The Upper Cretaceous Ammonite *Watinoceras* Warren in the Western Interior of the United States

U.S. GEOLOGICAL SURVEY BULLETIN 1788

The Upper Cretaceous Ammonite *Watinoceras* Warren in the Western Interior of the United States

By WILLIAM A. COBBAN

Contributions to Paleontology

Descriptions and illustrations of guide fossils to lower and middle Turonian rocks

U.S. GEOLOGICAL SURVEY BULLETIN 1788

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U. S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

UNITED STATES GOVERNMENT PRINTING OFFICE: 1988

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center
Box 25425
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Cobban, William Aubrey, 1916-
The Upper Cretaceous ammonite Watinoceras Warren in the western interior of the United States.

(U.S. Geological Survey bulletin ; 1788)
Bibliography: p.
Supt. of Docs. no.: I 19.3:1788
1. Watinoceras. 2. Paleontology—Cretaceous. 3. Paleontology—West (U.S.) I. Title. II. Series.
QE75.B9 no.1788 [QE807.A5] 557.3 s 87-600203
[564'.53]

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The Upper Cretaceous Ammonite *Watinoceras* Warren in the Western Interior of the United States

By William A. Cobban

Abstract

Watinoceras is widely distributed in rocks of Turonian Age in the Western Interior of the United States. Four zones are known at present. The oldest zone, from the base of the lower Turonian, is characterized by poorly preserved, crushed specimens that may be *W. praecursor* Wright and Kennedy. In the overlying zone of *W. coloradoense* (Henderson), the genus occurs in its greatest variety. *W. reesidei* Warren and the new forms *W. thompsonense* and *W. devonense flexuosum* are found here, as well as abundant *W. coloradoense*. The third zone, in the upper part of the lower Turonian, is characterized by the new species *W. hattini*. Above the lower Turonian, *Watinoceras* becomes very rare, and only *W. cobbani* Collignon, of early middle Turonian age, is known from one locality in west-central New Mexico.

INTRODUCTION

Watinoceras is a small to medium-sized ammonite that was named by P. S. Warren (1930, p. 67, 68) for some small specimens collected from the basal part of the Upper Cretaceous Smoky River Group near Watino, a small hamlet on the Smoky River in west-central Alberta, Canada. The genus was based on a single new species, *W. reesidei* Warren.

Ammonites assigned to *W. reesidei* have been recorded from many localities in western Alberta and northeastern British Columbia, where the species occurs in calcareous shale that also contains a bivalve referred to in the literature as *Inoceramus labiatus*. A "*Watinoceras* zone" was recognized by McLearn (1937, p. 114). A "*Watinoceras reesidei* zone" was noted by Stelck and Wall (1955, p. 16), and it was later referred to as the "*Watinoceras* and *Inoceramus labiatus* zone" (Wall and Germundson, 1963, p. 333; Jeletzky, 1968, p. 27).

In the Western Interior of the United States, a zone of "*Watinoceras reesidei* and *Inoceramus labiatus*" was noted at first (Cobban, 1951, fig. 2) but, soon thereafter, it was referred to only as the "zone of *Inoceramus labiatus*" (Cobban and Reeside, 1952, p. 1018). Recently, Hattin (1975, p. 66) has recognized a "*Mytiloides labiatus-Watinoceras reesidei* Assemblage Zone" in his extensive investigation of the Greenhorn Limestone of Kansas.

Another species, *Watinoceras coloradoense* (Henderson), was used as a guide fossil to one of the zones of the Greenhorn Limestone in the Pueblo area in southeastern Colorado (Cobban and Scott, 1972, table 4). The zone was later proposed as the basal part of the Turonian zonation in England (Wright and Kennedy, 1981, p. 120) and, more recently, for northwest Europe (Kennedy and others, 1983, p. 177; Hancock, 1984, p. 127; Kennedy, 1984, p. 150–152).

Neocardioceras Spath (1926, p. 81), a little-known ammonite from the upper Cenomanian of the Paris Basin, was recently discussed by Wright and Kennedy (1981, p. 49–51) who noted the close resemblance of this genus and *Watinoceras* and suggested that *Watinoceras* was derived from *Neocardioceras* merely by loss of siphonal tubercles. As a result of the extensive treatment of these genera by Wright and Kennedy (1981, p. 49–54, pl. 8, figs. 1–6, 8; pl. 9; pl. 10, figs. 1–18; text figs. 17; 18 C–G; 19 G–L, N, P, Q), it has become apparent that some of the specimens from the Western Interior region referred to as *Watinoceras* are really *Neocardioceras*. This report was prompted to emend these determinations and to define more firmly the American species of *Watinoceras*.

All specimens from the U.S. Geological Survey collections described in this report have been assigned USNM catalog numbers and are kept at the National Museum of Natural History in Washington, D.C. Casts of the new species are in the reference collections of the U.S. Geological Survey at the Federal Center, Denver, Colo. Robert E. Burkholder, of the U.S. Geological Survey, made the photographs. Prof. Donald E. Hattin, Indiana University, Bloomington, made available for study all the specimens of *Watinoceras* that he and colleagues collected from the Greenhorn Limestone of Kansas. C. R. Stelck, Professor Emeritus, University of Alberta, Edmonton, kindly loaned me many specimens of *Watinoceras* from western Canada. J. I. Kirkland, University of Colorado, Boulder, loaned me an unusual specimen of the new species *W. thompsonense* as well as a collection of the new subspecies *W. devonense flexuosum*.

LOCALITIES AT WHICH FOSSILS WERE COLLECTED

Ammonites in the collections of the U.S. Geological Survey described or reported on in this report came from 34 localities in Montana, Colorado, Kansas, Utah, and New Mexico as well as two localities in Canada and one in Alaska. U.S. Geological Survey localities in the conterminous United States are shown in figure 1, and data concerning these localities are given in table 1.

SEQUENCE OF SPECIES

Previously described species of *Watinoceras* found in the Western Interior of the United States are *W. reesidei* Warren, *W. coloradoense* (Henderson), and *W. cobbani* Collignon. In the present report, the following new species and subspecies are described: *W. hattini, W. thompsoni*, and *W. devonense flexuosum*. In addition, attention is drawn to *W.* cf. *W. praecursor* Wright and Kennedy and *W.* sp.

The oldest form, *W.* cf. *W. praecursor*, is represented by poorly preserved, flattened fragments of internal molds from a bed of limestone near the top of the lower third of the Bridge Creek Limestone Member of the Greenhorn Limestone near Pueblo, Colo. (Cobban and Scott, 1972, bed 86 of the Rock Canyon section). Both coarse- and fine-ribbed forms are present in this bed of very early Turonian age. Higher in the Bridge Creek Member, but below the middle, is a bed of limestone (Cobban and Scott, 1972, p. 23, bed 97) that contains *W. coloradoense, W. reesidei*, and the new subspecies *W. devonense flexuosum*. Occasional fragments of *Watinoceras* occur still higher near the middle of the Bridge Creek Member. The bed (97) that contains the *W. coloradoense* fauna persists eastward to central Kansas, where it forms the base of the Jetmore Chalk Member of the Greenhorn Limestone. Here, the bed contains *W. reesidei* and an occasional specimen of *W. coloradoense*. Higher in the Jetmore Member, near the top of the lower third, *W. hattini*, n. sp., occurs. *Watinoceras* has not been found in the uppermost part of the Greenhorn Limestone in Kansas and Colorado. This part of the formation is characterized by the ammonite *Collignoniceras woollgari woollgari* (Mantell) of early middle Turonian age. In west-central New Mexico, *C. woollgari woollgari* occurs with *Watinoceras cobbani* Collignon, which is the youngest known species of *Watinoceras* in North America. The age span of the genus in North America is from the base of the Turonian into the lower part of the middle Turonian.

The new species, *W. thompsonense*, has not been definitely placed in this sequence but, from the preservation of the holotype, the species is probably from the widely distributed bed (97) that contains the *W. coloradoense* fauna.

The sequence of species and subspecies of *Watinoceras* and their ages are summarized in table 2.

SYSTEMATIC DESCRIPTIONS

The specimens that are described or mentioned in this report have the following repository abbreviations: USNM (National Museum of Natural History, Washington, D.C. (formerly U.S. National Museum); UA (University of Alberta, Edmonton, Canada); KUMIP (University of Kansas Museum of Invertebrate Paleontology, Lawrence); IGS (Institute of Geological Sciences, London, England).

In the descriptions, umbilical widths are usually given as ratios to the shell diameter. Drawings of sutures have a heavy straight line that marks the middle of the venter as well as the middle of the external lobe. Only the major sutural elements are identified; E stands for the external lobe, L stands for the lateral lobe, and E/L stands for the saddle that separates these lobes. The umbilical seam is indicated by a small, curved solid line, and the umbilical shoulder is indicated by a larger, curved dashed line.

Family ACANTHOCERATIDAE de Grossouvre, 1894
Subfamily ACANTHOCERATINAE de Grossouvre, 1894
Genus WATINOCERAS Warren, 1930

Type species.—*Watinoceras reesidei* Warren, 1930, by original designation (= *Acanthoceras amudariense* Arkhangel'skii, 1916, according to Wright and Kennedy, 1981, p. 51).

Diagnosis.—*Watinoceras* is a small- to moderate-sized, somewhat involute to quite evolute genus that has, at most growth stages, a narrow, smooth to nearly smooth, flattened venter and conspicuously ribbed flanks with umbilical and both inner and outer ventrolateral tubercles. The little-incised external suture has a narrow to quadrate external lobe; a very broad, bifid first lateral saddle; and a small, rectangular to squarish, bifid lateral lobe.

Occurrence.—Wright and Kennedy (1981, p. 51) noted that *Watinoceras* is widely distributed in basal Turonian rocks in western Europe, Turkestan, Japan, Alaska, western Canada, the Western Interior of the United States, and parts of Africa (Morocco, Cameroon, Nigeria, Angola, and Madagascar). In addition, the genus has been recorded from Texas (Young, 1958, p. 292), Venezuela (Renz, 1982, p. 93), Brazil (Reyment and others, 1976, p. 257; Bengtson, 1983, p. 16, 44–46), Spain (Wiedmann, 1959, p. 723; 1964, p. 118), and questionably from Mexico (Kellum and Robinson, 1963, p. 240).

