NOTES ON CYCLOCERAS AND ASSOCIATED GENERA.

CAREY CRONEIS.

It is evident to anyone who has attempted to identify annulated orthoconic cephalopods, particularly from the Carboniferous, that the genera *Cycoceras* and *Protocycloceras* are poorly defined, hence unscientifically employed. In this paper the present status of these generic terms is indicated and redefinitions are proposed.

In 1844 McCoy[1] erected the genus *Cycloceras* to include "those conical species marked with prominent concentric rings, and having the surface frequently sculptured with transverse scaly laminae, and often decussated; siphuncle dorsal." Although McCoy did not indicate a genotype, there were listed from the Carboniferous of Ireland three species of this genus, *Cycloceras annulare* McCoy, *C. laevigatum* McCoy, and *C.* (*Orthoceras*) *lineolatum* (Phillips). Griffith,[2] in 1860, also used the generic term *Cycloceras* in describing *C. laevigatum,* but in 1878 Bigsby[3] referred the same species to *Orthoceras* and apparently McCoy's genus was little known. Hyatt,[4] however, in 1883, redescribed *Cycloceras* as "transversely striated Paleozoic longicones, which at some stages of growth have annular costae. The young are invariably smooth, that is, marked only by transverse striae of growth, as in *C.* (*Orthoceras*) *agassizi,* sp. Barr., and the annulations are subsequently introduced. It includes group 9 of M. Barrande. Sil., Dev., and Carb."

In other words, *Cycloceras,* as first amended by Hyatt, was identical with the original *Cycloceras* of McCoy. But later, in 1899, Hyatt[5] erected the new genus *Protocycloceras* which he described as: "Annulated orthoceracones and cyrtoceracones without longitudinal ridges. Siphuncle large. Type *P.* (*Orthaceras*) *lamarki* sp. Billings. Ordovician." At the same time he limited *Cycloceras* to those forms with discontinuous longitudinal ridges, and gave their range as Ordovician to Permian.

It is no doubt this citation to which Girty refers in the following discussion of annulated cephalopods from the Wewoka

[1] McCoy, Fos. Carb. Ire., 6, 1844.
[2] Griffith, R., Jour. Geol. Soc. Dub., **9**, 55, 1860.
[3] Bigsby, J. J., Thesaurus devonico-Carboniferous, 343.
[4] Hyatt, A., Proc. Bos. Soc. Nat. Hist. **22**, 275.
[5] Hyatt, A., Eastman-Zittel Textbook of Paleontology. First Ed., 1899.

formation of Oklahoma:[6] "Protocycloceras is described as including annulated orthoceratocones and cyrtoceratocones without longitudinal ridges, by the absence of which it is distinguished from Cycloceras. The siphuncle is large. Protocycloceras has previously been known only from the Ordovician, but Cycloceras is recorded from the Ordovician to the Permian. Partly influenced by the matter of range, I described under Cycloceras a species from the Caney shale of Oklahoma which was without longitudinal costae. But other Carboniferous species besides that from the Caney and those here noted from the Wewoka formation show annulations without longitudinal plications, so that it seems better to place these shells under Protocycloceras, whose range would thus be extended into the Carboniferous and be practically coextensive with that of Cycloceras. Though these shells are probably to be regarded as distinct from Cycloceras, they are as yet imperfectly known and when all the evidence is in they may prove to be distinct from Protocycloceras also."

The apparent difficulties in regard to the range of *Protocycloceras*, mentioned by Girty in the quotation given above, may easily be explained; for when Hyatt redefined *Cycloceras*, and made *Protocycloceras* essentially the same as his earlier *Cycloceras*, he left the range of the latter unchanged. Why this was done cannot be ascertained, as Hyatt's intention to publish suitable generic diagnoses has remained unfulfilled. It is certain, however, that Carboniferous annulated orthoceracones with longitudinal ridges, i.e. the genus *Cycloceras* as defined in the Eastman-Zittel Textbook, are as rare as the genus *Protocycloceras* is common in the same horizons. As a matter of fact, the three original species of *Cycloceras*, previously mentioned, all answer to the present description of *Protocycloceras*, since they are totally devoid of longitudinal ridges. As these shells are from the Carboniferous of Ireland, the genus *Protocycloceras*, as Hyatt defined it, is obviously not confined to the Ordovician.

In reviewing the literature, there has been found no Carboniferous cephalopod which *does* conform to Hyatt's latest description of *Cycloceras*, unless it might possibly be *Cyrtoceras* (*Orthoceras*) *rugosum* (Fleming), which is known from the Carboniferous of Northumberland, and from the Visean.[7]

[6] Girty, G. H., Fauna of the Wewoka Formation: U. S. Geol. Survey Bull., **544**, 236, 1915.

[7] de Koninck, Ann. Foss. Ter. Carb. Belg., 527, 1844.

On the other hand, a number of Carboniferous species possibly are referable to the genus *Protocycloceras*, although that generic term has been little used. Among these there may be mentioned (besides the three Irish species of the original *Cycloceras*) *Orthoceras annuloso-lineatum* de Koninck, *O. dactyliophorum* de Koninck, and *O. anceps* de Koninck, all from the Carboniferous (Visean) of Belgium.[8] None of these forms shows the slightest trace of longitudinal ridges. In addition, Waagen[9] has described from the Carboniferous of India *Orthoceras cyclophorum* and *O. oblique-annulatum* both of which are devoid of longitudinal markings.

