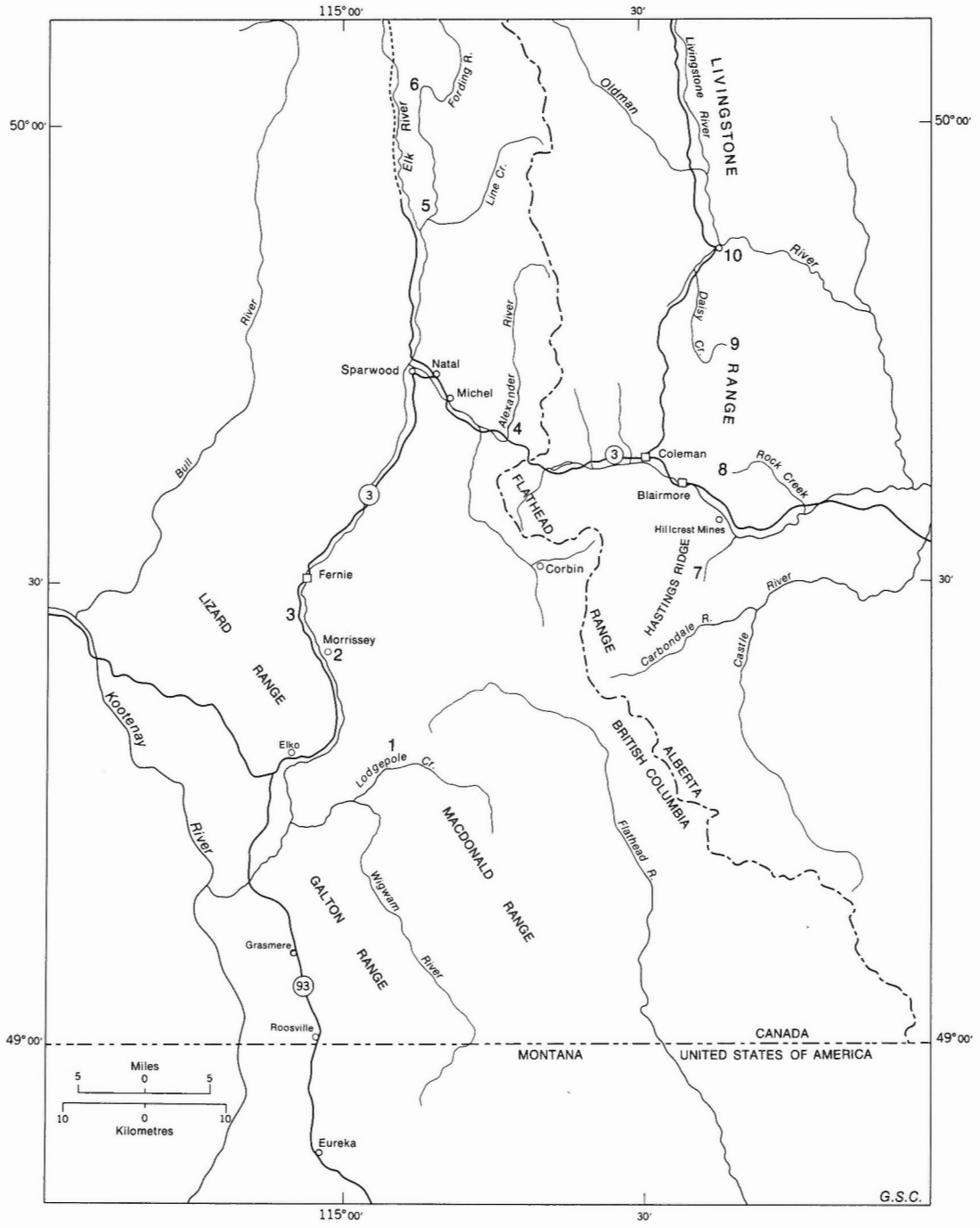
The field work on which this report is based was done after the writer's retirement from the Geological Survey of Canada in 1968. Work was done in 1969, 1970, 1971, 1972 and 1974. The writer is indebted to the Geological Society of America for grants received in 1970 and 1971 in support of this field work. The greater part of the field work was financed privately. Sincere thanks are due to his wife Britta for her untiring and successful search for fossils on which this report is based and to his friend Martin Baher of Fernie, British Columbia, for guiding and other valuable assistance.

STRATIGRAPHIC TERMINOLOGY

The subdivision of the Toarcian and Bajocian beds of the Fernie Group into substages, zones and subzones discussed in this report is based on the subdivision in northwestern Europe (Arkell, 1956; Dean *et al.*, 1961; Howarth, 1962a; *see* Table 1). The Lower Bajocian substage equals the Aalenian.

The rock unit "Toarcian paper shale" comprises dark, thin-bedded, commonly papery shales with harder limy bands and concretions. The age of this unit is Toarcian. It is underlain by various Sinemurian or Pliensbachian rocks and overlain by the Bajocian Rock Creek Member. At most localities, the boundaries of the "Toarcian paper shale" with rocks of the over- and underlying units are clearly marked by different colour and/or lithology. The "Toarcian paper shale" is the facies (c) of the Toarcian of Frebold (1957, p. 11) and equals the "Poker Chip shale" as used by Crockford (*in* McCrossan and Glaister, 1964, p. 142)[2]. No other

[2] The name "Poker Chip shale" was given by Spivak (1949, p. 541) for "basal Fernie beds which consist of black calcareous shale with thin limestones, some of which contain chert with white specks". The drilled thickness is, according to Spivak (loc. cit.), 1.8 – 14.4 m (6-48 ft). The name was applied in well sections in the eastern Foothills only and not to similar shales in sections in the western Foothills for which the present writer introduced the name "paper shale" (Frebold, 1957, p. 6). As Spivak (loc. cit.) correlated his Poker Chip shale with the limestones with chert of his "Nordegg Member" that is Sinemurian in age, his Poker Chip shale is probably older than the "Toarcian paper shale". In all sections seen by the writer (for example Snake Indian River and Cadomin Railway section) where the Nordegg Member is present, it is overlain by the "Toarcian paper shale" (*see* Frebold, 1957, Pl. III, fig. A).



Text-figure 1. Localities mentioned in the text. Southeastern British Columbia and adjoining parts of Alberta.

Explanation for Text-figure 1

1 = Lodgepole Creek locality;
2 = Elk River bridge at Morrissey Station;
3 = Highway 3, south of Fernie, B.C.;
4 = Crow Phosphate Mine;
5 = Fording River, 21 km (13 miles) north of Natal, B.C.;
6 = Fording River, about 14 km (9 miles) north of locality 5;
7 = Hastings Ridge;
8 = Rock Creek;
9 = Daisy Creek summit;
10 = Livingstone Gap.

STAGES	SUB-STAGES	STANDARD ZONES AND SUBZONES IN NORTHWEST EUROPE (Arkell, 1956 for Bajocian; Dean et al., 1961; Howarth, 1962a for Toarcian)		SOUTHEASTERN BRITISH COLUMBIA AMMONITE SUCCESSION	ROCK UNITS	ADJOINING AREAS	
BAJOCIAN	MIDDLE	Stephanoc. humphriesianum		Stephanoceratidae, Chondroceras spp.	Rock Creek Member / Sandstone with Sonninia underlain by greyish brown shale	North and east: predominantly shale Miette and Cadomin areas: sandy facies Montana: middle member Sawtooth & Piper Fms.	
		Otoites sauzei		?			
		Sonninia sowerbyi	Witchellia laeviuscula Shirbuirnia trigonalis Hyperlioceras discites	Sonninia aff. S. gracilis, S.modesta, S.spp. indet., Witchellia?, Pelecodites? Sonniniids?		Devil's Pt., Lake Minnewanka area: Sonninia gracilis. S. spp. Livingstone Range: calc. sdst. underlain by greyish brown shale Montana: lower mem. of Sawtooth & Piper Fms.?	
	LOWER	Graphoceras concavum Ludwigia murchisonae Tmetoceras scissum Leioceras opalinum		Not identified		Not identified	
TOARCIAN	UPPER	Dumortieria levesquei	Pleydellia aalensis Dumortieria moorei Dumortieria levesquei Phlyseogr. dispansum	Not identified		Not identified	
		Grammoceras thouarsense	Pseudogr. struckmanni Grammoc. striatulum				
	MIDDLE	Haugia variabilis		Haugia aff. H. navis. H. aff. illustris, H. spp.	"Toarcian paper shale"	Haugia spp., Brodieia? sp. indet.	Absent in Montana
		Hildoceras bifrons	Zugodactyl. braunianus Peronoceras fibulatum Dactylioceras commune	Possibly present		Possibly present	
	LOWER	Harpoceras falcifer	Harpoceras falcifer	Hildaites sp. nov.? Dactyl. (Orthod.), Peronoceras		Bighorn Creek: Hildaites cf. H. serpentiniformis, Harpoc. cf. H. falcifer, Dactyl.(Orthod.)	
			Harpoceras exaratum	Dactylioceras (Orthodactylites)		Bighorn & Canyon Creeks: Harpoc. exaratum, Dact. (Orthodactylites)	
		Dactylioceras tenuicostatum		Not identified		Not identified	

GSC

TABLE 1. SUBDIVISION AND CORRELATION OF THE TOARCIAN AND MIDDLE BAJOCIAN BEDS IN SOUTHEASTERN BRITISH COLUMBIA

Toarcian rock units are known in the Fernie Group. The basal conglomerates and fossil concentrations of the Fernie in the Blairmore and Livingstone areas, tentatively placed by the author in the Toarcian (Frebold, 1957, p. 8, 10, 11), were assigned later to the Sinemurian (Frebold, 1969, p. 79) and the shales and sandstones above the "Toarcian paper shale" in the Livingstone Range previously considered to be of Toarcian age (Frebold, 1957, p. 11) are now placed in the Bajocian. The sandstones that have not yielded any determinable fossils are Warren's original Rock Creek Member (Warren, 1934, p. 59), a term that was subsequently applied incorrectly to another Bajocian unit. The usage of the term Rock Creek Member is outlined as follows.

Warren (1934, p. 59) applied the name "Rock Creek Member" to a "bed of calcareous sandstone which occurs from 50 to 150 feet above the base of the formation" and which "varies in thickness from 5 to 30 feet". The type locality is at Rock Creek at the southern end of the Livingstone Range (*see* map; Text-fig. 1 and Pl. III, fig. 1). An unidentifiable, poorly preserved ammonite is the only fossil reported from this unit (Frebold, 1957, p. 77). On top of the sandstones are shales containing stephanoceratids of the Humphriesianum Zone. These shales were not mentioned by Warren.

As shown in the present report, calcareous sandstones with *Sonninia* spp., which are assigned to the Sowerbyi Zone, occur in parts of southeastern British Columbia (i.e. the Crow Phosphate Mine, Lodgepole Creek, Fernie and Fording River areas) in the same stratigraphic position as Warren's original Rock Creek Member (i.e. below beds of the Humphriesianum Zone). Accordingly, it is concluded that the sandstone with *Sonninia* and Warren's original Rock Creek Member are both within the Sowerbyi Zone and of the same age.

The calcareous sandstones with *Sonninia* in parts of southeastern British Columbia were unknown to Warren and, in areas outside his type locality, he applied the name Rock Creek Member to another, younger unit of calcareous sandstones that are intercalated in shales and contain a rich ammonite fauna of the Humphriesianum Zone. He traced this unit from the Crowsnest Pass area in the south to the Jasper Park area in the north (Warren, 1934, p. 62, 69; 1947, p. 67). The name Rock Creek Member was used also by Crockford (1949, p. 24, 27, 28, 48) for the same calcareous sandstone of the Humphriesianum Zone in the Ribbon Creek area and Frebold (1957, p. 14) thought accordingly that this unit was the Rock Creek Member sensu stricto.

Allan and Carr (1947, p. 21) extended the term Rock Creek Member to sandy shales and limestone lenses occurring west of the Misty Range in the Highwood-Elbow area which carry ammonites of the Humphriesianum Zone. The writer (Frebold, 1957, p. 14, 15) and Crockford (1964, p. 144) included in the Rock Creek Member dark grey shale with interbeds of calcareous sandstone or concretions and the local occurrences of a predominantly sandstone facies as developed in the Fiddle Creek and Cadomin areas. The dark grey shales are, in places, rusty weathering and contain beds filled with belemnites.

In this report the term Rock Creek Member is applied as used by the author (Frebold, 1957) and Crockford (*in* McCrossan and Glaister, 1964, Ch. 10). This is a much larger unit than that originally defined by Warren (1934, p. 59). Also included in the Rock Creek Member is the grey to greyish brown, in part rusty weathering shale with small concretions which lies between the "Toarcian paper shale" and the calcareous sandstone with *Sonninia*. As can be seen in Plate II, figure 1, this greyish shale is clearly distinguished from the underlying dark "Toarcian paper shale".

From the preceding discussion of the application of the term to different units by Warren and other authors, it is evident that a restriction of the term Rock Creek Member to Warren's original unit at the type locality would cause considerable confusion.

The Rock Creek Member, which is overlain by the Bathonian "grey beds", has yielded ammonites that indicate the presence of the Middle Bajocian Sowerbyi and Humphriesianum Zones. No ammonites have been found that would prove the presence of the Sauzei Zone.