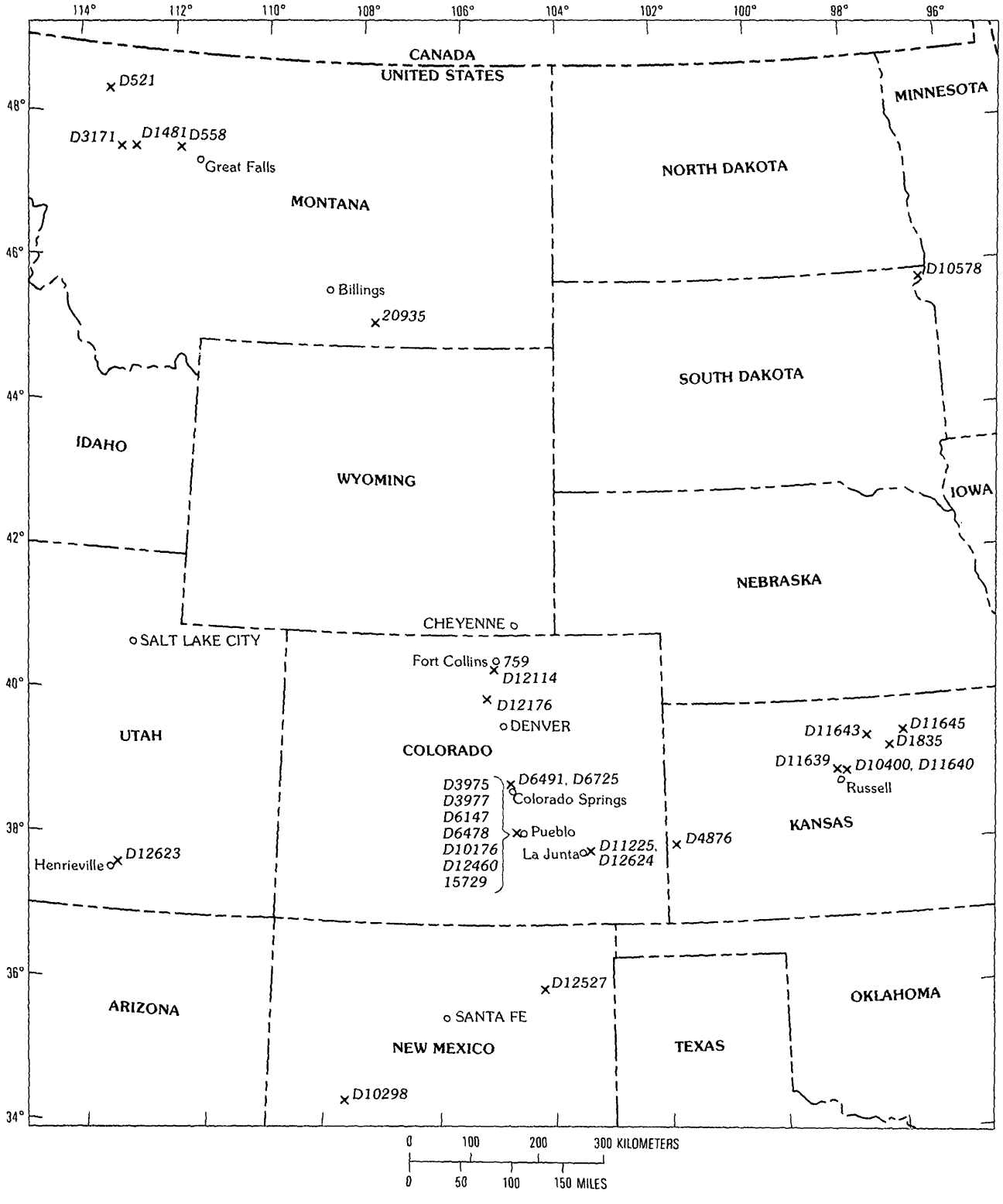

Figure 1. Map showing localities of collections of *Watinoceras* referred to in the text and in table 1.

Table 1. Localities at which fossils were collected

U.S. Geological Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
D521	W. A. Cobban, 1955. Southeast side of Summit Creek 15.4 km (9.6 mi) by road southwest of East Glacier, Glacier County, Mont. Cone Member of Marias River Shale.
D558	W. A. Cobban, 1955. SE¼ sec. 13, T. 22 N., R. 1 W., Teton County, Mont. Cone Member of Marias River Shale.
D1481	M. R. Mudge and R. E. Eggleton, 1957. North bank of Sun River in the NE¼ sec. 32, T. 22 N., R. 8 W., Lewis and Clark County, Mont. Cone Member of Marias River Shale (Mudge, 1972, p. A124).
D1835	D. F. Merriam and W. A. Cobban, 1958. Quarry in the SE¼ sec. 24, T. 8 S., R. 6 W., Mitchell County, Kans. Greenhorn Limestone, from basal part of Jetmore Chalk Member.
D3171	M. R. Mudge and Dale Snow, 1961. West side of South Fork of Sun River 1.2 km (3/4 mi) southwest of junction of Bear Creek, Lewis and Clark County, Mont. Cone Member of Marias River Shale (Mudge, 1972, p. A126).
D3975	G. R. Scott and W. A. Cobban, 1961. Rock Canyon Anticline in the SW¼ sec. 30, T. 20 S., R. 65 W., Pueblo County, Colo. Greenhorn Limestone, from bed 86 of measured section of Bridge Creek Limestone Member (Cobban and Scott, 1972, p. 23).
D3977	G. R. Scott and W. A. Cobban, 1961. Same locality as D3975. Greenhorn Limestone, from bed 97 of measured section of Bridge Creek Member (Cobban and Scott, 1972, p. 23).
D4876	G. R. Scott and W. A. Cobban, 1964. Bridge Creek in the NE¼ sec. 22, T. 23 S., R. 42 W., Hamilton County, Kans. Greenhorn Limestone, from 7.3 m (24 ft) above base of Bridge Creek Member.
D6147	W. H. Birchby, 1967. Rock Canyon anticline in the NW¼ sec. 1 and NE¼ sec. 2, T. 21 S., R. 66 W., Pueblo County, Colo. Greenhorn Limestone, from bed 97 of measured section of Bridge Creek Member.
D6478	G. R. Scott, 1968. Rock Canyon anticline in the NW¼ sec. 25, T. 20 S., R. 66 W., Pueblo County, Colo. Greenhorn Limestone, from bed 97 of measured section of Bridge Creek Member.
D6491	G. R. Scott, 1968. North of road to Castle quarry in the SE¼ sec. 22 and NE¼ sec. 27, T. 13 S., R. 67 W., El Paso County, Colo. Bridge Creek Member of Greenhorn Limestone.
D6725	G. R. Scott, 1968. Same locality as D6491. Bridge Creek Member of Greenhorn Limestone.
D10176	W. A. Cobban, 1977. Center of sec. 25, T. 20 S., R. 66 W., Pueblo County, Colo. Greenhorn Limestone, from bed 86 of measured section of Bridge Creek Member (Cobban and Scott, 1972, p. 23).
D10298	S. C. Hook and W. A. Cobban, 1976. East of D Cross Mountain in the SW¼ sec. 17, T. 3 N., R. 8 W., Socorro County, N. Mex. Upper part of Rio Salado Tongue of Mancos Shale.
D10400	E. A. Merewether, 1977. NW¼ sec. 24, T. 12 S., R. 13 W., Russell County, Kans. Greenhorn Limestone, from upper part of Jetmore Member.
D10578	Jayne Sieverding and Sheila Stenzel, 1978. East shore of Lake Traverse in the SE¼ sec. 2, T. 125 N., R. 49 W., Traverse County, Minn. Greenhorn Limestone.
D11225	G. R. Scott, S. C. Hook, and W. A. Cobban, 1980. Thompson Arroyo in the NW¼ sec. 5, T. 24 S., R. 54 W., Otero County, Colo. Bridge Creek Member of Greenhorn Limestone.
D11639	E. A. Merewether and W. A. Cobban, 1981. Beside highway in the SE¼ sec. 27, T. 12 S., R. 14 W., Russell County, Kans. Greenhorn Limestone, from base of Jetmore Member.
D11640	E. A. Merewether and W. A. Cobban, 1981. Bunker Hill in the NE¼ sec. 13, T. 13 S., R. 13 W., Russell County, Kans. Greenhorn Limestone, from base of Jetmore Member.
D11643	E. A. Merewether and W. A. Cobban, 1981. Spillway at Glen Elder dam in the SE¼ sec. 3, T. 7 S., R. 9 W., Mitchell County, Kans. Greenhorn Limestone, from 1.5 m (5 ft) above base of Jetmore Member.
D11645	E. A. Merewether and W. A. Cobban, 1981. Beside highway in the NW¼ sec. 16, T. 6 S., R. 3 W., Cloud County, Kans. Greenhorn Limestone, from base of Jetmore Member.
D12114	W. A. Cobban, 1982. NW¼ sec. 9, T. 6 N., R. 69 W., Larimer County, Colo. Bridge Creek Member of Greenhorn Limestone.
D12176	E. A. Merewether and W. A. Cobban, 1983. Lykins Gulch in the NW¼ sec. 7, T. 2 N., R. 70 W., Boulder County, Colo. Greenhorn Limestone, from same limestone bed in Bridge Creek Member as bed 97 of Pueblo section (Cobban and Scott, 1972, p. 23).

Table 1. Localities at which fossils were collected—Continued

U.S. Geological Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
D12460	W. A. Cobban, 1984. NE¼ sec. 25, T. 20 S., R. 66 W., Pueblo County, Colo. Greenhorn Limestone, from bed 86 of measured section of Bridge Creek Member (Cobban and Scott, 1972, p. 23).
D12527	G. R. Scott, E. A. Merewether, and W. A. Cobban, 1984. Old quarry northeast of Roy in the NE¼ sec. 26, T. 21 N., R. 26 E., Harding County, N. Mex. Greenhorn Limestone, from same bed as bed 97 of section of Bridge Creek Member near Pueblo, Colo. (Cobban and Scott, 1972, p. 23).
D12623	Collector and date unknown. Northeast of Henrieville, Garfield County, Utah. Tropic Shale, from a limestone concretion.
D12624	J. C. Myers, date unknown. Thompson Arroyo east of La Junta, Colo. [NW¼ sec. 5, T. 24 S., R. 54 W., Otero County]. Greenhorn Limestone.
759	T. W. Stanton, 1890. Spring Creek, Larimer County, Colo. [W½] sec. 33, T. 7 N., R. 69 W.]. Greenhorn Limestone.
15729	C. H. Dane, W. G. Pierce, and F. E. White, 1931. West of Pueblo and three-fourths of a mile below the Rock Canyon barrier dam on the Arkansas River, Pueblo County, Colo. [SW¼ sec. 31, T. 20 S., R. 65 W.]. Greenhorn Limestone [bed 97 of Bridge Creek Member].
20935	W. A. Cobban, 1947. East flank of Soap Creek dome in the SW¼ sec. 36, T. 6 S., R. 32 E., Big Horn County, Mont. Cody Shale, from septarian limestone concretions 12 m (40 ft) above base of Greenhorn Member.

Table 2. Age and zonation of *Watinoceras*

middle Turonian (part)	*Watinoceras cobbani*
early Turonian	*Watinoceras hattini* and *W. reesidei*
	Watinoceras reesidei, W. coloradoense, W. devonense flexuosum, W. thompsonense
	Watinoceras cf. *W. praecursor*

Watinoceras reesidei Warren
Plate 1, figures 1–26; text figure 3

1930. *Watinoceras reesidei* Warren, Research Council of Alberta Geological Survey Report 21, p. 67, pl. 3, fig. 2; pl. 4, figs. 9–12.
1947. *Watinoceras reesidei* Warren. Warren, Journal of Paleontology, v. 21, no. 2, p. 122, pl. 30, fig. 6.
1959. *Watinoceras reesidei* Warren. Il'in, Trudy Vsesoyuznyy Nauchno-Issledovatel'skiy Geologorazvedochnyy Neftyanoy Institut (VNIGNI), no. 23, text fig. 4r.
1961. *Watinoceras reesidei* Warren. Cobban and Gryc, Journal of Paleontology, v. 35, no. 1, p. 186, pl. 38, figs. 46–49; text fig. 2 g, h.
1969. *Watinoceras reesidei* Warren. Matsumoto and others, Kyushu University Faculty of Science Memoirs, Series D, Geology, v. 19, no. 2, p. 281, 282.
1972. *Watinoceras reesidei* Warren? Cobban and Scott, U.S. Geological Survey Professional Paper 645, pl. 28, fig. 4.
1977. *Watinoceras reesidei* Warren. Kauffman, The Mountain Geologist, v. 14, nos. 3-4, pl. 19, fig. 10.
1978. *Watinoceras* (*Watinoceras*) *coloradoense* (Henderson). Cooper, Annals of the South African Museum, v. 75, pt. 5, p. 123.
1981. *Watinoceras amudariense* (Arkhanguelsky). Wright and Kennedy, Palaeontographical Society [London] Monograph (Publication Number 560, part of v. 134 for 1980), p. 51.
1982. *Watinoceras reesidei* Warren. Renz, The Cretaceous ammonites of Venezuela, p. 94, pl. 29, figs. 9a, b.

Types.—Holotype UA Ct. 478, from the Kaskapau Formation near Watino, Alberta, Canada. Paratypes UA Ct. 479–481, from the same locality as the holotype. Hypotypes UA 7558–7566, from the same locality; USNM 401596, from the Shale Wall Member of the Seabee Formation of northern Alaska; USNM 401597–401600, from the Greenhorn Limestone of Colorado.

Diagnosis.—A small species characterized by fairly dense ribbing and a flattened venter on the adult body chamber.

Description.—Warren (1930) figured 4 specimens from the Kaskapau Formation at a locality in west-central Alberta. The holotype (Warren, 1930, pl. 4, fig. 9) is an entire specimen about 16.5 mm in diameter with an umbilical ratio of 0.42 (measurements from Warren's illustration). Ribs are narrow, prorsiradiate, slightly flexuous, and alternate between long and short. Longer ribs (primaries) begin from weak umbilical bullae located on the umbilical shoulder. Secondary ribs arise low on the flank. Total number of ribs per half whorl is 19 at a diameter of about 11.7 mm and 25 at a diameter of 16.5 mm. According to Warren (1930, p. 67), the ribs do not cross the venter. Two incomplete paratypes (Warren, 1930, pl. 4, figs. 11, 12) have 24 and 20 ribs per half whorl at diameters of 16.5 and 20.4 mm, respectively. The third paratype is much like the others, but it consists of less than half a whorl.

C. R. Stelck, Professor Emeritus at the University of Alberta, kindly loaned me 11 topotypes from a limestone concretion from 15.2 m (50 ft) above the base of the Kaskapau Formation. The concretion was septarian, and all but the smallest specimens grade into coarsely crystalline limestone on one of their sides. Seven of the specimens have some part of the body chamber preserved. Diameters at the base of the body chambers of these were measured or estimated at 13.5, 14.5, 15.0, 16.0, 16.7, 17.0, and 18.8 mm. Umbilical ratios range from 0.41–0.45. Ribs on the last half whorl of these adults number 18–26 (fig. 2). The smallest whorl on which the flanks and venter are visible has a diameter of 3.3 mm (pl. 1, fig. 2). At this size, the whorl is smooth and higher than wide, with flattened flanks and narrow, slightly flattened venter. Small, closely spaced, nodate outer ventrolateral tubercles arise at a diameter of about 4.0 mm and bound the narrow, now distinctly flat, venter. Ribs arise at a diameter of about 4.8 mm, and inner ventrolateral tubercles form at some larger diameter, possibly between 7 and 8 mm. These tubercles are bullate to nodate on the inner whorls and nodate to clavate on the body chamber. Outer ventrolateral tubercles are slightly larger and nodate on the inner whorls and nodate to clavate on the body chamber. Body chambers consist of about half a whorl. Only one specimen has some of the aperture preserved, which is apparently normal (pl. 1, fig. 11). The last few ribs are less pronounced, and the tubercles become progressively smaller.

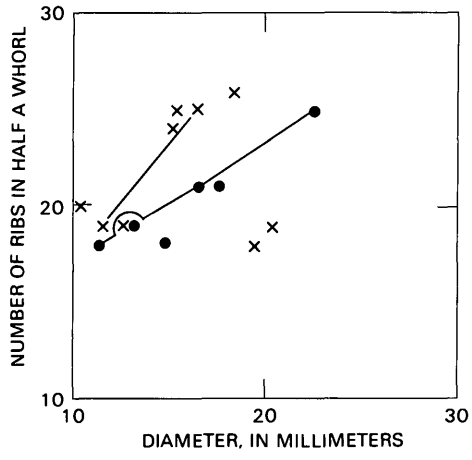

Figure 2. Scatter diagram showing number of ribs per half whorl of 11 specimens of *Watinoceras reesidei* Warren. Lines connect measurements on single specimens. X = holotype, paratypes, and hypotypes from the type locality of the species near Watino, Alberta, Canada. ● = specimens from the Shale Wall Member of the Seabee Formation at one locality in northern Alaska (USGS Mesozoic loc. 20420).

Well-preserved specimens of *Watinoceras reesidei* occur in the Seabee Formation in northern Alaska. Two adults figured by Cobban and Gryc (1961, pl. 38, figs. 46–49) have diameters of 17.8 and 20.4 mm and umbilical ratios of 0.39 and 0.38 respectively. Ribs per half whorl on the smaller specimen are 19 at a diameter of about 13 mm and 21 at a diameter of 17.8 mm. On the larger specimen, ribs per half whorl are 18 at a diameter of about 14.8 mm and 20 at 20.4 mm. An excellent specimen figured herein (pl. 1, figs. 12–14) from the same locality has rib counts per half whorl of 18 at a diameter of about 11.3 mm, 21 at about 16.6 mm, and 25 at 27.7 mm (fig. 2). The body chamber, which occupies half a whorl, is complete. Its narrow, flat, smooth venter persists to the aperture. Tubercles on the last two ribs are less prominent.

A few small specimens from the Bridge Creek Member of the Greenhorn Limestone near Pueblo, Colo., are probably referable to *W. reesidei* (pl. 1, figs. 19–26). These specimens are from a bed of limestone just below the middle of the Bridge Creek Member (Cobban and Scott, 1972, p. 23, bed 97). The specimens range in diameter from 20–27 mm and have umbilical ratios of 0.40–0.43. Ribs are narrow and prorsiradiate, and they tend to be alternately long and short on the outer whorl. Rib density increases with growth. Ribs number 16–21 per half whorl at diameters of 13.6–26.7 mm.

The suture of *Watinoceras reesidei* is simple and little divided (Warren, 1930, pl. 3, fig. 2; Cobban and Gryc, 1961, text fig. 2g, h). The external lobe (E) is narrow to squarish; the lateral lobe (L) is about the same size or slightly larger and bifid; the first lateral saddle (E/L) is very broad and bifid. Other lobes and saddles are small and either undivided or only slightly divided. The external suture of the specimen from northern Alaska is shown in figure 3.

Remarks.—Wright and Kennedy (1981, p. 51) regarded *Watinoceras reesidei* Warren (1930) as a synonym of *W. amudariense* (Arkhangel'skii, 1916). I believe they are separate species. Their inner whorls are indistinguishable, but the body chambers are different. Arkhangel'skii illustrated several specimens without

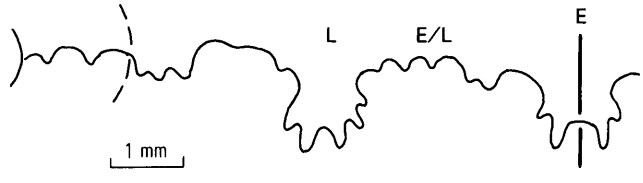

Figure 3. Last external suture of *Watinoceras reesidei* Warren at a diameter of 16.3 mm, from the Seabee Formation at USGS Mesozoic locality 20420 on Maybe Creek 2.4 km (1 1/2 mi) above junction with Anuk Creek, lat 69°16′ N., long 153°47′ W., in northern Alaska.

indicating one as the holotype. Wright and Kennedy designated as the lectotype a complete adult about 30 mm in diameter (Arkhangel'skii, 1916, pl. 7, fig. 12; figs. 8 and 9 seem to be front and rear views of this specimen). Arkhangel'skii (1916, p. 49) observed that the venter is narrow and flat on the early whorls but, as the shell enlarges, the venter becomes more rounded, and the ribs cross it in forwardly directed chevrons. Adult venters like that illustrated by Arkhangel'skii (1916, pl. 7, fig. 9) have not been observed on any of the American species of *Watinoceras*. In addition, *W. amudariense* attains much larger sizes than *W. reesidei*. One of the type specimens of Arkhangel'skii (1916, p. 49) is 53 mm in diameter, and Il'in (1957, fig. 1) illustrated a specimen that may be still larger. Specimens from England figured as *W. amudariense* by Wright and Kennedy (1981, pl. 10, figs. 6a, b, 14a-c) are more robust than American specimens of *W. reesidei*.

Occurrence.—Warren's types of *Watinoceras reesidei* are from near the base of the Kaskapau Formation of the Smoky River Group on Smoky River near Watino, Alberta, in the NW¼ sec. 21, T. 77, R. 24, W 5th meridian. *Scaphites delicatulus* Warren (1930, p. 66, pl. 3, fig. 3; pl. 4, figs. 7, 8) was probably found with them. Warren (1947, p. 122, 123, pl. 29, fig. 5; pl. 30, fig. 6) also figured *W. reesidei* and *S. delicatulus* from much farther north in the District of Mackenzie, from rocks now included in the Slater River Shale (Jeletzky, 1971, p. 51). The collection from the Slater River Shale was made by Prof. C. R. Stelck, who kindly loaned me the fossils. As noted by Stelck and Wall (1954, p. 14), the collection includes inoceramids and *Borissiakoceras* as well as *W. reesidei* and *S. delicatulus*. The *Borissiakoceras* specimens, although badly crushed, are most likely referable to *B. ashurkoffae* Cobban and Gryc, which occurs with *W. reesidei* in the Seabee Formation in northern Alaska (Cobban and Gryc, 1961, p. 179).

Ammonites assigned to *W. reesidei* have been recorded from many localities in western Alberta and northeastern British Columbia, especially from the Vimy Member of the Blackstone Formation and equivalent rocks (Warren and Stelck, 1940, p. 146; Stelck and Wall, 1954, p. 15; 1955, p. 16; Stelck, 1962, p. 15; Stott, 1961, p. 11; 1963, table 7; 1967, p. 25; Wall, 1967, p. 18; Wall and Rosene, 1977, p. 846).

On the Sweetgrass arch in north-central Montana (fig. 1, loc. 558), *W. reesidei* occurs as flattened impressions in the calcareous shale of the Cone Member of the Marias River Shale (Cobban, 1951, p. 2187; Cobban and others, 1976, p. 42, 43). Associated fossils include *Mytiloides columbianus* Heinz and *Scaphites delicatulus* Warren. Farther west, along the southeastern boundary of Glacier National Park, some of the flattened impressions in the Cone Member recorded as *W. reesidei* (Cobban, 1956, p. 1003) are that species, but some specimens (fig. 1, loc. D521) are the new species *W. hattini*. Farther south, in the Sun River area, Mudge (1972, p. A67) recorded impressions of *W. reesidei* in two small collections from the Cone Member. One lot (fig. 1, loc. D1481) is probably assignable to that species, but the other (fig. 1, loc. D3171) could be *W. hattini*.

In south-central Montana (fig. 1, loc. 20935), *W. reesidei* was recorded from the Greenhorn Member of the Cody Shale (Richards, 1955, p. 52; Knechtel and Patterson, 1956, p. 22). This record is based on a few small fragments that may well be *W. reesidei*. They came from the septarian limestone concretions that produced the large vascoceratid ammonite fauna described by Reeside (1923). All of Reeside's species of *Vascoceras* are now referred to the single species *Fagesia catinus* (Mantell) (Wright and Kennedy, 1981, p. 88, 97). The update list of ammonites and the inoceramid from this important locality are as follows: *Watinoceras reesidei* Warren, *Pseudaspidoceras*? sp., *Fagesia catinus* (Mantell), *Quitmaniceras reaseri* Powell, *Scaphites delicatulus* Warren, *Worthoceras* sp., *Allocrioceras*? sp., and *Mytiloides columbianus* (Heinz).