THE LOWER MIDDLE BAJOCIAN AND TOARCIAN BEDS IN SOUTHEASTERN PART OF BRITISH COLUMBIA

The area that has yielded the hitherto unknown ammonite faunas of early Middle Bajocian and Toarcian age lies between the International Boundary in the south and Fording River in the north. The distance between the southern and northern occurrences is about 100 km (62 miles). Sections studied in detail are in the Lodgepole Creek area, about 22 km (14 miles) south of Fernie; on highway 3, 4.5 km (2.8 miles south of Lizard Creek bridge south of Fernie; on Fording River, about 21 km (13 miles) north of Natal and 3.2 km (2 miles) east of the bridge crossing Fording River; at the abandoned Crow Phosphate Mine in Crowsnest Pass, just north of Highway 3. The position of these localities is shown on Text-figure 1.

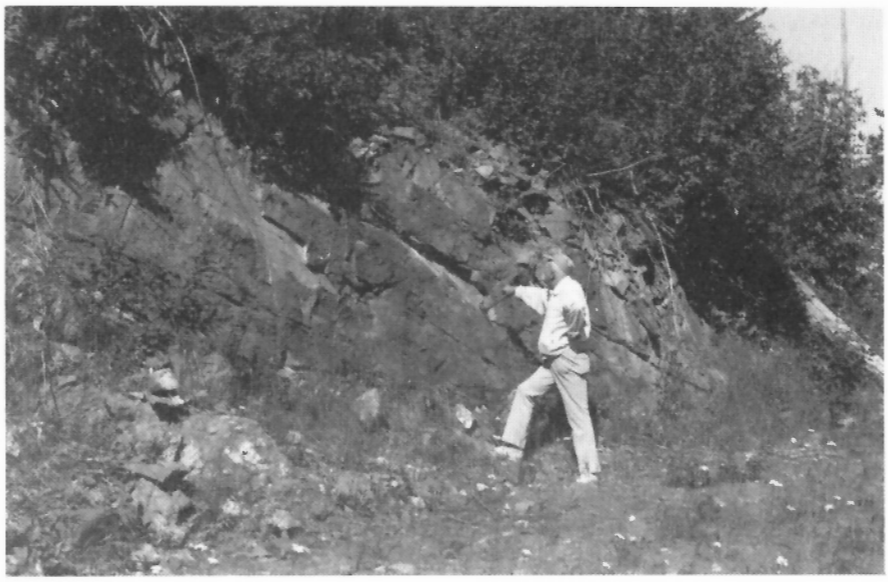
LODGEPOLE CREEK AREA

In this area beds of the lower part of the Middle Bajocian are well exposed at one locality on a small road uphill from the road to an abandoned oil well. The Toarcian beds in this area are known only from some poor outcrops.

Lower part of Middle Bajocian

The beds of the lower part of the Middle Bajocian consist of about 5.2 m (17 ft) of a calcareous sandstone with phosphate nodules (Pl. I, fig. 1), underlain by greyish, irregularly breaking shale with small soft concretions.

At the base of the sandstone are pebbles and a bed with *Oxytoma* (GSC loc. 84913). About 4.6 m (15 ft) above the base of the sandstone, *Sonninia* spp., undeterminable stephanoceratids?, *Trigonia* sp. and



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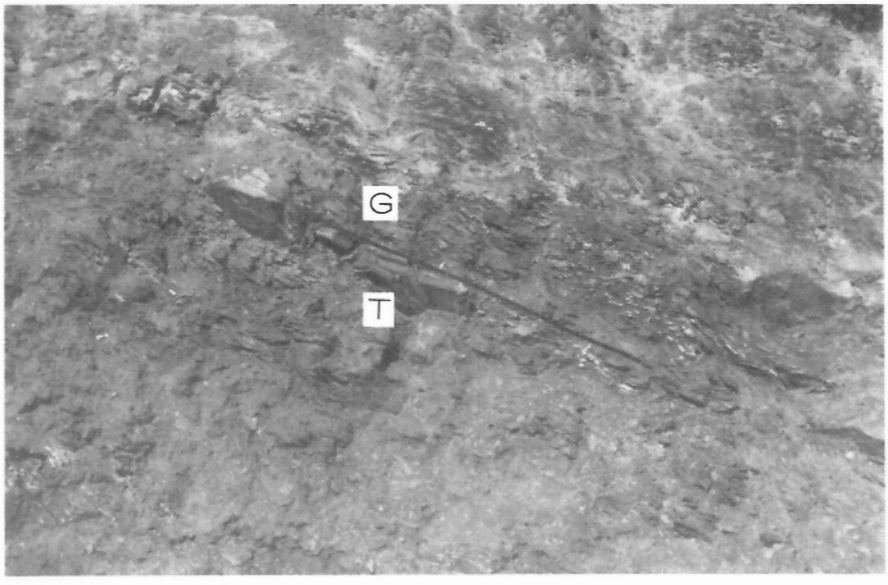

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Plate I

Figure 1. Bedding planes of vertically dipping calcareous sandstone with *Sonninia.* Lodgepole Creek area about 22 km (13.6 miles) southeast of Fernie, B.C.

Figure 2. Contact of Middle Toarcian "paper shale" (T) and greyish brown shale (G) underlying the sandstone with *Sonninia.* Detail of outcrop on Highway 3; 4.5 km (2.8 miles) south of Lizard Creek bridge, Fernie, B.C. (*see* Pl. II, fig. 1).

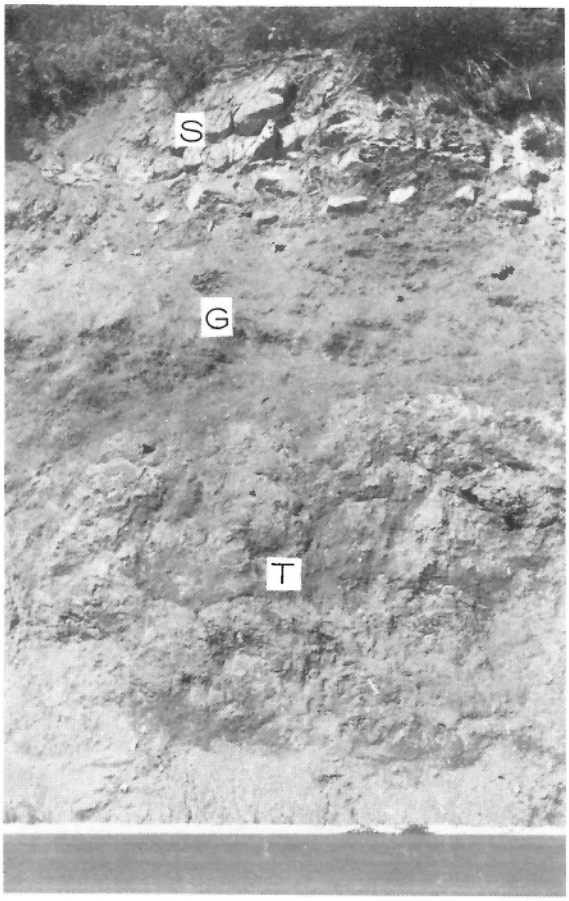

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Plate II

Figure 1. Section on Highway 3; 4.5 km (2.8 miles) south of Lizard Creek bridge, Fernie, B.C.
(S) = sandstone with *Sonninia*,
(G) = greyish brown shale,
(T) = Middle Toarcian "paper shale",
(S) and (G) = lower part of Rock Creek Member (*see* Pl. I, fig. 2).

Figure 2. (S) = sandstone with *Sonninia* and
(G) = greyish brown shale at tunnel entrance, Crow Phosphate Mine.

other pelecypods occur (GSC locs. 84912, 91938). On top is a 0.92 m (3 ft) bed with belemnites. The sandstone is assigned to the Middle Bajocian Sowerbyi Zone.

The calcareous sandstone with *Sonninia* is overlain by shale with stephanoceratids and *Chondroceras* which belong to the Humphriesianum Zone of the Middle Bajocian (GSC locs. 84915, 84916, 91932, 91933).

The shale below the sandstone with *Sonninia* which is very poorly exposed in a ditch, did not yield any ammonites at this locality. Only a few belemnite fragments (GSC loc. 84851) were found. As mentioned below, at the Crow Phosphate Mine poorly preserved *Sonninia*? or *Witchellia*? were found in a similar grey shale below the sandstone with *Sonninia*. Accordingly, the shale is assigned tentatively to the lower part of the Middle Bajocian. This grey shale is lithologically unlike that of the underlying Toarcian paper shale (*see* Pl. I, fig. 2).

Toarcian

Scattered small outcrops, below the grey shale assigned to the lower part of the Middle Bajocian, show the presence of the dark "Toarcian paper shale". From the lower part of this shale, about 2.7 m (9 ft) above beds now considered to be probably of Pliensbachian age, poorly preserved dactylioceratids, belemnites and pelecypods have been reported previously (Frebold, 1969, p. 83). They belong probably to the Lower Toarcian. Beds with Middle Toarcian ammonites have not been found exposed in this area.

HIGHWAY 3, SOUTH OF FERNIE, B.C.

This is the most complete section exposed in the studied area. The lower part of the Middle Bajocian, the contact with the underlying "Toarcian paper shale" and the Middle Toarcian beds are exposed (*see* Pl. I, fig. 2; Pl. II, fig. 1).

1

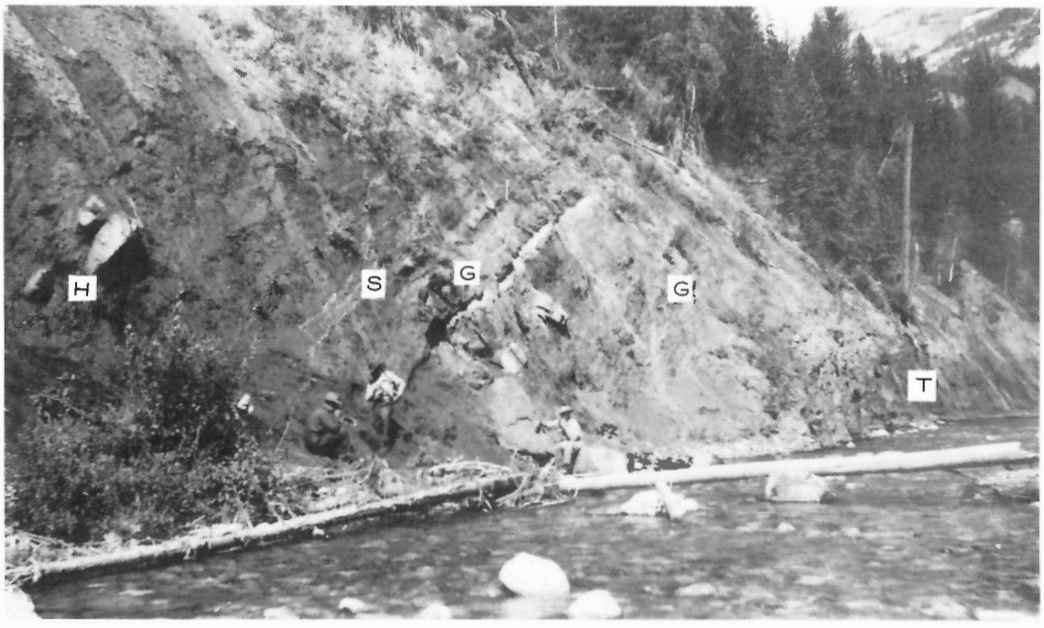

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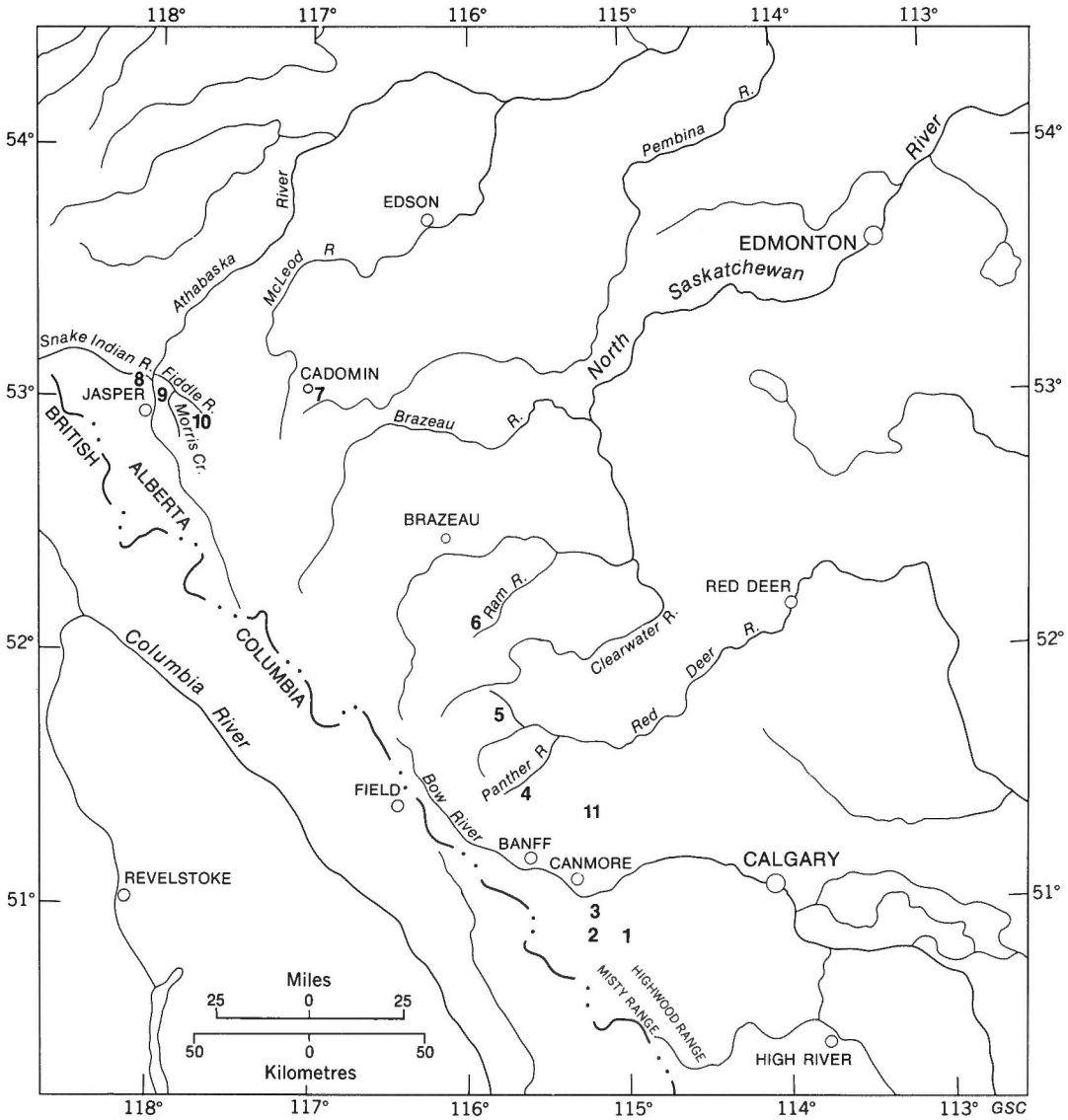
Plate III

Figure 1. (S) = Bajocian sandstone – the original "Rock Creek Member" of Warren (1934) and the equivalent of the calcareous sandstone with *Sonninia* in south-eastern British Columbia, overlain by
(H) = Middle Bajocian shale of the Humphriesianum Zone. Rock Creek, about 9 km (5.6 miles) east of Blairmore, Alberta.