Watinoceras coloradoense (Henderson)
Plate 2; plate 3, figures 4, 5; text figure 4

1908. *Acanthoceras coloradoensis* Henderson, U.S. National Museum Proceedings, v. 34, no. 1611, p. 259, pl. 13, figs. 10, 11.
1916. *Acanthoceras amudariense* Arkhangel'skii var. *horridum* Arkhangel'skii, Trudy Geologicheskago Komiteta, n. ser., no. 152, p. 49, pl. 8, figs. 8-10, 14, 15.
1928. *Acanthoceras coloradoense* Henderson. Adkins, Texas University Bulletin 3101, p. 62.
1931. "*Acanthoceras*" *coloradoense* Henderson. Adkins, Texas University Bulletin 3101, p. 62.
1937. *Watinoceras coloradoense* (Henderson). McLearn, Transactions of the Royal Society of Canada, 3d ser., sec. 4, v. 31, p. 115.
1959. *Arkhangelskiceras costatum* Il'in, Trudy Vsesoyuznyy Nauchno-Issledovatel'skiy Geologorazvedochnyy Neftyanoy Institut (VNIGNI), no. 23, p. 212, pl. 4, fig. 2a, b; pl. 5, fig. 1a, b; text fig. 6.
1959. *Arkhangelskiceras horridum* (Arkhangel'skii). Il'in, Trudy Vsesoyuznyy Nauchno-Issledovatel'skiy Geologorazvedochnyy Neftyanoy Institut (VNIGNI), no. 23, p. 213.
1972. *Watinoceras coloradoense* (Henderson). Cobban and Scott, U.S. Geological Survey Professional Paper 645, p. 76, pl. 27, figs. 11-19; pl. 28, figs. 1-3, 5-9; text figs. 36, 37.
1977. *Watinoceras coloradoense* (Henderson). Kauffman, The Mountain Geologist, v. 14, nos. 3-4, pl. 19, figs. 8, 9; pl. 22, figs. 7, 8.
1976 [1978]. *Watinoceras coloradoense* (Henderson). Kauffman, Cobban, and Eicher, Annales du Muséum d'Histoire Naturelle de Nice, v. 4, pl. 5, figs. 7, 8.

1978. *Watinoceras* (*Watinoceras*) *coloradoense* (Henderson). Cooper, Annals of the South African Museum, v. 75, pt. 5, p. 123 (parts), text figs. 31, 32 (part).

1981. *Watinoceras coloradoense coloradoense* (Henderson). Wright and Kennedy, Palaeontographical Society [London] Monograph, v. 134, no. 560, p. 53, text fig. 18 C-F.

1983. *Watinoceras coloradoense* (Henderson). Cobban, U.S. Geological Survey Professional Paper 1253, p. 15, pl. 15, fig. 12.

Types.—Holotype USNM 30877, from the Greenhorn Limestone near Lyons, Colo. Hypotypes USNM 401612-401626, from the Greenhorn Limestone of eastern Colorado.

Diagnosis.—*Watinoceras coloradoense* is large for the genus. Closely spaced ribbing on the inner whorls and sparse ribbing on the outer whorl are diagnostic features. Tubercles are high and conspicuous on the body chamber.

Description.—The holotype is a body chamber of 80 mm diameter enclosing the impression of two septate whorls (Henderson, 1908, pl. 13, figs. 10, 11). The umbilicus is fairly wide with a ratio to the shell diameter of 0.38. The intercostal section of the body chamber is ovate with broadly rounded flanks grading uniformly into the well-rounded umbilical shoulder and narrowly rounded venter. Greatest width is at the lower part of the flank. Ornament on the body chamber consists of 11 narrow, prorsiradiate ribs per half whorl most of which bear umbilical and inner and outer ventrolateral tubercles. Umbilical tubercles are bullate and located on the shoulder. Inner ventrolateral tubercles are nodate and pointed, and outer ones are larger, higher, and clavate. Ribs bend forward a little at the position of the inner ventrolateral tubercles and, after rising into the outer tubercles, cross the narrow venter as broad swellings. The impression of parts of two inner whorls in the umbilical area reveal more closely spaced ribbing than that on the body chamber. Ribs on the innermost of these whorls are narrow, prorsiradiate, and mostly of equal length; they number 15 in half a whorl at a diameter of about 22 mm. Only a small part of the next whorl is indicated by an impression; its ribbing is also prorsiradiate but sparser.

Watinoceras coloradoense is present in a single bed of limestone in the upper part of the Greenhorn Limestone at many localities from central Kansas to the Front Range in Colorado. The largest collection studied consists of 23 specimens from just below the middle of the Bridge Creek Member at USGS Mesozoic locality D3977 on the Rock Canyon Anticline just west of Pueblo, Colo. (Cobban and Scott, 1972, p. 23, bed 97). Umbilical ratios and number of ribs per half whorl were shown by Cobban and Scott (1972, fig. 35) for these specimens and for others from the same bed at other localities on the Rock Canyon Anticline. Umbilical ratios range from 30 to 43 percent without any apparent change with growth. Rib density decreases with growth on the smaller specimens, and then gradually increases on the larger specimens. Most specimens 10–30 mm in diameter have 17–20 ribs per half whorl; specimens 40–50 mm in diameter have 13–17 ribs per half whorl; those with diameters of 50–60 mm have 10–13 ribs per half whorl; and specimens 70–116 mm in diameter have 13–17 ribs per half whorl. Ribs on the early whorls are a little flexuous (pl. 2, figs. 2, 6) but, on the larger whorls, ribs are usually straight (pl. 2, figs. 10, 18). The change from dense ribbing to sparse ribbing takes place almost abruptly, usually in the diameter range of 23–28 mm. On the early whorls, ribs are of two lengths. The longer or primary ribs arise from nodate to bullate umbilical tubercles on the umbilical shoulder, and the shorter or secondary ribs arise on the lower part of the flank (pl. 2, figs. 1, 10). There are 1 or 2 secondaries for each primary. All ribs on the early whorls bear nodate to clavate inner ventrolateral tubercles and terminate in clavate outer ventrolateral tubercles that bound a narrow flattened venter. All tubercles are equal sized on the early whorls but, on the later whorls, the outer ventrolateral tubercles become noticably larger than the inner ones and form short spines (pl. 2, fig. 13).

The adult body chamber has a different ornament than that of the inner whorls. Secondary ribs become weak and infrequent or they may disappear on the older part of the body chamber. Umbilical and ventrolateral tubercles remain prominent almost to the aperture. Near the aperture, secondary ribs arise again, and tubercles greatly diminish in size (Cobban and Scott, 1972, pl. 27, figs. 17–19; pl. 28, figs. 3, 7, 9). The aperture is normal.

The species is dimorphic. Adults range in diameter from 60 mm or less to around 115 mm (Cobban and Scott, 1972, pl. 28, figs. 7, 9). Occasional individuals attained an adult size between 30–40 mm (pl. 2, fig. 7).

Most adults resemble the holotype in form and ornament. A few individuals are more compressed and more densely ribbed (pl. 2, fig. 13) or more robust and more coarsely ornamented (pl. 2, figs. 14–17).

Sutures are rarely preserved on the specimens from the Greenhorn Limestone, and no complete suture is known. Most of an external suture figured by Cobban and Scott (1972, fig. 37) is reproduced here (fig. 4).

Occurrence.—The holotype came from "* * * 10 miles north of Boulder in one of the limestone bands of the upper Fort Benton shales" (Henderson, 1908, p. 260). The locality is in Lykins Gulch north of the center of sec. 7, T. 2 N., R. 70 W., Boulder County, Colo. (fig. 2, loc. D12176). Here, a bed of limestone in the Bridge Creek Member of the Greenhorn Limestone contains *W. coloradoense* associated with *Vascoceras* (*Greenhornoceras*) *birchbyi* Cobban and Scott and *Mytiloides* cf. *M. columbianus* (Heinz). This bed of limestone persists northward beyond Fort Collins, Colo., where it also contains these fossils. The bed persists southward from Lykins Gulch

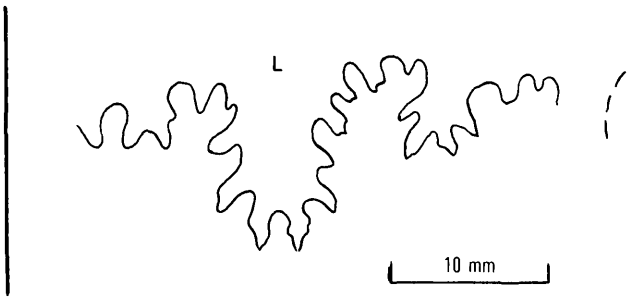

Figure 4. Most of the last external suture of *Watinoceras coloradoense* (Henderson) at a diameter of about 70 mm, from the Bridge Creek Member of the Greenhorn Limestone at USGS Mesozoic locality 15729 (text fig. 1). From Cobban and Scott (1972, fig. 37).

past Denver and Colorado Springs to the Rock Canyon anticline just west of Pueblo, Colo., where it is bed 97 of the measured section of the Bridge Creek Member (Cobban and Scott, 1972, p. 23). Here, the bed contains *W. coloradoense, W. devonense flexuosum* Cobban, n. subsp., *W. reesidei* Warren, *Pseudaspidoceras flexuosum* Powell, *Fagesia catinus* (Mantell), *Vascoceras* (*Greenhornoceras*) *birchbyi* Cobban and Scott, *Neoptychites cephalotus* (Courtiller), *Puebloites spiralis* Cobban and Scott, and *Mytiloides* cf. *M. columbianus*. The bed persists eastward down the Arkansas River valley to southwestern Kansas (fig. 1, loc. D4876), where *W. coloradoense* occurs with some of the same fossils (Cobban and Scott, 1972, p. 21, bed 40). The bed also extends southward across the Raton basin of northeastern New Mexico, where *W. coloradoense* occurs with *V.* (*Greenhornoceras*) *birchbyi* and *M.* cf. *M. columbianus*. An additional ammonite, *Kamerunoceras puebloense* (Cobban and Scott), was found with *W. coloradoense* on the south side of the Raton basin (fig. 1, loc. D12527).

Outside the United States, specimens assigned to *W. coloradoense* have been recorded from the Kaskapau Formation in the Smoky River-Peace River area of western Alberta (Gleddie, 1949, p. 529) and northeastern British Colombia (Stott, 1967, table 2). In addition, the species has been recorded from Brazil (Bengtson, 1983, p. 45) and described from Turkestan under the name of *Acanthoceras amudariense* var. *horridum* Arkhangelsk'ii (1916, p. 49).

Watinoceras thompsonense Cobban, n. sp.
Plate 3, figures 1–3, 6–8

Types.—Holotype USNM 401627 and paratype USNM 401628, from the Greenhorn Limestone on Thompson Arroyo, near La Junta, Otero County, Colo.

Diagnosis.—This peculiar species attains a large size and has paired ribs and constrictions on the penultimate whorl.

Description.—The holotype (pl. 3, figs. 6–8) is an internal mold of nearly half a whorl of body chamber that encloses in its umbilical area an impression of the penultimate whorl and part of the next inner whorl. The complete shell probably had a diameter of at least 130 mm, an umbilicus of 55 mm, and an umbilical ratio of 0.42. The preserved part of the body chamber is uncrushed and has an ovate whorl section higher than wide with the greatest width at the umbilical shoulder. Flanks are broadly rounded and grade evenly into the more narrowly rounded umbilical and ventrolateral shoulders. The umbilical wall is steep but sloping, and the venter is narrow and narrowly rounded. Ornament on the body chamber consists of narrow, bar-like, prorsiradiate, slightly flexuous, tuberculate ribs separated by much broader interspaces. Each rib arises from an umbilical bulla and supports a nodate inner ventrolateral tubercle and a larger and higher clavate outer one. Ribs cross the venter transversely and number about 17 per half whorl. A faint, nontuberculate rib lies in the interspaces between a few of the ribs. The aperture is not preserved. The impression of the penultimate whorl reveals an ornament of paired ribs generally separated by wide, smooth interspaces (pl. 3, fig. 6). Five of these pairs occur in half a whorl. A constriction separates the ribs of a pair. All ribs are narrow, straight, and prorsiradiate. Some ribs arise from nodate umbilical tubercles, and all ribs have inner ventrolateral tubercles. An impression of a small part of the next inner whorl reveals closely spaced ribbing like that on the inner whorls of *Watinoceras coloradoense*. The suture is unknown.

Remarks.—*Watinoceras thompsonense* differs from *W. coloradoense* in having nearly equal-sized ventrolateral tubercles on the body chamber and paired ribs and constrictions on the penultimate whorl. The ornament on that whorl is much like that on *Schindewolfites inaequicostatus* Wiedmann (1964, p. 125, text figs. 5a, b) from the lower Turonian of Spain. A specimen from the *Watinoceras* bed at Pueblo, Colo. (Cobban and Scott, 1972, p. 23, bed 97) loaned to me by J. I. Kirkland, University of Colorado, Boulder, is unusual in that it has weak, nodate siphonal tubercles on the younger part of the body chamber. The specimen consists of nearly half a whorl of an adult body chamber that has a diameter of about 117 mm. Parts of two inner whorls are attached.

Occurrence.—The types are from the Bridge Creek Member of the Greenhorn Limestone at USGS Mesozoic localities D12624 and D11225 along Thompson Arroyo east of La Junta, presumably in the NE¼sec. 5, T. 24 S., R. 54 W., Otero County, Colo. (fig. 1). Specimens of *Mytiloides columbianus* (Heinz) occur with the types. The types are probably from the same bed of limestone as bed 97 of the section of Greenhorn Limestone at Pueblo, Colo. (Cobban and Scott, 1972, p. 23).

Watinoceras devonense devonense Wright and Kennedy

1978. *Watinoceras* (*Watinoceras*) *coloradoense* (Henderson). Cooper, Annals of the South African Museum, v. 75, pt. 5, p. 123 (part), text figs. 18C, D, 32 (part), 33.
1981. *Watinoceras devonense* Wright and Kennedy, Palaeontographical Society [London] Monograph, v. 134, no. 560, p. 52, pl. 10, figs. 7, 10, 12, 13, 16.

Description.—Wright and Kennedy (1981, p. 52) distinguished this species chiefly by its high, compressed whorls and long, bar-like, straight, narrow ribs. Primary ribs begin from weak umbilical bullae, and secondary ribs arise low on the flank or as high as on the ventrolateral shoulder. Ribs number about 50 to a whorl. Inner and outer ventrolateral tubercles are small and nearly equal sized.

The holotype (Wright and Kennedy, 1981, pl. 10, fig. 7a–c) consists of just less than half a whorl, presumably part of a body chamber. The full half whorl probably had a diameter of about 36 mm with an umbilical ratio of approximately 0.27. Ribs number about 26 in half a whorl. Wright and Kennedy also figured several smaller paratypes, which are fragments of whorls.

Occurrence.—The types are from the base of the lower Turonian Middle Chalk of Devon, England. Other ammonites from this stratigraphic level in Devon include *Watinoceras amudariense* (Arkhangel'skii), *W. depressum* Wright and Kennedy, *W. coloradoense praecursor* Wright and Kennedy, *W.* cf. *jaekeli* (Solger), and *Mammites* cf. *nodosoides* (Schlüter) (Wright and Kennedy, 1981, p. 120).

Watinoceras devonense flexuosum Cobban, n. subsp.
Plate 1, figures 27–40; text figure 5

1972. *Watinoceras reesidei* Warren? Cobban and Scott, U.S. Geological Survey Professional Paper 645, p. 75, pl. 27, figs. 7–10.
1978. *Watinoceras* (*Watinoceras*) *coloradoense* (Henderson). Cooper, Annals of the South African Museum, v. 75, pt. 5, p. 123 (part).
1981. *Watinoceras devonense* Wright and Kennedy, Palaeontographical Society [London] Monograph, v. 134, no. 560, p. 52 (part).

Types.—Holotype USNM 401601, from the Tropic Shale in Garfield County, Utah. Paratypes USNM 401602–401606, from the Greenhorn Limestone near Pueblo, Colo.; UA 7567, from the Kaskapau Formation in northeastern British Columbia, Canada.

Diagnosis.—This small, moderately evolute species has flattened flanks, narrow, flattened venter, and numerous flexuous ribs. Ventrolateral tubercles are small and inconspicuous.

Description.—Although Wright and Kennedy (1981, p. 52) stressed the compressed whorl section of their *Watinoceras devonense*, the English specimens are much stouter than closely related American forms. Specimens from the Greenhorn Limestone near Pueblo, Colo., and from the Tropic Shale of southern Utah resemble *W. devonense* in their rib density and general appearance, but the American specimens are more compressed and have more flexuous ribs; the specimens are treated herein as a new subspecies.

The holotype (pl. 1, figs. 36–38) is most of an adult 30.2 mm in diameter with an umbilical width of 9.9 mm and an umbilical ratio of 0.33. The specimen is uncrushed and retains much of its shell material. A quarter of a whorl of body chamber is preserved; diameter at its base is 25 mm. Whorls are much higher than wide with flattened flanks, narrowly rounded umbilical shoulder, well-rounded ventrolateral shoulder, and narrow, flat venter. Primary and secondary ribs are numerous, prorsiradiate, and flexuous. Primary ribs arise singularly or in pairs from umbilical bullae. One or two secondary ribs arise low on the flank between each pair of primaries. All ribs bend forward at the ventrolateral shoulder, where they bear small bullate inner ventrolateral tubercles. The ribs then trend at an angle to the edge of the narrow, flat venter, where they terminate in nodate outer ventrolateral tubercles that are a little larger than the inner ones. There are 69 ribs on the last complete whorl. The last 6 ribs are less prominent. Only part of the suture is visible (fig. 5). It is little incised, and is characterized by its long, narrow lateral lobe and broad, bifid saddles.

Most of the paratypes from the Greenhorn Limestone near Pueblo, Colo., have fewer and coarser ribs than the holotype. Some specimens resemble the holotype in that the final ribs become lower and numerous (pl. 1, fig. 29). A paratype from British Columbia, Canada, also shows these features (pl. 1, fig. 35).

Remarks.—The innermost whorls of the holotype are densely ribbed, but rib counts cannot be made owing to the overlap of the later whorls. A collection from a

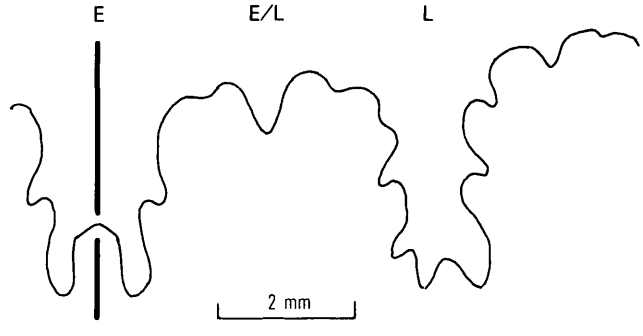

Figure 5. Part of the last external suture of *Watinoceras devonense flexuosum* Cobban, n. subsp., at a diameter of 25 mm, from the Tropic Shale near Henrieville, Garfield County, Utah. Holotype USNM 401601 (pl. 1, figs. 36–38).

very fine grained, calcareous bed of sandstone in the Rio Salado Tongue of the Mancos Shale near Springerville in eastern Arizona made by J. I. Kirkland (University of Colorado, Boulder) consists of many small, densely ribbed specimens that probably represent *W. devonense flexuosum*. Six specimens, 8.3–13.0 m in diameter, have 30–37 narrow, flexuous ribs per half whorl.

Occurrence.—The holotype was purchased by the late James P. Conlin of Fort Worth, Tex., from a dealer in minerals and fossils who resided in Henrieville, Utah. The specimen came from a limestone concretion in the Tropic Shale in Garfield County, Utah. Other fossils from this concretion include small ammonites that resemble the internal whorls of the form figured as *Fagesia haarmanni* Böse by Powell (1963, p. 320, pl. 33, fig. 2; pl. 34, figs. 1–5; text figs. 2 h-k) and later assigned to *F. catinus* (Mantell) by Wright and Kennedy (1981, p. 88).

The paratypes from the Pueblo area of southeastern Colorado came from a bed of limestone near the base of the middle third of the Bridge Creek Member (bed 97 of Cobban and Scott, 1972, p. 23). Two specimens from this bed were figured as *Watinoceras reesidei* Warren? by Cobban and Scott (1972, p. 75, pl. 27, figs. 7–10).

Watinoceras hattini Cobban, n. sp.
Plate 4

1975. *Watinoceras reesidei* Warren. Hattin, Kansas Geological Survey Bulletin 209, pl. 8, fig. J; pl. 9, fig. F.
1975. *Watinoceras* sp. Simpson, Geological Association of Canada Special Paper 13, pl. 6, fig. 6.
1977. *Watinoceras reesidei* Warren. Hattin, The Mountain Geologist, v. 14, nos. 3-4, fig. 6 (4).
1978. *Watinoceras reesidei* Warren. Hattin, American Association of Petroleum Geologists Guidebook Series 3, Upper Cretaceous stratigraphy and depositional environments of western Kansas, fig. 7 (4).
1982. *Watinoceras* sp. Simpson, Saskatchewan Geological Survey Report 150, pl. 19, fig. 1.

Types.—Holotype USNM 401629 (pl. 4, figs. 6, 9). Paratypes USNM 401630–401633, KUMIP 219870–219874. The holotype is from the lower part of the Jetmore Chalk Member of the Greenhorn Limestone at USGS Mesozoic locality D11643 in the SE¼sec. 3, T. 7 S., R. 9 W., Mitchell County, Kans. (fig. 1). Paratypes are from a bed of limestone at the top of the lower third of the Jetmore Chalk Member in Kansas (marker bed JT-6 of Hattin, 1975, p. 34).

Name.—After D. L. Hattin, for his extensive investigations on the stratigraphy and depositional environments of the Greenhorn Limestone.

Diagnosis.—This large evolute species has densely ribbed inner whorls and a more coarsely ribbed body chamber.

Description.—The holotype (pl. 4, figs. 6, 9) is a crushed internal mold of an adult 91 mm in diameter that has an umbilical width of 44.5 mm and an umbilical ratio of 0.49. The specimen consists of the outer whorl enclosing an impression of a small part of the penultimate whorl. About two-thirds of the outer whorl is body chamber. Although crushed, the specimen appears to have had compressed whorls with narrow, flattened venter; broadly rounded flanks; narrowly rounded ventrolateral shoulder; and steep umbilical wall. Ornament on the outer whorl consists of 41 narrow, fairly straight, prorsiradiate primary and secondary ribs that have faint, nodate to bullate inner ventrolateral tubercles and much stronger and higher, nodate to clavate outer ventrolateral tubercles. Nearly every other rib is primary and arises from an umbilical bulla located on the umbilical shoulder. Secondary ribs arise low on the flank. Ribs on the penultimate whorl are narrow, prorsiradiate, and more closely spaced than those on the outer whorl. The aperture is not preserved, and the septa are mostly destroyed.