Figure 2. Middle Bajocian and Toarcian beds on Fording River, about 21 km (13 miles) north of Natal, B.C.
(T) = Toarcian,
(G) = greyish brown shale,
(S) = approximate position of thin band with *Sonninia*,
(H) = Middle Bajocian shale with concretions, Humphriesianum Zone,
G, S, H, = Rock Creek Member.



Text-figure 2. Localities mentioned in the text. Northern area.

Explanation for Text-figure 2

1 = Canyon Creek, Moose Mountain area;
2 = Ribbon Creek;
3 = Pigeon Creek;
4 = Sheep Creek, Panther River area;
5 = Bighorn Creek;
6 = Cripple Creek area;
7 = Cadomin;
8 = Snake Indian River;
9 = Morris Creek;
10 = Fiddle Creek;
11 = Lake Minnewanka.

Lower part of Middle Bajocian

The upper part of the section is formed by the calcareous sandstone which contains poorly preserved specimens of *Sonninia* spp., undeterminable stephanoceratids?, and belemnites (GSC locs. 91912, 91918, 91937). The general appearance is the same as in the Lodgepole Creek area and at the Crow Phosphate Mine. Some of the beds contain pebbles. The thickness of this unit is about 3.6 m (12 ft), which is somewhat less than in the Lodgepole Creek area.

Below the calcareous sandstone are 6.3 m (21 ft) of greyish brown shale of the same appearance as in the Lodgepole Creek area. Part of this shale is rusty weathering. No fossils were obtained from the grey shale but, on account of the presence of *Sonninia?* or *Witchellia?* in the same shale at the Crow Phosphate Mine and at Fording River, it is tentatively assigned, together with the overlying sandstone with *Sonninia* to the lower part of the Middle Bajocian (Sowerbyi Zone).

A few kilometres to the south, near the bridge crossing the river at the former Morrissey Station of the C.P.R., a concretion was found among the boulders carried by the river (GSC loc. 91921). The concretion contained *Sonninia modesta* S. Buckman. It is likely that the concretion was not transported very far.

Middle Toarcian

The grey shale assigned to the Sowerbyi Zone is underlain by typical "Toarcian paper shale" of which about 10.1 m (33 ft) are exposed (*see* Pl. II, fig. 1). The top of the Toarcian shale is formed by a 0.11 – 0.15 m (0.4 – 0.5 ft) thick, hard calcareous band. Less than 0.5 m (1.5 ft) below the top, poorly preserved Phymatoceratinae, probably belonging to *Haugia*, were found (GSC loc. 84850, 91939). Even less well preserved ammonites, found previously at the same locality, had been considered to resemble *Grammoceras* and *Phlyseogrammoceras* (Frebold, 1969, p. 83), but the new, somewhat better preserved material shows that they are Phymatoceratinae. These ammonites are assigned to the Middle Toarcian Variabilis Zone. No Upper Toarcian ammonites have been found at this or other Toarcian localities in this area. Apparently both the Lower Bajocian and Upper Toarcian are missing.

CROW PHOSPHATE MINE

Lower part of Middle Bajocian

At the tunnel entrance of the Crow Phosphate Mine, and in other outcrops close by, 1.25 m (4 ft) of calcareous sandstone are exposed (GSC locs. 79148, 84844, 91915, 91929). It contains poorly preserved specimens of *Sonninia* aff. *S. gracilis* (Whiteaves), *Sonninia* sp. indet., undeterminable stephanoceratidae? and a few pelecypods. The upper 0.5 m (1.5 ft) are rich in belemnites. Pebbles are common. The sandstone is developed identically to the sandstone with *Sonninia* on Highway 3 south of Fernie, B.C. and in the Lodgepole Creek area, but its thickness is smaller.

Below the sandstone is the greyish brown, irregularly breaking shale with small concretions as found at the Highway 3 and Lodgepole Creek localities. At the Crow Phosphate Mine, the exposed thickness is about 4.6 m (15 ft). Poorly preserved specimens of *Sonninia?* sp. indet. or *Witchellia?* sp. indet. were found (GSC locs. 91930, 91931).

The calcareous sandstone with *Sonninia* and the underlying greyish brown shale are shown in Plate II, figure 2. Both units are assigned to the Sowerbyi Zone of the lower part of the Middle Bajocian.

Middle Toarcian

In front of the tunnel entrance is a pile of "Toarcian paper shale" that has been dug out of the tunnel. Some *Posidonomya* and numerous ammonites all belonging to various species of *Haugia* were found in this shale (GSC locs. 84842, 84843). Unfortunately they are all flattened or are impressions. This genus indicates a Middle Toarcian age, i.e. the same age as for the Toarcian shale in the section on Highway 3 south of Fernie, B.C. The presence of Middle Toarcian beds at these localities was unknown previously. Beds of Late Toarcian age are probably absent.

FORDING RIVER, 3.2 km (2 miles) UPSTREAM FROM FORDING RIVER BRIDGE

The locality is on the north bank of the Fording River. Another outcrop is close by on a poor road leading from the river uphill to an abandoned mine tunnel.

Lower part of Middle Bajocian

Below shale with big concretions and ammonites of the Middle Bajocian Humphriesianum Zone is a similar shale with a thin band or lenses of calcareous sandstone with pebbles. It is 0.25 – 0.3 m (0.8 – 0.9 ft) thick and contains *Sonninia* sp. indet., belemnites and pelecypods. Lithologically and faunally it is very similar to the sandstone with *Sonninia* at the Crow Phosphate Mine, on Highway 3 and in the Lodgepole Creek area, but is much thinner. Below this band with *Sonninia* is the same grey shale with poorly preserved sonniniids? (GSC loc. 91941), as at the Crow Phosphate Mine farther south. It also has the same stratigraphic position. The grey shale and the band with *Sonninia* are assigned to the Middle Bajocian Sowerbyi Zone.

Middle Toarcian

The grey shale of the lower part of the Middle Bajocian is here, as at the other localities farther south, underlain by "Toarcian paper shale". A few additions to a previous description (Frebold, 1969, p. 83) are made here.

An outcrop on the river contains compressed specimens and impressions of Phymatoceratinae including various species of *Haugia* (GSC loc. 31430). The age

of this part of the section is accordingly Middle Toarcian. It is equivalent in age to the Middle Toarcian at the Crow Phosphate Mine, and on Highway 3.

The section at Fording River is shown on Plate III, figure 2.

Lower Toarcian

The oldest bed of the Toarcian paper shale is exposed at the tunnel entrance above the river. Here poorly preserved dactylioceratids, probably belonging to *Orthodactylites*, occur above beds of Late Sinemurian and Pliensbachian? age which, in turn, are underlain by the Lower Sinemurian phosphate bed with arietitids. At the contact of the Toarcian with the older beds is a bed with *Atractites*. The bed with dactylioceratids is assigned to the Lower Toarcian.

No Late Toarcian or Early Bajocian ammonites were found at this locality in the Fording River area.

THE TOARCIAN BEDS IN THE AREA BETWEEN SNAKE INDIAN AND FIDDLE RIVERS IN THE NORTH AND FORDING RIVER IN THE SOUTH

As shown in the preceding chapter, the presence of the Middle Toarcian Variabilis Zone in parts of southeastern British Columbia has now been established. The same zone and, in addition, the hitherto unknown Falcifer Subzone of the Lower Toarcian are represented also in the area between Fording River and Snake Indian and Fiddle Rivers. The new localities in this area are listed below.

Middle Toarcian

Some very poorly preserved ammonites, previously collected in the "Toarcian paper shale" of Bighorn Creek, Ya-ha-tinda Ranch, north of the Red Deer River (GSC locs. 78841, 78852, 78853; *see* Fig. 2, loc. 5), had been said to resemble *"Phlyseogrammoceras"* and a Late Toarcian age had been considered possible (Frebold, 1969, p. 77, 83). These ammonites now are assigned tentatively to the genus *Brodieia* Buckman which would indicate the Variabilis Zone of the Middle Toarcian rather than the previously suggested Upper Toarcian Dispansum Subzone. The Variabilis Zone is indicated also to be present at Morris and Fiddle Creeks in the Miette area (Fig. 2, locs. 9, 10).

Lower Toarcian

Falcifer Zone

Falcifer Subzone

In the Bighorn Creek section, below the bed with *Brodieia*? and a covered interval, *Hildaites* cf. *H. serpentiniformis* Buckman, *Harpoceras* cf. *H. falcifer* (Sowerby), *Whitbyiceras*?, small dactylioceratids, *Inoceramus* and *Ostrea* were found (GSC locs. 91936, 91943). This new fauna occurs just above *Harpoceras exaratum* (Young and Bird) in a thin bed that dips upstream into the creek where it is covered by boulders.

Beds with *Hildaites* sp. nov.? were found at other localities in the northern area; near the bridge crossing Snake Indian River north of Jasper (GSC loc. 79915); at George Creek, Cripple Creek area (GSC loc. 19557); at Sheep Creek, Panther River area (GSC loc. 88027); and at Fording River, 35 km (22 miles) north of Sparwood, B.C. (GSC loc. 78594). At most of these localities, *Hildaites* sp. nov.? was found associated with poorly preserved specimens of *Peronoceras*.

Hitherto, *Hildaites* cf. *H. serpentiniformis* Buckman and *Hildaites* sp. nov.? were not found associated with each other.

Judging from the biostratigraphical position of *Hildaites* and *Peronoceras* in northwestern Europe, they should not be associated with each other. There, *Hildaites* occurs in the Lower Toarcian Falcifer Subzone of the Falcifer Zone whereas *Peronoceras* belongs to the Fibulatum Subzone of the Middle Toarcian Bifrons Zone (Dean *et al.*, 1961, p. 479, 482). Most specimens of *Peronoceras* from the Toarcian Fernie Group are very poorly preserved and cannot be identified exactly with known species. It is possible that the vertical range of *Hildaites* or *Peronoceras* is slightly different in Canada from that in northwestern Europe. The Canadian occurrences are placed in the Falcifer Subzone of the Lower Toarcian Falcifer Zone.

Exaratum Subzone

Almost directly below and downstream from the *Hildaites* locality in Bighorn Creek is the previously described bed with numerous *Harpoceras exaratum* (Young and Bird) and *Orthodactylites* spp. (GSC locs. 78843, 78844) (Frebold, 1969, p. 83). This bed is assigned to the Exaratum Subzone of the Falcifer Zone. Beds below this zone, including the contact of the Lower Toarcian with the underlying Upper Pliensbachian, are covered. The presence of the older Tenuicostatum Zone below the Exaratum Subzone cannot be proven because of these unfavourable outcrop conditions. The Exaratum Subzone is present also in Canyon Creek, Moose Mountain area (Frebold, 1957, p. 83).

Contrary to previously made suggestions (Collet, 1931; Frebold, 1969), the presence of Upper Toarcian beds in the northern area has not been proven, as is the case in the southern area between the International Boundary and Fording River. The previously suggested presence of the Upper Toarcian Dispansum Subzone in the Bighorn Creek section has been discarded above. Collet (1931, p. 17) mentioned *Hammatoceras insigne* Schübler, *Dumortieria* or *Catulloceras* sp. indet. and *Pleydellia* sp. indet. from the Fiddle Creek section, Miette area and assigned them to the Upper Toarcian and Lower Bajocian, respectively. The specimens were not described or figured. None of the above species has been found subsequently at this or other Fernie Group localities. Since Collet's material was poorly preserved, misidentifications may be considered possible.

COMPARISON WITH ADJOINING EASTERN AND SOUTHERN AREAS

In the area to the east of the described sections, two different facies developments are recognized in beds of Middle Bajocian age. At Hastings Ridge, 29 km (18 miles) southeast of Crow Phosphate Mine, no sandstone is present comparable to the calcareous sandstone with *Sonninia* in southeastern British Columbia. Here brownish shale that overlies "paper shale" of Middle Toarcian age[1], apparently replaces the sandy facies. No ammonites have been found in this shale, but the presence of some pelecypods, particularly *Inoceramus*, indicates that this sequence is Middle Bajocian and represents at least part of the Rock Creek Member. The shale probably was deposited in the seaway that connected western inundated areas with the bay in southern parts of Alberta, Saskatchewan and Manitoba.