The smaller whorls are visible on several paratypes from the Jetmore Member (pl. 4, figs. 1–4). Ribs are numerous, usually prorsiradiate, and straight to slightly flexuous; they number 19–29 per half whorl at diameters from 10–36 mm and become sparser at larger diameters (fig. 6). Tubercles are small, inconspicuous, and mostly nodate. Only bits of sutures are preserved.

The species attained diameters as much as those of large specimens of *W. coloradoense*. A crushed fragment of a body chamber (unfigured paratype USNM 401633) that was associated with the holotype has a whorl height of 43 mm, which suggests a total shell diameter of about 140 mm.

Remarks.—The inner whorls of *Watinoceras hattini* are more densely ribbed than most comparably sized specimens of *W. reesidei*. The larger size and more evolute shell distinguish *W. hattini* from *W. devonense* Wright and Kennedy and the new subspecies *W. devonense flexuosum*. An unusually large specimen from British Columbia illustrated by Jeletzky (1970, pl. 26, fig. 4a, b) as *Watinoceras* cf. *coloradoense* (Henderson) is as evolute as *W. hattini*, but is more robust and more sparsely ribbed.

Occurrence.—*Watinoceras hattini* is most abundant in a single bed of limestone at the top of the lower third of the Jetmore Member of the Greenhorn Limestone of central Kansas. This bed, designated marker bed JT-6 by Hattin (1975, p. 34), has abundant *Mytiloides* but few other fossils. Flattened specimens of *Baculites yokoyamai* Tokunaga and Shimizu are the only other ammonites in the U.S. Geological Survey collections from this bed in Kansas. Bed JT-6 persists westward from Kansas to the Front Range area of Colorado. At Pueblo, this bed, number 105 of the Greenhorn sequence (Cobban and Scott, 1972, p. 23), contains a varied ammonite fauna

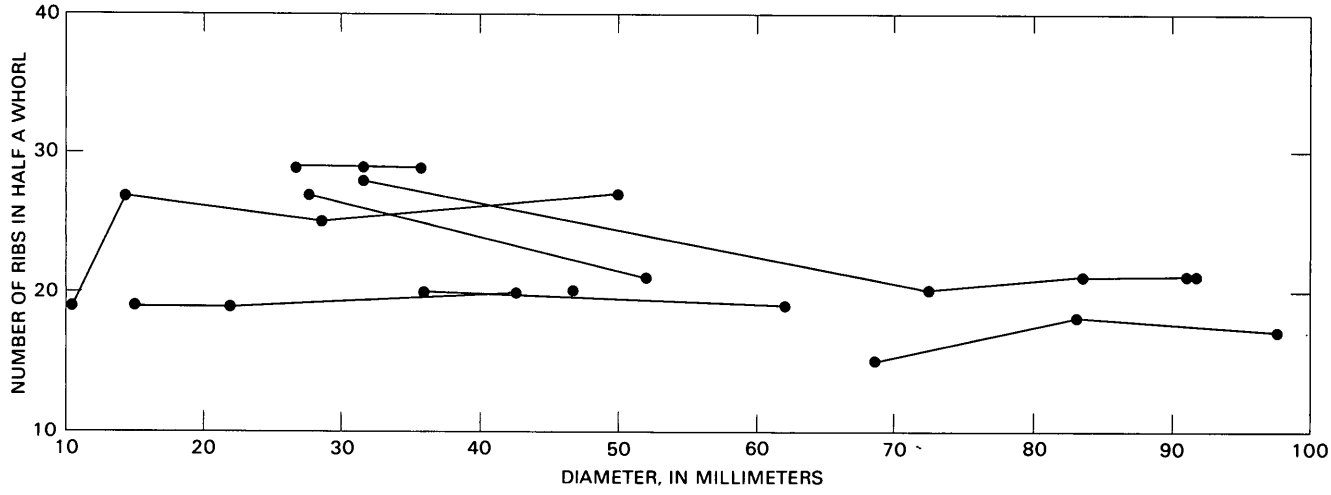

Figure 6. Scatter diagram showing number of ribs per half whorl of the specimens of *Watinoceras hattini*, n. sp., shown on plate 4. Lines connect measurements on single specimens.

but no *Watinoceras*. Ammonites in this bed at Pueblo (Cobban, 1985, p. 137) are *Tragodesmoceras bassi* Morrow, *Kamerunoceras puebloense* (Cobban and Scott), *Morrowites wingi* (Morrow), *Paravascoceras* aff. *P. hartti* (Hyatt), *Fagesia* sp., *Choffaticeras pavillieri* (Pervinquiere), *Neoptychites cephalotus* (Courtiller), *Baculites yokoyamai* Tokunaga and Shimizu, and *Puebloites greenhornensis* Cobban and Scott.

Watinoceras hattini occurs as flattened impressions in the Cone Member of the Marias River Shale along the southeastern boundary of Glacier National Park in northwestern Montana. Some of these specimens were assigned to *W. reesidei* (Cobban, 1956, p. 1003). Some of the records of *W. reesidei* farther north in the Canadian Foothills may be *W. hattini*. A core from a boring in west-central Saskatchewan revealed the presence of *W. hattini* in the northern Great Plains (Simpson, 1975, pl. 6, fig. 6; 1982, pl. 19, fig. 1).

Watinoceras cobbani Collignon
Plate 1, figures 41–45

1966. *Watinoceras cobbani* Collignon, Morocco Service Géologique, Notes et Mémoires 175, p. 36, pl. 19, figs. 8, 8a, b.
1979. *Watinoceras cobbani* Collignon. Cobban and Hook, New Mexico Bureau of Mines and Mineral Resources Memoir 37, p. 17, pl. 5, figs. 1-8; text figs. 7, 8.
1981. *Watinoceras coloradoense coloradoense* Wright and Kennedy, Palaeontographical Society [London] Monograph (Publication Number 560, part of v. 134 for 1980), p. 53.

Types.—The holotype is from Morocco. Hypotypes USNM 252817-252820 are from the Rio Salado Tongue of the Mancos Shale of west-central New Mexico.

Diagnosis.—This small, robust species has smooth inner whorls and a strongly ornamented outer whorl.

Description.—The holotype, from the lower Turonian of Morocco, has a diameter of 23 mm, an umbilical width of 6 mm, and an umbilical ratio of 0.26 according to Collignon (1966, p. 36). Cobban and Hook (1979, p. 17) pointed out that the umbilical ratio appears to be closer to 0.31 as measured from Collignon's illustration. The smooth inner whorls have a rounded section, but the outer whorl has a squarish section with flattened flanks and a fairly broad, flattened venter. Ribs arise almost abruptly at the base of the last two-thirds of the outer whorl. These ribs, which number 16 or 17 per half whorl, are strong and rectiradiate on the flank. Longer (primary) ribs begin from conspicuous bullate umbilical tubercles, and shorter (secondary) ribs arise low on the flank. Primary ribs, and some of the secondaries, rise into strong, pointed, inner ventrolateral tubercles at the ventrolateral shoulder. From there, the ribs bend forward and cross the venter as chevrons. Most ribs bear small outer ventrolateral tubercles.

Cobban and Hook (1979, p. 17) described several examples of this species from New Mexico. Most are fragments of specimens that were about the size of the holotype. A nearly complete individual has a diameter of 27.7 mm and an umbilical ratio of 0.36 (Cobban and Hook, 1979, p. 17, pl. 5, figs. 1-3). Ribs number 20 in half a whorl.

Remarks.—Wright and Kennedy (1981, p. 53) regarded the specimens from New Mexico as *W. coloradoense coloradoense* (Henderson). They are quite different from *W. cobbani*. *Watinoceras coloradoense* is

much larger and has ornamented inner whorls. In addition, the venter of *W. coloradoense* is either smooth or crossed by broad fold-like ribs instead of the narrow ribs of *W. cobbani*.

Occurrence.—The holotype is from the "Niveau à *Watinoceras*" assigned to the upper part of the middle Turonian of the Tarfaya Basin of Morocco (Collignon, 1966, p. 67). In the Western Interior of the United States, the species is known from only one locality in west-central New Mexico (fig. 1, loc. D10298). Here, the species occurs in septarian limestone concretions in the upper part of the Rio Salado Tongue of the Mancos Shale associated with *Tragodesmoceras socorroense* Cobban and Hook, *Morrowites depressus* (Powell), and *Collignoniceras woollgari woollgari* (Mantell) of middle Turonian age.

Watinoceras cf. W. praecursor Wright and Kennedy
Plate 1, figures 50–55

cf. 1981. *Watinoceras coloradoense praecursor* Wright and Kennedy, Palaeontographical Society [London] Monograph, v. 134, no. 560, p. 53; pl. 10, figs. 4, 8, 9, 11, 15, 17, 18; text fig. 19 G, H.

Types.—Holotype IGS Zn9152, from the Middle Chalk of Devon, England. Figured specimens USNM 401608-401611.

Description.—Many poorly preserved, crushed fragments of ammonites from a bed of limestone in the Greenhorn Limestone near Pueblo, Colo., resemble *Watinoceras praecursor* Wright and Kennedy in their sparse ribbing and conspicuous ventrolateral tubercles. The largest specimens have diameters of 48–52 mm and umbilical ratios of 0.32–0.36. Ribs are prorsiradiate and number 13–14 per half whorl. Inner ventrolateral tubercles are nodate (pl. 1, fig. 55), and outer ones are either nodate (pl. 1, fig. 51) or clavate (pl. 1, figs. 52, 53).

Remarks.—The Greenhorn specimens may well be *W. praecursor*, but their crushed condition prevents definite specific assignment. None of the illustrated English specimens has outer ventrolateral tubercles as clavate as those on one of the Greenhorn specimens (pl. 1, figs. 52–54).

Occurrence.—The figured specimens are from a bed of limestone in the lower part of the Bridge Creek Member of the Greenhorn Limestone near Pueblo, Colo. (bed 86 of Cobban and Scott, 1972, p. 23). Other ammonites from this bed are *Kamerunoceras* sp., *Nigericeras*? sp., *Baculites* sp., and *Puebloites* sp. (Cobban, 1985, fig. 1).

Watinoceras? n. sp.

The bed of limestone in the Bridge Creek Member of the Greenhorn Limestone near Pueblo, Colo. (Cobban and Scott, 1972, p. 23, bed 86) that contains *Watinoceras* cf. *W. praecursor* Wright and Kennedy also contains crushed fragments of an undescribed species that has weak siphonal clavi. In this respect the specimens seem to be transitional from *Neocardioceras* which has conspicuous nodate to clavate siphonal tubercles. To which genus the specimens belong must await better material.

Watinoceras sp.
Plate 1, figures 46–49

Type.—Figured specimen USNM 401607, from the Tropic Shale of southern Utah.

Description.—Associated with the holotype of *Watinoceras devonense flexuosum* is part of a small nonseptate whorl that differs from *W. devonense flexuosum* in having nearly smooth flanks. The specimen has a compressed whorl section with flattened flanks and narrow, flat venter. Ornament consists of widely spaced, strong umbilical bullae; barely visible flexuous striae on the flanks; and small, sharp, outer ventrolateral clavi.

Remarks.—The specimen could be a juvenile of some species that has smooth or nearly smooth inner whorls. *Watinoceras guentherti* Reyment (1957, p. 57, pl. 9, fig. 6a–c) and *W. hesslandi* Reyment (1957, p. 58, pl. 11, fig. 4a–c), from the lower Turonian of West Africa (Cameroon), have compressed inner whorls that appear smooth. Ventrolateral tubercles are absent on these early whorls. Collignon (1966, p. 36, 37) described several species of *Watinoceras* (*W. cobbani, W. inerme, W. semicostatum*) from the lower Turonian of Morocco that have smooth inner whorls, but that lack ventrolateral tubercles.

Occurrence.—Same as that of the holotype of *Watinoceras devonense flexuosum* Cobban, n. subsp. (fig. 1, loc. D12623).

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PLATES 1–4

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PLATE 1

[All figures natural size except as indicated. Arrows mark base of body chambers]

FIGURES 1–26. *Watinoceras reesidei* Warren (p. 5).

1, 2. Hypotype UA 7558, from 15 m (50 ft) above base of Kaskapau Formation near Watino, Alberta, Canada, in the SW¼ sec. 21, T. 77, R. 24, W. 5th Mer.

3. Hypotype UA 7559, from the same locality.

4, 5. Hypotype UA 7560, from the same locality.

6, 7. Hypotype UA 7561, from the same locality.

8. Hypotype UA 7562, from the same locality.

9. Hypotype UA 7563, from the same locality.

10. Hypotype UA 7564, from the same locality.

11. Hypotype UA 7565, from the same locality.

12–14. Hypotype USNM 401596, from the Seabee Formation at USGS Mesozoic locality 20420 on Maybe Creek on the North Slope of Alaska, lat 69°16′ N., long 153°47′ W.

15–18. Hypotype UA 7566, from the same locality as UA7558 (figs. 1, 2).

19, 20. Hypotype USNM 401597, from the Greenhorn Limestone at USGS Mesozoic locality D3977 (text fig. 1).

21, 22. Hypotype USNM 401598, from the same locality.

23, 24. Hypotype USNM 401599, from the Greenhorn Limestone at USGS Mesozoic locality D6491 (text fig. 1).

25, 26. Hypotype USNM 401600, from the Greenhorn Limestone at USGS Mesozoic locality D6147 (text fig. 1).

27–40. *Watinoceras devonense flexuosum* Cobban, n. subsp. (p. 10).

27, 28. Paratype USNM 401602, from the Greenhorn Limestone at USGS Mesozoic locality D3977 (text fig. 1).

29, 30. Paratype USNM 401603, from the Greenhorn Limestone at USGS Mesozoic locality D6478 (text fig. 1).

31, 32. Paratype USNM 401604, from the same locality.

33, 34. Paratype USNM 401605, from the Greenhorn Limestone at USGS Mesozoic locality D6147 (text fig. 1).

35. Paratype UA 7567, from the Kaskapau Shale on Dawson Creek in northeastern British Columbia.

36–38. Holotype USNM 401601, from the Tropic Shale at USGS Mesozoic locality D12623 (text fig. 1).

39, 40. Paratype USNM 401606, from the same locality as USNM 401602 (figs. 27, 28).

41–45. *Watinoceras cobbani* Collignon (p. 12).

Hypotypes USNM 252817–252820, from the Rio Salado Tongue of the Mancos Shale at USGS Mesozoic locality D10298 (text fig. 1). From Cobban and Hook (1979).

46–49. *Watinoceras* sp. (p. 13).

Figured specimen USNM 401607, from the same locality as USNM 401601 (figs. 36–38).

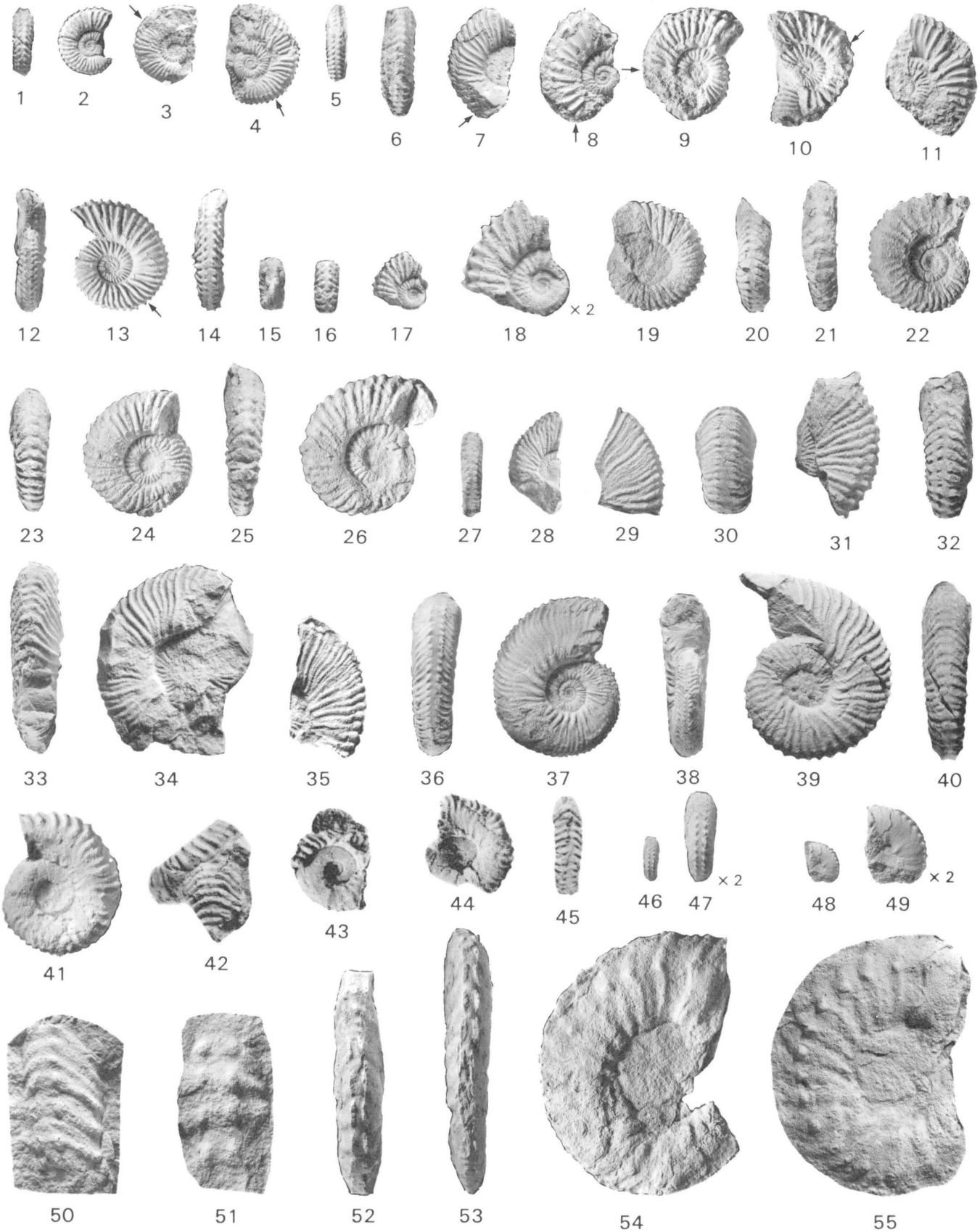
50–55. *Watinoceras* cf. *W. praecursor* Wright and Kennedy (p. 13).

50. Figured specimen USNM 401608, from the Greenhorn Limestone at USGS Mesozoic locality D10176 (text fig. 1).

51. Latex cast of figured specimen USNM 401609, from the Greenhorn Limestone at USGS Mesozoic locality D3975 (text fig. 1).

52–54. Top, rear, and side views of figured specimen USNM 401610, from the Greenhorn Limestone at USGS Mesozoic locality D12460 (text fig. 1).

55. Latex cast of figured specimen USNM 401611, from the same locality.



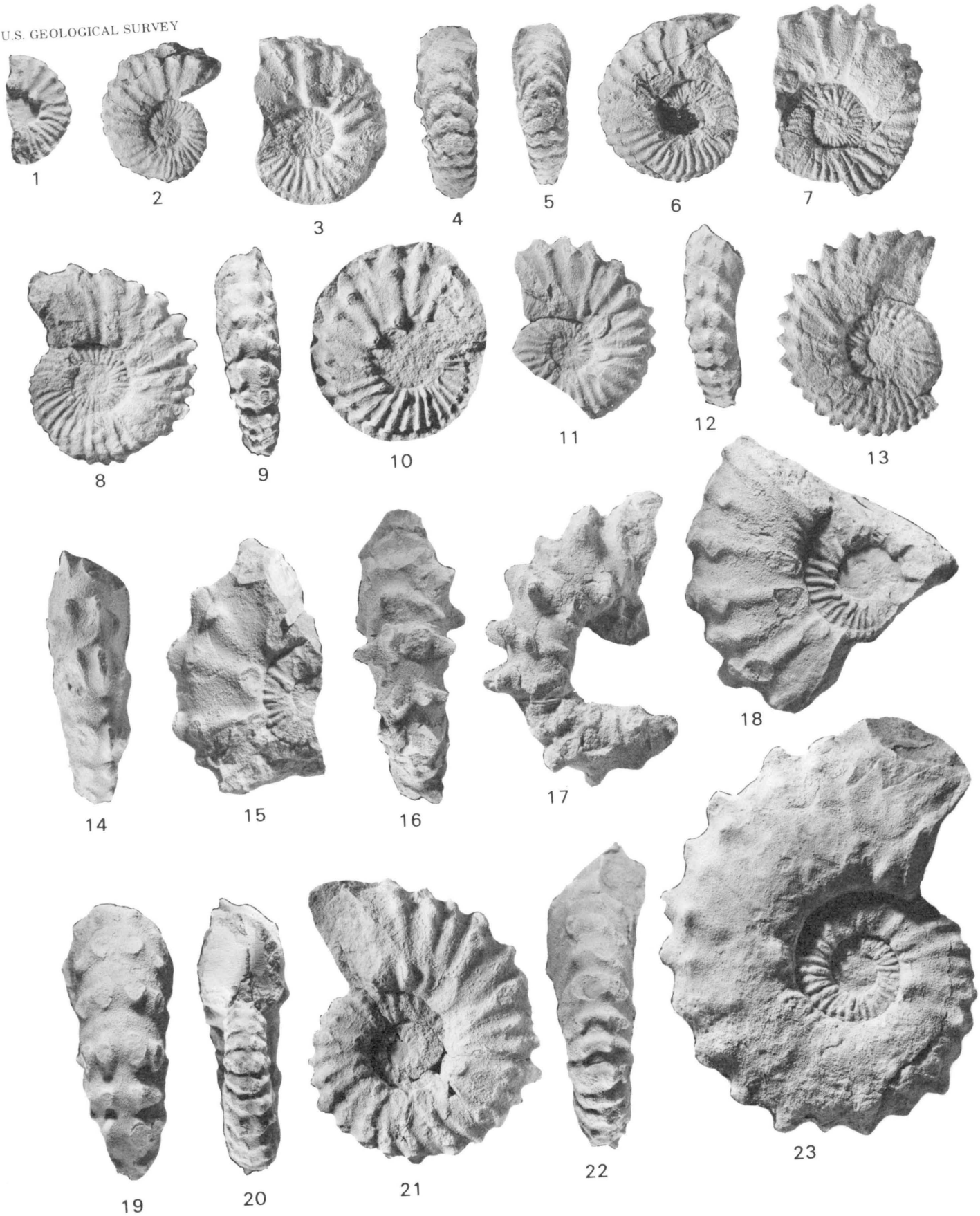
WATINOCERAS

PLATE 2

[All figures natural size]

FIGURES 1–23. *Watinoceras coloradoense* (Henderson) (p. 7).