Another facies is developed 13 km (8 miles) northeast of Hastings Ridge and 9 km (5.6 miles) east of Blairmore. Here, in Rock Creek, at the southern end of the Livingstone Range, there occurs a calcareous sandstone[2] originally defined by Warren (1934, p. 59) as Rock Creek Member (*see* Pl. III, fig. 1). It is present also at more northerly localities in the Livingstone Range; at Daisy Creek Summit, where it is underlain by greyish brown shale; and at Livingstone Gap on Oldman River. At the Livingstone Range localities, "Toarcian paper shale" is below and shale with sandy limestones containing stephanoceratids and *Chondroceras* of the Middle Bajocian Humphriesianum Zone are above the calcareous sandstone. No *Sonninia* has yet been found in the calcareous sandstone or the underlying greyish brown shale, but the stratigraphic position of this sandstone and shale is the same as that of the sandstone with *Sonninia* and the underlying greyish brown shale in the Lodgepole Creek, Fernie and Crow Phosphate Mine areas. It is concluded, therefore, that they are time equivalents.

The calcareous sandstone of the Livingstone Range area is, however, thicker than in the described areas of southeastern British Columbia. At the Livingstone Gap it reaches a thickness of about 20 m (65 ft).

The calcareous sandstone of the Livingstone Range area and other sandstones farther to the north (for instance at Cadomin and Mountain Park, and in Fiddle and Morris Creeks in the Miette area) indicate the nearness of the land toward the east. The decrease of the thickness of the sand beds toward the west, the area of the sandstone with *Sonninia* in southeastern British Columbia, is explained by the greater distance of this area from the eastern land.

South of the occurrences in southeastern British Columbia and the International Boundary, Bajocian beds are present in the lower part of the middle members of the Sawtooth and Piper Formations of Montana. Near their base occur *Chondroceras* and *Stemmatoceras*, characteristic of the Humphriesianum Zone (Imlay, 1967, p. 21). They are guide fossils in the time-equivalent parts of the Canadian Rock Creek Member. The presence of the beds with *Sonninia*, which, in southeastern British Columbia are so well documented below the shaly beds of the Humphriesianum Zone, has not been established in Montana by guide fossils. There, however, as in southeastern British Columbia, calcareous sandstones underlie directly the shaly beds of the Humphriesianum Zone. The thickness of this sandstone that has yielded a non-distinctive pelecypod fauna varies from 0 to 2.5 m (0 to 8 ft) (Cobban, 1945). In his stratigraphic chart, Imlay (1967, p. 20) tentatively placed this basal sandstone of northwestern and north-central Montana into the Humphriesianum Zone. However, as this sandstone has the same stratigraphic position as the sandstone with *Sonninia* of southeastern British Columbia, the two sandstones could be considered as time equivalents.

No Toarcian or older Jurassic rocks, as are present on the Canadian side of the International Boundary, are known from Montana. The Middle Bajocian beds lie directly on Paleozoic strata, part of which formed "Belt Island" during Middle Bajocian and younger Jurassic times (Cobban, 1945; Imlay *et al.*, 1948; Imlay, 1967). In eastern Idaho, the Nugget sandstone is considered by Imlay (Imlay, 1952, p. 966) to be of Early Jurassic age. It is surprising that the southernmost occurrences of the Toarcian in southeastern British Columbia do not show any indications of a southern coastline.

COMPARISON WITH ADJOINING NORTHERN AREAS

Middle Bajocian

In sections of the Fernie Group at Canyon Creek in the Moose Mountain area (Beach, 1934, p. 4b; Frebold, 1957, p. 83), and in the Ribbon Creek-Pigeon Creek area (Crockford, 1949, p. 24, 27; Frebold, 1957, p. 81, 82), the "Toarcian paper shale" is overlain by shale with stephanoceratids and *Chondroceras* of the Middle Bajocian Humphriesianum Zone. In the Ribbon Creek-Pigeon Creek area, these ammonites are numerous in a calcareous sandstone, 0.6 m (2 ft) thick (Crockford, 1949, p. 24, 27), that is younger than the calcareous sandstone with *Sonninia* of southeastern British Columbia and its probable time equivalents in the Livingstone Range. In these sections, no rock unit comparable with the sandstone with *Sonninia* is present.

A calcareous sandstone possibly equivalent to the sandstone with *Sonninia* in the south is present near the Burns Mine in the Highwood-Elbow area. According to Allan and Carr (1947, p. 21), the Rock Creek Member is there 14.5 m (48 ft) thick. At its base are

[1] The upper part of the Toarcian beds at this locality previously described as a platy thin-bedded sandstone (Frebold, 1969, p. 84 and Fig. 1, Sec. 4) is rather a platy sandy shale. It is older than the sandstones of the Bajocian Rock Creek Member in the Livingstone Range.

[2] Previously Frebold (1957, p. 79 and Fig. 3, sec. 5; 1969, p. 84 and Fig. 1, Secs. 5, 6) assigned this sandstone in the Livingstone Range to the Toarcian.

4.3 m (14 ft) of thin-bedded, calcareous sandstones with worn belemnites overlain by 0.45 m (1.5 ft) of sandstone with pyrite and phosphate nodules. This unit which is overlain by 8.5 m (28 ft) of siltstone and silty shale and 1.2 m (4 ft) of highly fossiliferous calcareous siltstone with ammonites of the Humphriesianum Zone at the top, has the same stratigraphic position and apparently a similar lithology as the sandstone with *Sonninia* in the south. Since no *Sonninia* was found at this locality, safe correlation is impossible.

Toarcian

The occurrences of the hitherto unknown Variabilis Zone and the Falcifer Subzone in parts of the northern area are described on p. 10 of this report. Apparently the Toarcian of the northern area is very similar to that in the south.

SYSTEMATIC DESCRIPTION OF GUIDE-AMMONITES

Family Dactylioceratidae Hyatt, 1867
Subfamily Dactylioceratinae Hyatt, 1867
Genus *Dactylioceras* Hyatt, 1867
Subgenus *Orthodactylites* Buckman, 1926
Dactylioceras (Orthodactylites) spp.
Plate IV, figures 1, 2

Occurrence. Several species from Lower Toarcian beds, some associated with *Harpoceras exaratum* (Young and Bird), particularly at Bighorn Creek, Ya-ha-tinda Ranch (GSC locs. 78843, 78844); others associated with *Hildaites* sp. indet. at Snake Indian River Bridge, (GSC locs. 88015, 91923); Fording River (GSC loc. 91942) and other localities. All specimens are crushed or impressions.

Descriptions. *Dactylioceras (Orthodactylites)* sp. A from Bighorn Creek (GSC locs. 78843, 78844). The average diameter of the numerous specimens is about 50 mm. Approximate measurements of the specimen shown on Plate IV, figure 2 are: diameter, 49 mm; whorl height, 12 mm (0.25); width of umbilicus, 25 mm (0.50). Ratios to diameter are given in brackets. Cross-section, venter and suture lines are not visible. The ribs are straight and rather sharp. Most of them bifurcate, but there are also intercalated ribs. The strength of the primaries and secondaries is equal, the point of division just hidden by the next younger whorl. The ribs of the inner whorls are very fine and close together. There are about 50 primaries on the last whorl. For comparisons see under *Orthodactylites* sp. B.

Dactylioceras (Orthodactylites) sp. B from Bighorn Creek (GSC locs. 78843, 78844, Pl. IV, fig. 1), is distinguished from *O.* sp. A by less numerous ribs on the inner whorls and more numerous ribs on the last whorl at the same diameter as *O.* sp. A. Furthermore, toward the end of the last whorl the ribs are somewhat bent and forwardly inclined, and bifurcation is rare but intercalated ribs are frequent.

No identification of the two "species" A and B with known species of the subgenus *Orthodactylites* is possible. *Dactylioceras (O.) tenuicostatum* (Young and Bird) is easily distinguished by its more numerous ribs, also *D. (O.) anguinum* (Reinecke) and *O. directum* Buckman have more ribs. Most of the specimens of *D. (O.) semicelatum* (Simpson) figured by Buckman (1927, Pl. 31a, figs. 1, 2) and Schmidt-Effing (1972, Pl. 4, figs. 1-4) have, also, more numerous ribs except on the inner whorls which have less ribs than our specimens. *Dactylioceras (O.) hispanum* Schmidt-Effing (1972, p. 101, Fig. 19, Pl. 5, figs. 1-4) has more forwardly inclined ribs than *D. (O.)* "species A". *Dactylioceras (O.) ernsti* Lehmann (1968, p. 46, Pl. 17, figs. 5, 6; Pl. 19, figs. 2, 4) is possibly closer to *D. (O.)* "species A" but the holotype of Lehmann's species has more forwardly inclined ribs.

Genus *Peronoceras* Hyatt, 1867
Peronoceras spp. indet.
Plate IV, figures 3-6

Occurrence. Daisy Creek Summit, GSC loc. 19095; opposite George Creek Valley, GSC loc. 19557; Cadomin Railway section, GSC loc. 31413; Snake Indian River bridge, GSC loc. 79915; Red Deer River, exact locality unknown.

Descriptions. The specimens hitherto found are either fragments or completely flattened impressions. No suture lines are preserved and cross-sections can be seen only in the small specimen from Red Deer River which, originally, had been assigned to *Peltoceras* (Whiteaves, 1907, p. 80-82). Frebold (1951, p. 15, 16, Pl. 6, figs. 4a, b) placed the specimen in the genus *Porpoceras* Buckman which now is considered to be a synonym of *Peronoceras* Hyatt. The specimen is here re-illustrated in Plate IV, figure 3.

The other previously described *Peronoceras* found opposite George Creek Valley (Frebold, 1957, p. 46, Pl. 18, fig. 1), here re-illustrated in Plate IV, figure 6, also was compared with *P. subarmatum* (Young and Bird). The specimen has, however, considerably more ribs than the specimen of *P. subarmatum* described by Howarth (1962b, p. 117, Pl. 17, figs. 5a, b) as the neotype (?holotype) of this species. Our specimen from the Cadomin Railway section (Pl. IV, Fig. 5), the very poorly preserved specimen from Snake Indian River bridge (Pl. IV, Fig. 4), and the fragment from Daisy Creek Summit also have very fine and numerous ribs and may belong to the same species as the George Creek Valley specimen.

The unsatisfactory state of preservation of all these specimens renders specific identification impossible.

Family Hildoceratidae Hyatt, 1867
Subfamily Harpoceratinae Neumayr, 1875
Genus *Harpoceras* Waagen, 1869
Harpoceras exaratum (Young and Bird)
Plate V, figure 1

Ammonites exaratus Young and Bird, 1826, p. 266
Harpoceras exaratum (Young and Bird), Wright, 1878-1886, p. 441-443, Pl. 62, figs. 1-3.
Harpoceras exaratum (Young and Bird), Buckman, 1909, Pl. 5.

Harpoceras cf. *H. exaratum* (Young and Bird) Frebold, 1957, p. 47, Pl. 17, fig. 1, Pl. 18, figs. 2, 3.

Occurrence. Canyon Creek, GSC locs. 12879, 12880 and Bighorn Creek, Ya-ha-tinda Ranch, GSC locs. 78843, 78844. At both localities, the species is associated with *Dactylioceras (Orthodactylites)* spp.

Description and comparisons. The specimens from Canyon Creek have been described previously (Frebold, 1957, p. 47, Pl. 17, fig. 1; Pl. 18, figs. 2, 3). The numerous specimens occurring in Bighorn Creek are all completely flattened or are impressions. In all observable characteristics they agree very well with the specimens from Canyon Creek.

Harpoceras cf. *H. falcifer* (Sowerby)
Plate V, figure 2

Occurrence. Bighorn Creek, Ya-ha-tinda Ranch, GSC loc. 91936. One impression associated with other poorly preserved Harpoceratinae, rather frequent *Hildaites* cf. *H. serpentiniformis* Buckman and dactylioceratids. The bed with these ammonites overlies the bed with *Harpoceras exaratum* (Young and Bird).

Description. The specimen has a maximum diameter of 51 millimetres. The cross-section and suture lines cannot be seen. There is a fairly high ventral keel. The ribs are falcate, stronger and less numerous at the beginning of the last whorl than nearer its end. The tops of the ribs are not flattened contrary to those in *H. exaratum* (Young and Bird).

Comparison. The incomplete preservation of the specimen does not permit detailed comparisons. In its general outline and the shape of its ribs it is similar to *H. falcifer* (Sowerby).

Whitbyiceras? sp. indet.
Plate V, figure 3

Occurrence. Bighorn Creek, Ya-ha-tinda Ranch, GSC loc. 91936. Several poorly preserved impressions in the same bed as *Harpoceras* cf. *H. falcifer* (Sowerby), *Hildaites* cf. *H. serpentiniformis* Buckman and dactylioceratids. The figured specimen was found loose (GSC loc. 91943) just below GSC loc. 91936.

Description. The specimen has a diameter of about 57 millimetres. Suture lines and cross-sections cannot be seen. The ribs are slightly bent, not falcate, and some of them can be seen to be joined in pairs at the umbilical margin. Near the end of the last whorl the inner part of the ribs has become faint or extinguished. There is a fairly high ventral keel.

Comparison. In its general outline and the shape of the ribs the specimen resembles *Whitbyiceras* Buckman. This genus has a ventral keel with two furrows which, due to incomplete preservation, cannot be seen in this or other similar Bighorn Creek specimens. An assignment to *Whitbyiceras* is, therefore, questionable.