1. Hypotype USNM 401612, from the Greenhorn Limestone at USGS Mesozoic locality D3977 (text fig. 1).
2. Hypotype USNM 401613, from the same locality.
3, 4. Hypotype USNM 401614, from the Greenhorn Limestone at USGS Mesozoic locality D6491 (text fig. 1).
5, 6. Hypotype USNM 401615, from the same locality as USNM 401612 (fig. 1).
7. Hypotype USNM 401616, from the same locality.
8, 9. Hypotype USNM 401617, from the Greenhorn Limestone at USGS Mesozoic locality 759 (text fig. 1).
10. Latex cast of hypotype USNM 401618, from the same locality.
11, 12. Hypotype USNM 401619, from the Greenhorn Limestone at USGS Mesozoic locality D11225 (text fig. 1).
13. Hypotype USNM 401620, from the same locality as USNM 401612 (fig. 1).
14, 15. Hypotype USNM 401621, from the Greenhorn Limestone at USGS Mesozoic locality D6147 (text fig. 1).
16, 17. Hypotype USNM 401622, from the Greenhorn Limestone at USGS Mesozoic locality D6491 (text fig. 1).
18, 19. Hypotype USNM 401623, from the same locality as USNM 401612 (fig. 1).
20–22. Hypotype USNM 401624, from the Greenhorn Limestone at USGS Mesozoic locality D6725 (text fig. 1).
23. Hypotype USNM 401625, from the Greenhorn Limestone at USGS Mesozoic locality D12114 (text fig. 1).



WATINOCERAS

PLATE 3

[All figures natural size]

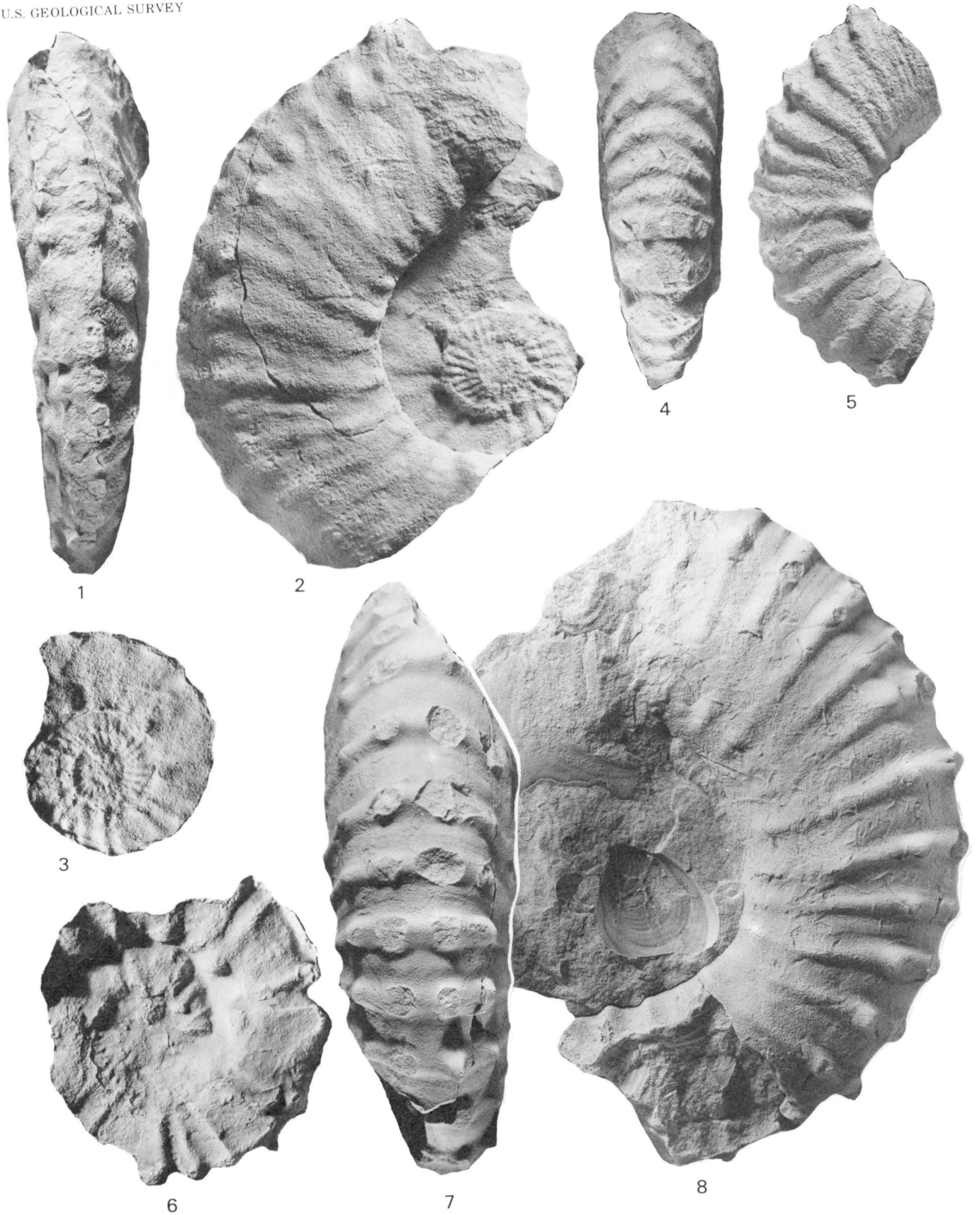
FIGURES 1–3, 6–8. *Watinoceras thompsonense* Cobban, n. sp. (p. 9).

1–3. Paratype USNM 401628, from the Greenhorn Limestone at USGS Mesozoic locality D11225 (text fig. 1). Figure 3 is latex cast of inner whorls.

6–8. Holotype USNM 401627, from the Greenhorn Limestone at USGS Mesozoic locality D12624 (text fig. 1). Figure 6 is latex cast of inner whorls on opposite side of figure 8.

4, 5. *Watinoceras coloradoense* (Henderson) (p. 7).

Hypotype USNM 401626, from the Greenhorn Limestone at USGS Mesozoic locality D6147 (text fig. 1).



WATINOCERAS

PLATE 4

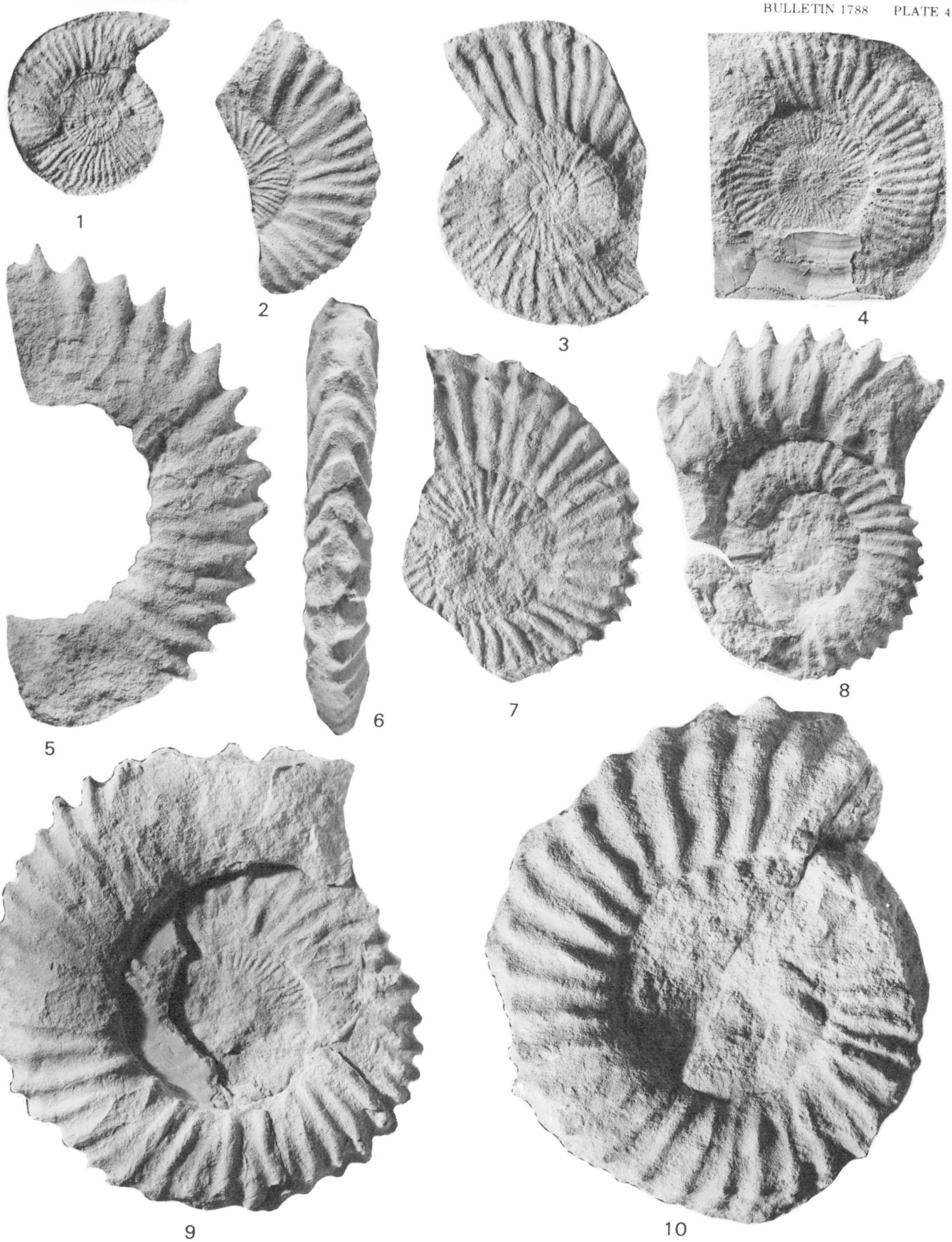
[All figures natural size]

FIGURES 1–10. *Watinoceras hattini* Cobban, n. sp. (p. 11).

1. Paratype KUMIP 219873, from marker bed JT–6 in the Jetmore Member of the Greenhorn Limestone, in the NW¼ sec. 7, T. 12 S., R. 9 W., Lincoln County, Kans.
2. Latex cast of paratype USNM 401630, from the Jetmore Member of the Greenhorn Limestone at USGS Mesozoic locality D1835 (text fig. 1).
3. Paratype KUMIP 219874, from marker bed JT–6 in the Jetmore Member of the Greenhorn Limestone, in the SW¼ sec. 4, T. 3 S., R. 1 W., Republic County, Kans.
4. Latex cast of paratype KUMIP 219871, from marker bed JT–6 in the Jetmore Member of the Greenhorn Limestone, at the same locality as KUMIP 219873 (fig. 1).
5. Paratype USNM 401631, from the Jetmore Member of the Greenhorn Limestone, at the same locality as USNM 401630 (fig. 2).

6, 9. Holotype USNM 401629, from the Jetmore Member of the Greenhorn Limestone, at USGS Mesozoic locality D11643 (text fig. 1).

7. Latex cast of paratype USNM 401632, from the Jetmore Member of the Greenhorn Limestone, at USGS Mesozoic locality D10400 (text fig. 1).
8. Paratype KUMIP 219872, from marker bed JT–6 in the Jetmore Member of the Greenhorn Limestone, in the SW¼ sec. 24, T. 22 S., R. 22 W., Hodgeman County, Kans.
10. Paratype KUMIP 219870, from marker bed JT–6 in the Jetmore Member of the Greenhorn Limestone, in the SW¼ sec. 8, T. 3 S., R. 1 E., Washington County, Kans.



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