Subfamily Hildoceratinae Hyatt, 1867
Genus *Hildaites* Buckman, 1921
Hildaites sp. nov.?
Plate VI, figure 1; Plate VII, figures 1, 2

Occurrence. Fording River, B.C., GSC loc. 78594; opposite George Creek Valley, Cripple Creek area, Alberta, GSC loc. 19557; Snake Indian Valley, Alberta, GSC locs. 88015, 91923.

Description. Most of the specimens are very poorly preserved and completely flattened. One of the two comparatively best preserved specimens was found opposite George Creek Valley, the other at Fording River.

The George Creek Valley specimen (Pl. VII, fig 2) shows on one side the penultimate whorl fairly well, whereas details of the inner whorls are not clearly visible. Only a small fragment of the last whorl is preserved on this side of the specimen. In all stages of growth the umbilical wall is fairly high; it slopes gently toward the umbilicus and grades into the flanks. The ribs begin faintly on the umbilical wall, they are gently inclined forward on the inner part of the whorls, swing backward in their outer part and forward again in the ventro-lateral region, where they reach their greatest thickness. The venter itself is not exposed and no suture lines are visible. The other side of the specimen shows fairly strong ribs on the outer part of the last whorl.

The illustrated specimen from Fording River (Pl. VII, fig. 1), which has a diameter of 110 mm, is completely crushed. On the inner whorls the ribs are very similar to those of the above-described specimen; they are rather strong and bent backward on the outer part of the flank of the last whorl. On its inner part they are invisible. Venter, cross-section and suture lines cannot be seen.

Apparently both specimens belong to the same species.

Other specimens, like the one illustrated in Plate VI figure 1, are numerous at Fording River and in Snake Indian Valley. They cannot be studied in detail because of their very poor preservation but seem to be similar to the two above-described specimens. None of them has a lateral furrow and, accordingly, are assigned to the genus *Hildaites* Buckman rather than to *Hildoceras* Hyatt.

Comparisons. The type species of the genus *Hildaites* Buckman is *H. subserpentinus* Buckman (Buckman, 1919-1921, v. 3, Pl. 217). This species is distinguished from *Hildaites* sp. nov.? mainly by its finer ribs. *"Hildoceratoides" propeserpentinus* Buckman (Buckman, *ibid.* Pl. 218), the type species of *Hildoceratoides* Buckman (= *Hildaites*), has similar ribs on the penultimate whorl but is clearly distinguished from the Canadian specimens by finer and more sharply bent ribs on the last whorl. It is possible that the specimens described here may belong to a new species.

Associations. The genus *Hildaites* occurs in England in the zone of *Harpoceras falcifer*. The specimens described here were not found associated with that guide-ammonite. At the localities in Snake Indian Valley, opposite George Creek Valley, and at Fording River, *Hildaites* sp. nov.? is associated with *Dactylioceras* and *Peronoceras*.

Hildaites cf. *H. serpentiniformis* Buckman
Plate V, figures 4, 5; Plate VI, figure 2

Occurrence. Several specimens, all flattened or preserved as impressions from Bighorn Creek, Ya-ha-tinda Ranch, GSC loc. 91936. They occur almost directly above the bed with *Harpoceras exaratum* (Young and Bird) and are associated with *Harpoceras* cf. *H. falcifer* (Sowerby), *Whitbyiceras*? sp. indet. and dactylioceratids.

Description and comparisons. Cross-sections and suture lines cannot be observed in any of the specimens. A lateral furrow is absent. A fairly high ventral keel can be seen in some of the specimens. The ribs of the inner whorls swing forward on the inner part of the whorl and bend sharply backward on its outer part. On the last whorl of large specimens the ribs become weaker and tend to disappear on the inner part of the whorl.

At the end of the last whorl of the largest specimen only fine lines of growth are present. The specimens differ from the above-described *Hildaites* sp. nov.? by their finer ribs, particularly on the last whorl and more sickle-shaped ribs on their inner whorls. Similar ribs are present in some species of *Hildaites*. Among these, *H. serpentiniformis* Buckman (Buckman, 1923, Pl. 267B) seems to be closest also in general shape and apparent loss of ribs on the last whorl.

Family Hammatoceratidae Buckman, 1887
Subfamily Phymatoceratinae Hyatt, 1900
Genus *Haugia* Buckman, 1888
Haugia aff. *H. navis* Dumortier
Plate VII, figure 3

Material. Several specimens from Crow Phospate Mine, GSC locs. 84842, 84843, 84846.

Description. All specimens are secondarily flattened or impressions. Approximate measurements of specimen shown on Plate VII, figure 3 are: diameter, 50 mm; whorl height, 18 mm; umbilical width, 19 mm.

The ventral keel is visible in most specimens. At the umbilical margin are nodes or swellings from which originate two or three fairly strong, more or less straight to slightly bent ribs. In some cases the third rib is intercalated and extends only from the ventral border to about half the height of the flank.

Suture line and cross-section are not visible.

Comparison The specimens are similar in general outline and shape of ribs to *Ammonites navis* Dumortier (Dumortier, 1874, p. 89, Pl. 20, figs. 3, 4, 6), Denckmann's *Ammonites navis* (Denckmann, 1887, p. 77, Pl. 6, fig. 4) and *Haugia navis* (Dumortier) *in* Buckman (1887-1907, Suppl. p. 22, Fig. 5). Also similar are *Ammonites ogerieni* Dumortier (Dumortier, 1884, p. 78, Pl. 19, figs. 3, 5) and *Ammonites* cf. *ogerieni* Dumortier *in* Denckmann (1887, Pl. 5, fig. 1). As no cross-sections and suture lines can be seen, the species identification of our specimens has to remain doubtful.

Haugia aff. *H. illustris* (Denckmann)
Plate VII, figure 5

Occurrence. Several impressions and flattened specimens from Crow Phosphate Mine, GSC loc. 84843.

Description and comparisons. The illustrated medium-size specimen is an impression. The ribs are slightly sinuous, begin at the umbilical margin, are subdivided on the inner part of the flank into two or three branches, and extend to the ventral keel. No nodes are visible at the umbilical border which is poorly preserved. A fragment of the positive of the specimen shows slight swellings at the point where the ribs are subdivided.

The specimen is distinguished from the above-described *Haugia* aff. *H. navis* (Dumortier) by its narrower umbilicus, finer ribs, absence of strong nodes and apparently higher whorls. In these characteristics it is similar to the medium-size specimen of *H. illustris* (Denckmann) (Denckmann, 1887, p. 74, Pl. 5, figs. 2, 2a). Denckmann's specimen, *(ibid.* Pl. 6, fig. 1) is much larger than the specimen from the Crow Phosphate Mine and his specimen (*ibid.*, Pl. 3, fig. 6) too poorly preserved for comparison. Similar also are the specimens of *H. illustris* (Denckmann) figured by Guex (1972, Pl. 1, figs. 4, 9; Pl. 2, fig. 2) and the form considered by him to be transitional from *H. ogerieni* (Dumortier) to *H. illustris* (Denckmann) (Guex, *ibid.*, Pl. 1, fig. 10).

Haugia spp. indet.
Plate VII, figures 4, 8, 9

Occurrence. The specimen illustrated in Plate VII, figure 4 is from the Crow Phosphate Mine, GSC loc. 84843, the specimens in Plate VII, figures 8, 9 from Fording River, GSC loc. 31430.

Description and comparisons. The specimen shown on Plate VII, figure 4 is similar in general outline to the above-described *H.* aff. *H. illustris* (Denckmann) but is distinguished by finer ribs. The two young specimens (Pl. VII, figs. 8, 9) have a wider umbilicus and lower whorls than *H.* aff. *H. illustris* (Denckmann) and may be early stages of growth of *H. ogerieni* (Dumortier) or related forms. A detailed comparison of these poorly preserved small specimens with known species is impossible.

Brodieia? S.S. Buckman sp. indet.
Plate VI, figure 3; Plate VII, figures 6, 7

Material. The specimens were found at the bottom of the cliff formed by Toarcian shales in Bighorn Creek,

Ya-ha-tinda Ranch at GSC locs. 78841, 78852, 78853. Apparently they originated from the same bed. One fragment of a *Dactylioceras* sp. indet. was found associated with *Brodieia*? in the same piece of rock.

Description. The completely flattened specimens and imprints are moderately involute. The largest illustrated specimen has a diameter of 38 mm. The ribs are inclined forward on the inner part of the flanks, are bent backward on their outer part and swing forward again in the ventro-lateral region. At or somewhat above the umbilical border, two or three ribs are united but no nodes or swellings are developed at this point. No sculpture could be seen on the innermost whorls. In all specimens the ribs are more numerous and finer at the beginning of the last whorl than nearer its end. There is a ventral keel. No cross-section and no suture lines can be seen.

Comparisons. The insufficient preservation of the specimens does not warrant detailed comparisons with known genera and species of the subfamily Phymatoceratinae to which they are assigned here. Among the genera of this subfamily the genus *Brodieia* S. S. Buckman (Buckman, 1898-1907, Suppl. p. XXXI-XXXIII) seems to be closest to our specimens in general aspect, absence of tubercles and shape of the ribs. The type species of the genus *B. curva* Buckman (Buckman, 1898-1907, Pl. 22, figs. 35, 36; description loc. cit., Suppl. p. XXXII) is similar but has less ribs than our specimens. Similar also are *B. anonyma* (Meneghini) and *B. viallii* (Venzo) as described by Pinna (1963, p. 87, Pl. 11, figs. 23, 24 and p. 88, Pl. 11, figs. 21-22, respectively).

Family Sonniniidae Buckman, 1892

Most of the hitherto undescribed Sonniniids found in recent years in the southern parts of the Canadian Rocky Mountains are very poorly preserved. Fragments of specimens are locally frequent in a calcareous sandstone of the lower part of the Rock Creek Member.

Representatives of this family in the Fernie Group previously were known only from a locality 4. 8 km (3 miles) north of Devils Point, east end of Lake Minnewanka. Whiteaves (1889) erroneously assigned them to the Cretaceous genus *Schloenbachia*. This error was corrected by F. H. McLearn (1927) who placed them into *Sonninia*.

Genus *Sonninia* Bayle, 1879
Sonninia gracilis (Whiteaves)
Plate VIII, figure 2; Plate IX, figure 2

Schloenbachia gracilis Whiteaves, 1889, p. 171, Pl. 23, figs. 2, 2a
Sonninia gracilis (Whiteaves) Frebold, 1957, p. 48, Pl. 19, figs. 1a, b

Occurrence. Two fragmentary specimens, including the holotype, and an impression of inner whorls from the locality 4. 8 km (3 miles) north of Devils Point, east end of Lake Minnewanka. Fragmentary specimens resembling *S. gracilis* were found at various new localities in the Lodgepole Creek, Fernie, Fording River and Crowsnest areas. One of these is described below under *Sonninia* sp. indet. aff. *S. gracilis* (Whiteaves).

Description. Some additions to Whiteaves' description of the holotype were given previously (Frebold, 1957, p. 48), but some inaccuracies of the drawing given by Whiteaves had not been pointed out. In Whiteaves' figure 2, the ribs, particularly on the last whorl, are bent too strongly and the low, pointed tubercles on the ribs are not visible. Furthermore, the ventral areas on both sides of the keel slope to a much lesser degree than shown in Whiteaves' figure 2a.

The description of the species is here summarized: Wide-umbilicate, the whorls embracing each other only very slightly. Ribs fairly strong on the flanks, raised to greatest height in a node above the half height of the flanks from which point they are bent forward. They disappear before reaching the ventral keel. Some of the ribs are more or less rursiradiate. Ventral keel fairly low, no ventral furrows. Inner whorls with more numerous and finer ribs. Suture line poorly visible on penultimate whorl of holotype. Preserved part of last whorl belongs to the body-chamber.

The suture line can be seen better on the last whorl of the smaller hitherto not figured paratype. The suture line is moderately incised, the first lateral lobe is tripartite and apparently deeper than the ventral lobe and much deeper than the second lateral lobe. The external saddle is tripartite, and is higher and larger than the lateral saddle.

The measurements in millimetres of the holotype and paratype are:

	Diameter	Height of last whorl	Width of last whorl	Umbilical width
Holotype	110	30	24	58
Paratype	74	22	18	36

Sonninia sp. indet. aff. *S. gracilis* (Whiteaves)
Plate IX, figure 1

The large specimen illustrated in Plate IX, figure 1 is from the calcareous sandstone at the tunnel entrance of the Crow Phosphate Mine (GSC loc. 79148). It is secondarily compressed and otherwise very poorly preserved. Its diameter is about 159 mm, the height of the last whorl approximately 52 mm, and the width of the umbilicus about 61 mm. The ribs are straight and blunt and somewhat rursiradiate. The cross-section is not determinable, but the venter is apparently rather flat. The ventral keel is poorly visible. The specimen resembles *Sonninia gracilis* Whiteaves and may represent a larger size of this species but, as the inner whorls are missing, this cannot be proven.

Sonninia modesta S. Buckman
Plate VIII, figure 1

Sonninia modesta S. Buckman, 1894, p. 325, 422, Pl. 95, figs. 3-5, Pl. 68, figs. 1-2, Pl. 103, fig. 5, not Pl. 96, figs. 1-2.

Sonninia inaequa S. Buckman, 1894, p. 400, Pl. 101, figs. 4-6.
Sonninia modesta S. Buckman. Hiltermann, 1939, p. 153, Pl. 10, figs. 5, 6, Pl. 11, fig. 11, Text-figs. 25-29.
Sonninia (Euhoploceras) modesta S. Buckman. Imlay, 1973, p. 62, Pls. 7-10.
For further synonyms *see* Hiltermann, 1939, p. 153.

Occurrence. One specimen found in a loose concretion on the bank of Elk River at the bridge at Morrissey Station, south of Fernie, B.C. (GSC loc. 91921). The concretion originates probably from nearby where *Sonninia* beds are exposed.

Description. Parts of the ammonite and its impression are fairly well preserved. Part of the last and the penultimate whorls are badly damaged.

The measurements in millimetres are:

Diameter	Height of whorl	Width of whorl	Width of umbilicus
at 118	44(.37)[1]	31(.26)	40(.34)

The actual diameter of the ammonite is slightly larger than indicated above but could not be measured because of damage at the end of the whorl. The preserved part of the last whorl belongs to the body chamber which has an oval cross-section with the greatest width near the half height of the flank. The flanks grade gently into the venter, and there is no indication of ventral furrows. The transition of the flanks into the steep, almost perpendicular wall is almost abrupt. In the lower half of the last whorl the ribs are slightly inclined backward, they are thickest at half the height of the flanks. In the outer part of the whorl they are bent forward, they disappear toward the keel but the trend of the sculpture is clearly visible in the lines of growth which extend to the keel.

On the inner whorls, the visible parts of the ribs are straight and somewhat irregularly spaced. Some of them have very slight swellings close to the umbilical border but there are no real nodes.

Suture lines are not visible.

Comparisons and discussion. The specimen agrees very well with the "type-specimen" of *Sonninia modesta* Buckman (Buckman, 1894, Pl. 94, figs. 3-5) which was figured at one-half natural size. The percentage values of the measurements of Buckman's specimen, its sculpture and cross-section agree well with our specimen. However, as the central whorls of Buckman's specimen are damaged no comparison with the innermost whorls of our specimen is possible. Similar also is Buckman's *Sonninia inaequa* in the percentage values of the measurements and the costation, but the cross-section of this specimen appears to be less oval than that of our specimen. Hiltermann (1939) has already included *S. inaequa* Buckman and a number of other forms previously described as species in his list of synonyms of *S. modesta*. Westermann (1966, p. 289-312) goes still farther in the reduction of the number of *Sonninia* species. He considered 64 of Buckman's 69 *Sonninia* species which originated from the Sowerbyi Zone of Bradford Abbas, Dorset, England to belong to one single species, i.e. *Sonninia (Euhoploceras) adicra* (Waagen). This species, according to Westermann, varies from rather involute smooth forms with finely costose nucleus and compressed-oval or subrectangular whorl section... "to very evolute forms with subcircular, heavy spinous whorls throughout" (Westermann, *ibid.*, p. 310). Accordingly, our specimen would have to be named *Sonninia adicra* forma *modesta*. At present the writer is hesitating to accept Westermann's opinion fully and prefers to consider *Sonninia modesta* Buckman as a species.

Westermann (1969, p. 92-94) retains the subgenus *Euhoploceras* Buckman 1913 but admits that "the distinction of *Sonninia (Euhoploceras)* from *Sonninia sensu stricto* is certainly not sharp"... "Nevertheless, the subgenus has been retained in the Treatise and most recently by Westermann (1966) especially because of stratigraphic usefulness". Following Dorn (1935), Hiltermann (1939), and Oechsle (1958), the writer considers *Euhoploceras* to be synonymous with *Sonninia*.

Sonninia spp. indet.
Plate VIII, figures 3, 4

Occurrences. Various localities in the studied area.

Descriptions and discussion. The poorly preserved specimen illustrated on Plate VIII, figure 3 is from the Lodgepole Creek area, GSC loc. 89912, where it was found in the calcareous sandstone with *Sonninia*. A small part of the penultimate whorl shows some remnants of faint, widely-spaced ribs. On the preserved part of the last whorl, ribs are visible only on the inner part of the flanks; they are bent backward. The ventral keel is high, ventral furrows are absent. The cross-section of the last whorl is not accurately determinable, but the flank grades gently into the venter and more steeply into the umbilicus. Remnants of suture lines are present at the beginning of the last whorl. No spines or nodes seem to be developed.

The whorl fragment illustrated in Plate VIII, figure 4 is from the calcareous sandstone with *Sonninia* at the Crow Phosphate Mine. The specimen is laterally compressed, apparently has a narrow venter with keel, moderately falcoid ribs, and apparently a moderately wide umbilicus. Nodes or spines are absent. The species is indeterminate.

Genus *Witchellia* Buckman, 1889
Witchellia? cf. *W. adnata* Imlay
Plate VIII, figure 5

Occurrence, description and comparison. The specimen illustrated in Plate VIII, figure 5 was found in the calcareous sandstone with *Sonninia* at the Lodgepole Creek locality, GSC loc. 78596. Its diameter is 37 mm, the height of the last whorl is 16 mm and its thickness

[1] Ratios to diameter are given in brackets.

is 11 mm. The umbilicus is covered with matrix but its width apparently is moderate. The specimen is compressed, the last whorl higher than wide. Preceding whorls cannot be seen. The venter is narrow, very gently rounded and has a keel. Ventral furrows are apparently absent. The ribs are numerous, slightly flexuous, slightly inclined forward in the ventro-lateral area. Some ribs are joined in pairs near the umbilical border, others are subdivided in the lower part of the flanks. No suture lines can be seen.

In general outline and sculpture the specimen resembles the paratype of *Witchellia adnata* (Imlay (Imlay 1964, p. B34, Pl. 6, fig. 6) but the poor preservation of the Lodgepole specimen prohibits detailed comparison. The assignment of Imlay's species to the genus *Witchellia* Buckman which commonly has ventral furrows that are absent in Imlay's species and the Lodgepole specimen may be questioned. Imlay's species occurs in the Sauzei Zone (upper part of the Red Glacier Formation northwest of Cook Inlet, Alaska).

Genus *Pelecodytes* Buckman, 1923
Pelecodytes? sp. indet.
Plate VIII, figures 6a, b

Occurrence. Lodgepole Creek area, GSC loc. 84912. In the calcareous sandstone with *Sonninia*.

Description. Several fragments of small whorls. The cross-section of the illustrated specimen is higher than wide with slightly convex flanks. The venter has a keel and moderately deep furrows. The impression of the preceding whorl shows the keel but no furrows. Some of the ribs are sickle-shaped and slightly rursiradiate, others are moderately falcoid. The ribs stop abruptly at the ventral margin where they are bent forward. Some of the ribs are joined close to the umbilical margin. A smaller specimen shows the same characteristics.

The specimens are assigned tentatively to *Pelecodytes* Buckman.

Sonniniidae, gen. et sp. indet.

Occurrence. In the greyish brown shale below the sandstone with *Sonninia* at Crow Phosphate Mine (GSC locs. 91930, 91940) and below the thin band with *Sonninia* at Fording River (GSC loc. 91916).

Description. All specimens are crushed or completely flattened and break easily when taken out of the shale. This explains why hitherto no ammonites had been reported from this unit.

The specimens are moderately wide-umbilicate and have a ventral keel. The ribs are slightly flexuous, not prominent, and apparently comparatively stronger on the inner whorls. Close to the umbilical border some of the ribs are joined in pairs, others seem to be subdivided at about the middle of the flanks. No cross-sections or suture lines can be seen. Nodes or spines seem to be entirely absent.

The extremely poor preservation of these ammonites prohibits identification with any genus. They resemble some forms of *Sonninia* without nodes or of some weakly ornate *Witchellia*.

Family Stephanoceratidae Neumayr, 1875

At the Crow Phosphate Mine (GSC loc. 79148), in the section on Highway 3 south of Fernie, B.C. (GSC loc. 91937), and at the Lodgepole Creek locality (GSC loc. 84912), poorly preserved fragments of ammonites possibly belonging to the Stephanoceratidae were found. Of these, the specimen illustrated in Plate IX, figure 3 from the calcareous sandstone with *Sonninia* at the Crow Phosphate Mine (GSC loc. 79148) is the best preserved. It is a wide-umbilicate form with a whorl-section about as high as wide and fairly strong straight ribs that bifurcate on the middle of the flank or somewhat above it. The point of the subdivision is marked by a node-like swelling. The secondaries also are strong and seem to cross the venter transversely.

The assignment of this specimen and other fragments to the family Stephanoceratidae is tentative. Better material has to be found before a positive identification can be made.

References

Allan, J.A. and Carr, J.L.
1947: Geology of Highwood-Elbow area, Alberta, Res. Counc. Alberta, Rep. 49.

Arkell, W.J.
1956: Jurassic Geology of the World; Oliver and Boyd Ltd., Edinburgh & London.

1957: *In* "Treatise on Invertebrate Paleontology, Part L, Mollusca 4, Cephalopoda, Ammonoidea"; Geol. Soc. Am. and Univ. Kansas Press.

Beach, H.H.
1943: Moose Mountain and Morley Map-Areas, Alberta; Geol. Surv. Can., Mem. 236.

Buckman, S.S.
1887-
1907: A monograph of the ammonites of the Inferior Oolite Series of the British Islands; Paleontogr. Soc. London.

1909-
1930: Yorkshire Type Ammonites; London.

Cobban, W.A.
1945: Marine Jurassic Formations of Sweetgrass Arch, Montana; Am. Assoc. Petrol. Geologists, Bull. v. no. 29.

Collet, Léon-W.
1931: Résultats de l'Expédition géologique de l'Université de Harvard dans les Montagnes Rocheuses du Canada (Jasper National Park, 1939). Note no. 2. Sur la présence du Lias supérieur et du Bajocien dans les couches de Fernie de Fiddle Creek; Compte rendu des séances de la Société de Physique et d'Histoire naturelle de Geneva, v. 48.

Crickmay, C.H.
1931: Jurassic history of North America: its bearing on the development of continental structure; Proc. Am. Philosoph. Soc., v. LXX, no. 1.

Crockford, M.B.B.
1949: Geology of Ribbon Creek Area, Alberta; Res. Counc. Alberta, Rep. 52.

1951: Geology of Carbondale River Area, Alberta; Res. Counc. Alberta, Rep. 59.

1964: *In:* McCrossan, R.G. and Glaister, R.P. (eds.) Geological History of Western Canada; Chapter 10, Jurassic; Alberta Soc. Petrol. Geologists, Calgary, Alberta.

Dean, W.T., Donovan, D.T., and Howarth, M.K.
1961: The Liassic zones and subzones of the North-West European Province; Bull. Brit. Mus. (Nat. History), v. 4, no. 10.

Denckmann, A.
1887: Über die geognostischen Verhältnisse der Umgegend von Dörnten nördlich Goslar mit besonderer Berücksichtigung der Fauna des oberen Lias; Abh. geol. Spezialk. von Preussen und den Thüringischen Staaten, v. 82.

Donovan, D.T.
1952: The ammonites of the Blue Lias of the Bristol District; Ann. Mag. Nat. Hist., ser. 12, v. 5.

1954: Synoptic supplement to T. Wright's "Monograph on the Lias Ammonites of the British Islands" (1878-86); Palaeontogr. Soc. London.

Dorn, P.
1935: Die Hammatoceraten, Sonninien, Ludwigien, Dorsetensien and Witchellien des süddeutschen, insbesondere Fränkischen Doggers; Palaeontographica, v. 82, Abt. A.

Dumortier, E.
1864-
1874: Etudes paléontologiques sur les dépôts Jurassiques du Bassin du Rhône; Paris.

Fischer, R.
1966: Die Dactylioceratidae (Ammonoidea) der Kammerker (Nordtirol) und die Zonengliederung des alpinen Toarcian; Bayr. Akad. Wiss. Math.-Nat. Kl. Abh. N.F., Heft 126.

Frebold, Hans
1951: Contributions to the Palaeontology and Stratigraphy of the Jurassic System in Canada; Geol. Surv. Can., Bull. 18.

1957: The Jurassic Fernie Group in the Canadian Rocky Mountains and Foothills; Geol. Surv. Can., Mem. 287.

1962: The Devonian-Jurassic contact and the subdivision of the Fernie Group in the Banff area, Alberta; Geol. Surv. Can., Paper 62-3.

1963: Ammonite faunas of the Upper Middle Jurassic beds of the Fernie Group in western Canada; Geol. Surv. Can., Bull. 93.

1964: Lower Jurassic and Bajocian ammonoid faunas of northwestern British Columbia and southern Yukon; Geol. Surv. Can., Bull. 116.

1966: Upper Pliensbachian beds in the Fernie Group of Alberta; Geol. Surv. Can., Paper 66-27.

1967: The Pliensbachian beds in the Rocky Mountains and Foothills; *in* Report of Activities, Part A, May to October 1966, Geol. Surv. Can., Paper 67-1, p. 200-201.

1969: Subdivision and facies of Lower Jurassic rocks in the southern Canadian Rocky Mountains and Foothills; Proc. Geol. Assoc. Can., v. 20, p. 76-89.

Frebold, Hans, Mountjoy, E., and Reed, Ruth
1959: The Oxfordian beds of the Jurassic Fernie Group, Alberta and British Columbia; Geol. Surv. Can., Bull. 53.

Frebold, Hans and Tipper, H.W.
1970: Status of the Jurassic in the Canadian Cordillera of British Columbia, Alberta, and southern Yukon; Can. J. Earth Sci., v. 4, p. 1-21.

Guex, J.
1972: Répartition biostratigraphique des ammonites du Toarcien moyen de la bordure sud des Causses (France) et révision des ammonites décrites et figurées par Monestier (1931), Eclogae geol. Helv., v. 65, no. 3.

Hiltermann, H.
1939: Stratigraphie und Palaeontologie der Sonninienschichten von Osnabrück and Bielefeld. 1. Teil. Stratigraphie und Ammonitenfauna; Palaeontographica, v. 90, Abt. A.

Howarth, M.K.
1962a: Whitbian and Yeovilian Substages; Colloque du Jurassique, Luxembourg. Comptes rendus et Mémoires; L'Institut grand-ducal, Sect. Sciences nat. phys. et mathém.

1962b: The Yorkshire type ammonites and nautiloids of Young and Bird, Phillips and Martin Simpson; Palaeontology, v. 5, pt. 1.

Hyatt, A.
1867: The Fossil Cephalopods of the Museum of Comparative Zoology; Bull. Mus. Comp. Zool., v. 1.

Imlay, R.W., Gardner, L.S., Rodgers, C.P., and Hadley, H.D.
1948: Marine Jurassic formations of Montana, U.S. Geol. Surv., Oil and Gas Inv. Prelim. Chart 32.

Imlay, R.W.
1952: Correlation of the Jurassic formations of North America exclusive of Canada; Bull. Geol. Soc. Am. v., no. 63.

1964: Middle Bajocian ammonites from the Cook Inlet Region, Alaska; U.S. Geol. Surv., Prof. Paper 418-B

1967: Twin Creek Limestone (Jurassic) in the western Interior of the United States; U.S. Geol. Surv., Prof. Paper 540.

1973: Middle Jurassic (Bajocian) Ammonites from Eastern Oregon; U.S. Geol. Surv., Prof. Paper 756.

Lehmann, U.
1968: Stratigraphie und Ammonitenführung der Ahrensburger Glazial-Geschiebe aus dem Lias epsilon (= Unt. Toarcium); Mitt. Geol. Staatsinst., Hamburg, 37.

McLearn, F.K.
1927: Some Canadian Jurassic Faunas; Trans. Roy. Soc. Can., ser. 3, sec. IV, v. 21.

Merla, G.
1933: Ammoniti giuresi dell'Appennino Centrale. 1. Hildoceratidae; Palaeontogr. Italica, v. 33 (n. ser. v. 3).

Oechsle, E.
1958: Stratigraphie und Ammonitenfauna der Sonninienschichten des Filsgebietes unter besonderer Berücksichtigung der Sowerbyi-Zone (Mittlerer Dogger, Württemberg); Palaeontographica, v. 111, Abt. A.

d'Orbigny, A.
1842-
1851: Paléontologie Française. Terrains Jurassiques, v. 1; Céphalopodes; Paris.

Pinna, G.
1963: Ammoniti del Lias Superiore (Toarciano) dell'Alpe Turati (Erba, Como). Generi Mercaticeras, Pseudomercaticeras e Brodieia; Mem. Soc. Ital. Scienze Naturali., v. 13. fasc. 2.

Pinna, G. and Levi-Setti, Franco
1971: I Dactylioceratidae della Provincia Mediterranea (Cephalopoda Ammonoidea); Mem. Soc. Ital. Scienze Naturali., v. 19, fasc. 2.

Schmidt-Effing, R.
1972: Die Dactylioceratidae, eine Ammoniten-Familie des unteren Jura, Münstersche Forschungen zur Geologie und Palaeontologie, Heft 25/26, Münster.

Spivak, J.
1949: Jurassic Sections in Foothills of Alberta and northeastern British Columbia; Bull. Am. Assoc. Petrol. Geologists, v. 33.

Warren, P.S.
1934: Present status of the Fernie Shale; Am. J. Sci., v. 27.

1947: Description of Jurassic Ammonites from the Fernie Formation; Appendix to J.A. Allan and Carr, J.L., Geology of Highwood-Elbow area, Alberta; Res. Counc. Alberta, Rep. 49.

Westermann, G.E.G.
1964: Occurrence and Significance of the Arctic *Arkelloceras* in the Middle Bajocian of the Alberta Foothills (Ammonitina, Jurassic); J. Paleontol., v. 38, no. 2.

1966: Covariation and taxonomy of the Jurassic ammonite *Sonninia adicra* (Waagen); Neues Jahrb. Geol. Pal. Abh., v. 24.

1969: The Ammonite Fauna of the Kialagvik Formation at Wide Bay, Alaska Peninsula. Part II. Sonninia Sowerbyi Zone (Bajocian); Bull. Am. Paleontol., v. 57, no. 255.

Whiteaves, J.F.
1889: Fossils from the Rocky Mountains. Three miles north of the east end of Devil's Lake; Geol. Surv. Can., Contrib. Can. Paleont., v. 1, pt. 2.

1907: Description of a Canadian species of *Peltoceras;* Field Nat., v. 21.

Wright, T.
1878-
1886: Monograph on the Lias Ammonites of the British Islands; Paleontogr. Soc. London.

Young, G. and Bird, John
1822: A geological survey of the Yorkshire coast, Whitby.

1828: *ibid.*; Second edition, Whitby.

Plates IV – IX

All figures in natural size.
Types in Type collection of the Geological Survey of Canada

Plate IV

Figure 1. *Dactylioceras (Orthodactylites)* sp. B. Figured specimen. GSC 41652, GSC photo 202493-0. Bighorn Creek. Ya-ha-tinda Ranch. GSC loc. 78843. Lower Toarcian, Exaratum Subzone. Page 12 .

Figure 2. *Dactylioceras (Orthodactylites)* sp. A. Figured specimen GSC 41653, GSC photo 202494-B. Same locality and bed as figure 1. Page 12.

Figure 3. *Peronoceras* sp. Figured specimen. GSC 5825, GSC photo 202577-A. Red Deer River. Exact locality unknown. Lower Toarcian. Page 12.

Figure 4. *Peronoceras* sp. indet. Figured specimen. GSC 41654, GSC photo 202493-K. Snake Indian River. GSC loc. 79915. Lower Toarcian. Page 12.

Figure 5. *Peronoceras* sp. indet. Figured specimen. GSC 41655, GSC photo 202493-H. Cadomin Railway section. GSC loc. 31413. Lower Toarcian. Page 12.

Figure 6. *Peronoceras* sp. indet. Figured specimen. GSC. 12878, GSC photo 202577. Opposite George Creek. GSC loc. 19557. Lower Toarcian. Page 12.

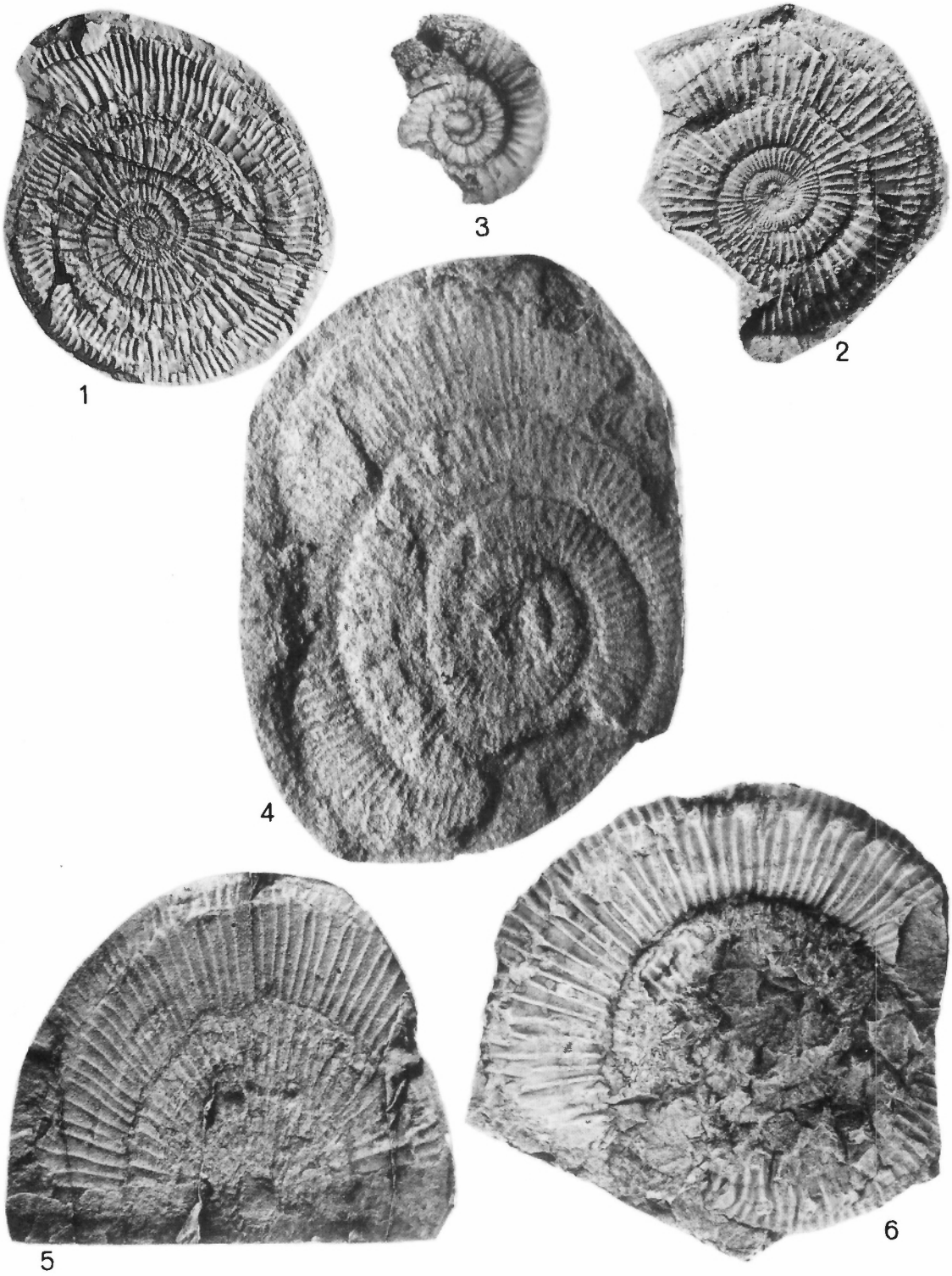

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Plate V

Figure 1. *Harpoceras exaratum* (Young and Bird). Hypotype. GSC 41656, GSC photo 202493-E. Bighorn Creek. Ya-ha-tinda Ranch, GSC loc. 78844. Lower Toarcian, Exaratum Subzone. Page 12.

Figure 2. *Harpoceras* cf. *H. falcifer* (Sowerby). Figured specimen. GSC 41657, GSC photo 202673-B. Bighorn Creek. Ya-ha-tinda Ranch. GSC loc. 91936. Lower Toarcian, Falcifer Subzone. Page 13.

Figure 3. *Whitbyiceras*? sp. indet. Figured specimen. GSC 41658, GSC photo 202494-L. Bighorn Creek, Ya-ha-tinda Ranch, GSC loc. 91943 Lower Toarcian, Falcifer Subzone. Page 13.

Figure 4. *Hildaites* cf. *H. serpentiniformis* Buckman. Figured specimen. GSC 41659, GSC photo 202577-E. Same locality as fig. 2. Page 14.

Figure 5. *Hildaites* cf. *H. serpentiniformis* Buckman. Figured specimen. GSC 41660, GSC photo 202494-Y. Same locality as fig. 2. Page 14.

PLATE V

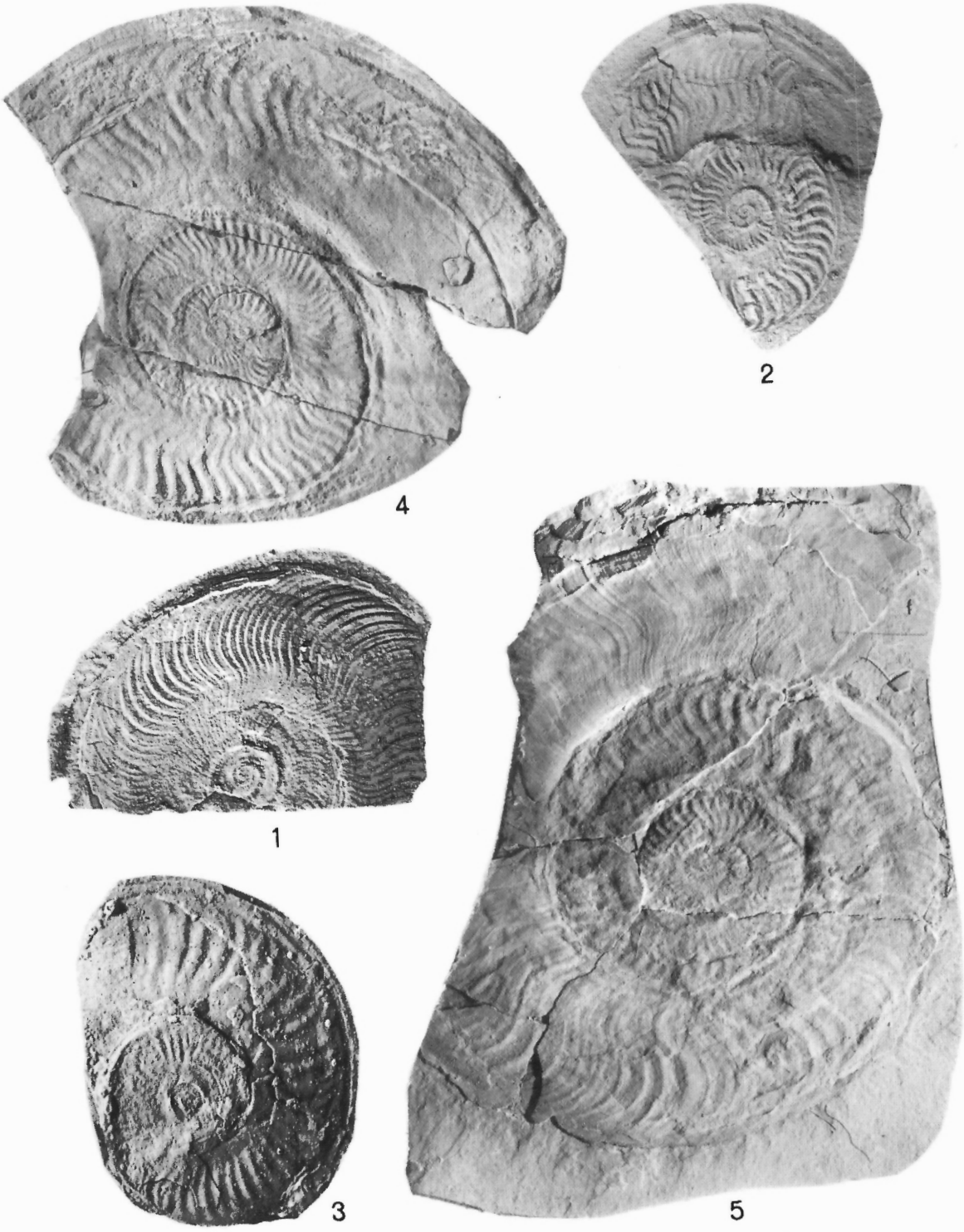

Plate VI

Figure 1. *Hildaites* sp. nov.? Figured specimen. GSC 41661, GSC photo 202673. Snake Indian Valley. GSC loc. 79915. Lower Toarcian, Falcifer Subzone. Page 13.

Figure 2. *Hildaites* cf. *H. serpentiniformis* Buckman. Figured specimen. GSC 41662, GSC photo 202673-A. Bighorn Creek, Ya-ha-tinda Ranch. GSC loc. 91936. Lower Toarcian, Falcifer Subzone. Page 14.

Figure 3. *Brodieia?* sp. indet. Figured specimen. GSC 41663, GSC photo 202493-Q. Bighorn Creek, Ya-ha-tindà Ranch. GSC loc. 78853. Middle Toarcian. Page 14.

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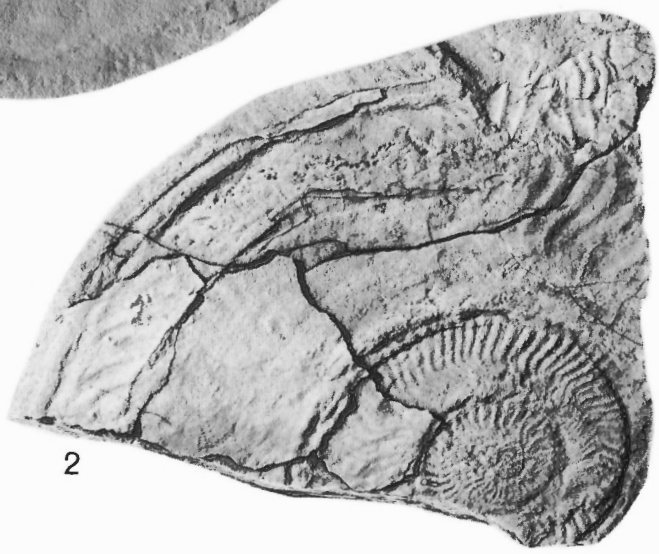

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Plate VII

Figure 1. *Hildaites* sp. nov.? Figured specimen. GSC 41664, GSC photo 202494-O Fording River. GSC loc. 78594. Lower Toarcian, Falcifer Subzone. Page 13.

Figure 2. *Hildaites* sp. nov.? Figured specimen. GSC 41665, GSC photo 202493-D. Opposite George Creek. GSC loc. 19557. Lower Toarcian, Falcifer Subzone. Page 13.

Figure 3. *Haugia* aff. *H. navis* (Dumortier). Figured specimen. GSC 41666, GSC photo 202493-U. Crow Phosphate Mine. GSC loc. 84842 Middle Toarcian, Variabilis Zone. Page 14.

Figure 4. *Haugia* sp. indet. Figured specimen. GSC 41667, GSC photo 202493-G. Crow Phospate Mine. GSC loc. 84843. Middle Toarcian, Variabilis Zone. Page 14.

Figure 5. *Haugia* aff. *H. illustris* (Denckmann). Figured specimen. GSC 41668, GSC photo 202493. Crow Phosphate Mine. GSC loc. 84843. Middle Toarcian, Variabilis Zone. Page 14.

Figure 6. *Brodieia?* sp. indet. Figured specimen. GSC 41669 GSC photo 202494-K. Bighorn Creek, Ya-ha-tinda Ranch. GSC loc. 78853. Middle Toarcian. Page 14.

Figure 7. *Brodieia?* sp. indet. Figured specimen. GSC 41670, GSC photo 202493-F. Same locality as fig. 6. Page 14.

Figure 8. *Haugia* sp. indet. Figured specimen. GSC 41671, GSC photo 202493-L. Fording River. GSC loc. 31430. Middle Toarcian, Variabilis Zone. Page 14.

Figure 9. *Haugia* sp. indet. Figured specimen GSC 41672, GSC photo 202493-X. Same locality as fig. 8. Middle Toarcian, Variabilis Zone. Page 14.

PLATE VII

Plate VIII

Figure 1. *Sonninia modesta* Buckman. Hypotype. GSC 41673, GSC photo 202494-U. Boulder, Elk River at bridge near Morrissey Station. GSC loc. 91921. Lower part of Middle Bajocian, Sowerbyi Zone. Page 15.

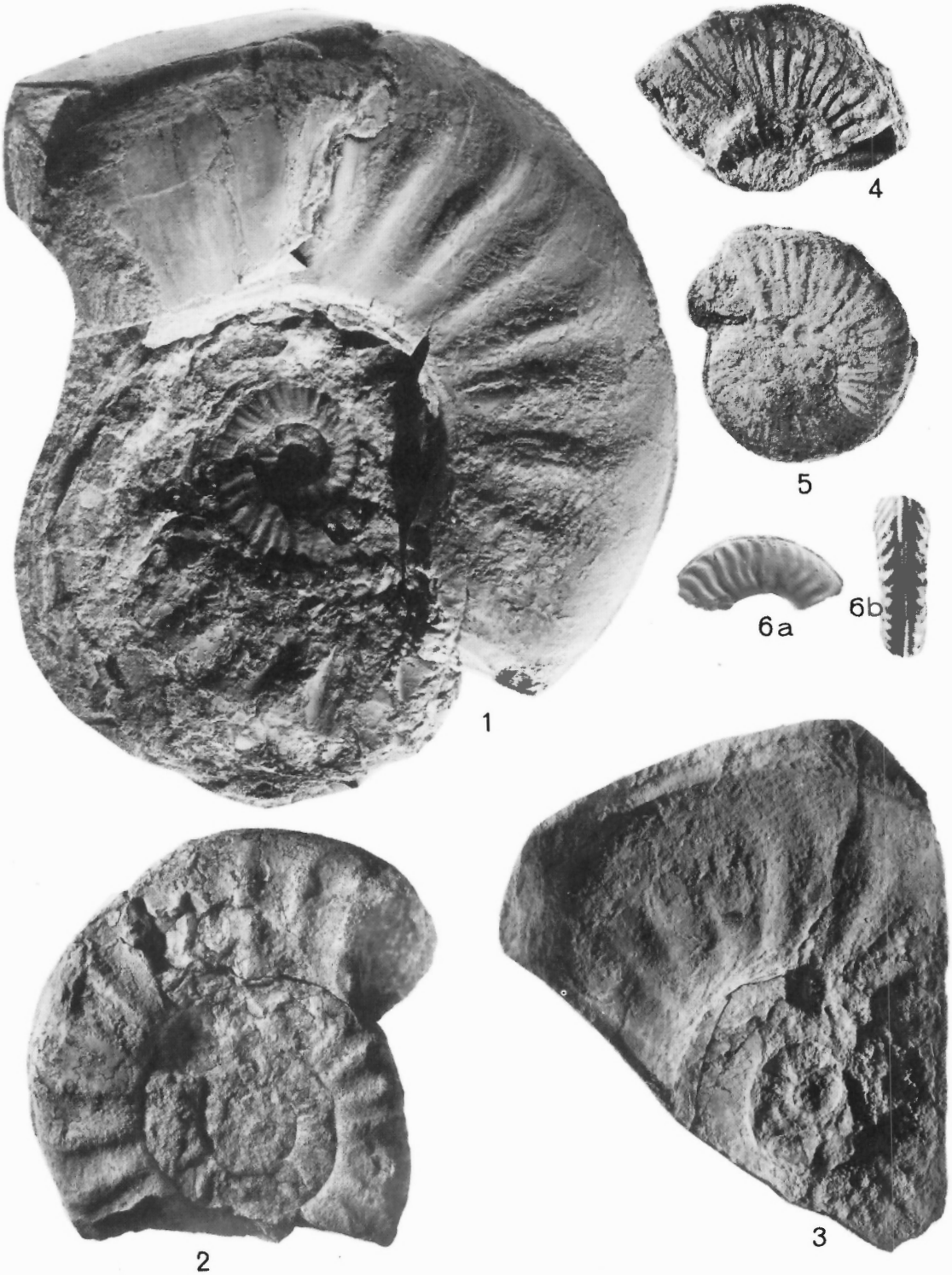
Figure 2. *Sonninia gracilis* (Whiteaves). Paratype. GSC 41674, GSC photo 202493-Y. North of Devil's Point. Lake Minnewanka area. Lower part of Middle Bajocian, Sowerbyi Zone. Page 15.

Figure 3. *Sonninia* sp. indet. Figured specimen. GSC 34165, GSC photo 202494-M. Lodgepole Creek area, GSC loc. 84912. Sandstone with *Sonninia*. Lower part of Middle Bajocian, Sowerbyi Zone. Page 16.

Figure 4. *Sonninia* sp. indet. Figured specimen. GSC 34166, GSC photo 202674. Crow Phosphate Mine. GSC loc. 79148. Sandstone with *Sonninia*. Lower part of Middle Bajocian, Sowerbyi Zone. Page 16.

Figure 5. *Witchellia*? cf. *W. adnata* Imlay. Figured specimen. GSC 34167, GSC photo 202679-A. Lodgepole Creek area, GSC loc. 78596. Sandstone with *Sonninia*. Lower part of Middle Bajocian, Sowerbyi Zone. Page 16.

Figure 6 a, b. *Pelecodytes*? sp. indet. Figured specimen. GSC 34168, GSC photo 202679, B, C. Lodgepole Creek area. GSC loc. 84912. Page 17.
6a = lateral view.
6b = venter.
Sandstone with *Sonninia*. Lower part of Middle Bajocian, Sowerbyi Zone.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2
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6a
6b

Plate IX

Figure 1. *Sonninia* sp. indet. aff. *S. gracilis* (Whiteaves). Figured specimen. GSC 34169, GSC photo 202494. Crow Phosphate Mine. GSC loc. 79148. Sandstone with *Sonninia.* Lower part of Middle Bajocian, Sowerbyi Zone. Page 15.

Figure 2. *Sonninia gracilis* (Whiteaves). Holotype. GSC 4809, GSC photo 202493-W. North of Devil's Point. Lake Minnewanka area. Lower part of Middle Bajocian, Sowerbyi Zone. Page 15.

Figure 3. Stephanoceratid? gen. et sp. indet. Figured specimen. GSC 28013, GSC photo 202494-W. Crow Phosphate Mine. GSC loc. 79148. Sandstone with *Sonninia.* Lower part of Middle Bajocian, Sowerbyi Zone. Page 17.

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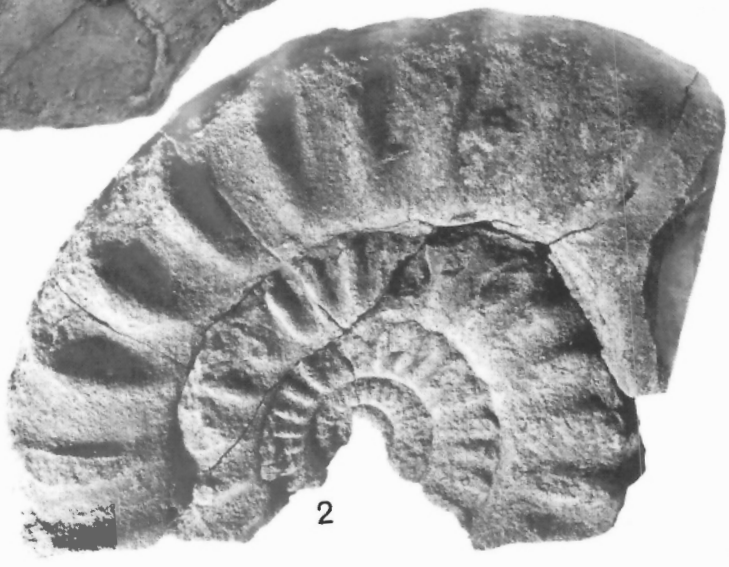

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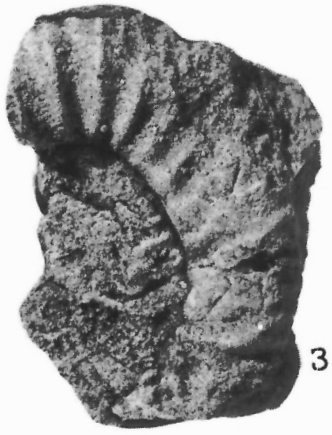

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