Orthoceras randolphense Meek and Worthen is listed by Grabau and Shimer under the genus *Cycloceras,* in spite of the fact that it conforms to their own description of *Protocycloceras.* Moreover, it is the only *Cycloceras* which they list as ranging higher than the Ordovician. *Orthoceras annulo-costatum* Meek and Worthen, which is probably a synonym of the above mentioned name, and *O. chesterensis* Swallow are without longitudinal ridges, as is the *Protocycloceras? rushense?* which Plummer and Moore[10] have recently listed and figured, but not described, from the Wayland division of the Graham formation of Texas.

Snider[11] lists *Cycloceras sequoyahensis* Snider as occurring in both the Fayetteville and Pitkin formations of northeastern Oklahoma; and Girty has described *C. ballianum* from the Caney[12] shale of the same State. Later, however, Girty described generically similar shells from the Wewoka[13] formation of Oklahoma as *Protocycloceras rushense* and *P. rushense* var. *crebricinctum.* His reasons for using the genus *Protocycloceras* rather than *Cycloceras* have been quoted previously in this paper. Finally, there are in the writer's collection of fossils from the Chester series of northern Arkansas at least three new species of cephalopods whose generic characteristics are near those of *Protocycloceras.*

On the other hand, all these forms which have been cited as

[8] de Koninck, Ann. Foss. Ter. Carb. Belg., 518, 1844, and Faune Du Calc. Carb. Belg., II pt., 60, 1880.

[9] Waagen, Palaeontologica Indica. Salt Range Fossils, **1**, 68-69, 1887.

[10] Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian of North-Central Texas: Univ. Tex. Bull., **2132**, pl. 22, 1921.

[11] Snider, L. C., Okla. Geol. Survey, Bull. **24**, 119, 1915.

[12] Girty, G. H., Fauna of the Caney Shale, U. S. Geol. Survey, Bull., **377**, 47, 1909.

[13] Girty, G. H., Fauna of the Wewoka Formation, U. S. Geol. Survey, Bull., **544**, 235-236, 1915.

possibly referable to *Protocycloceras* have small siphuncles, whereas the genus as defined by Hyatt is characterized by large siphuncles. Large is only a relative term, but Hyatt's type, *Orthoceras lamarcki,* has a siphuncle which makes up one third the diameter of the shell, and Ordovician representatives of the genus *Protocycloceras* probably never have a siphuncle whose diameter is less than one fourth the diameter of the conch. In the Carboniferous specimens the diameter of the siphuncle ranges from one tenth to one eighth the total diameter. This rather striking difference serves to lend weight to Girty's suspicion that these annulated Carboniferous cephalopods are probably distinct from both *Protocycloceras* and *Cycloceras.*

Foerste[14] has recently (1924) pointed out the fact that the original description of *Cycloceras* was accompanied by a small figure showing vertical striae or ribs. This figure, however, does not resemble *any* species described by McCoy in his Synopsis of the Carboniferous Fossils of Ireland. For this reason Foerste believes "that McCoy included in his genus *Cycloceras* at least two distinct types of structure" and that Hyatt's first description of *Cycloceras* is "based on the species (of that genus) cited in McCoy's text," whereas Hyatt's later "definition is based on the original description of the genus and the small accompanying figure." The later definition is accepted as the more correct interpretation of the generic term. Thus, according to Foerste, "the forms possessing only transverse striae and no longitudinal markings have no distinct generic designation." For these shells he erects the genus *Perigrammoceras* defined as: "Orthoceracones with transverse annulations and striae, but without vertical striae or ribs. Carboniferous."

The genotype of *Perigrammoceras* is *Orthoceras* (*Cycloceras*) *laevigatum* (McCoy) as figured by Foord in Carboniferous Cephalopods of Ireland, 1897. But, of the three species of *Cycloceras* which McCoy described, *C. laevigatum* was the only form which was illustrated. Although he did not designate it as such, it seems reasonable to presume that McCoy intended this species to serve as the genotype of *Cycloceras,* not only because it is figured, but because in describing the form he said:[15] "....This species belongs to

[14] Foerste, August, American Paleozoic Cephalopods, Jour. Den. Univ. Sci. Lab., 20, 222-224, 1924.

[15] McCoy, loc. cit., 10.

the very interesting, but difficult division of the Orthoceratites, to which, from the prominent ring-like elevation of the surface, I have given the name of Cycloceras. . . . ." McCoy considered the surface of *C. laevigatum* to be smooth; but Foord has shown the presence of transverse striae where the surface is well preserved. Since, however, the other two species of *Cycloceras* were both described as possessing girdling striae, it is logical to suppose that McCoy intended Cycloceras to include shells with or without transverse striations; in fact the definition of the genus indicates as much.

That McCoy intended *Cycloceras* to include both the longitudinally and transversely striated types of annulated cephalopods is not nearly so certain, although Foerste, as noted before, is of this opinion. In favor of this interpretation of McCoy's intentions, there is the small text figure which does show longitudinal markings, and the fact that the words "often decussated" occur in the definition. On the other hand, one might conclude from a number of facts that McCoy included only transversely striated shells in his genus. He never described under *Cycloceras* a form which *was* longitudinally striated; and whereas "transverse laminae" are mentioned in the definition, the presence of longitudinal striae must be inferred from the word "decussated"; moreover, too much reliance should not be placed on the text figure as Foerste[16] himself "suggests that these figures were intended to be diagrammatic, and not accurate representations of type specimens"; and finally, the species McCoy described under this genus do not have their surfaces "decussated," nor "sculptured with transverse *scaly* laminae"; nor do they have markedly eccentric siphuncles.

Obviously, McCoy's definition of *Cycloceras* is a loose one. Considered with the text diagram, the description might possibly be interpreted to include forms usually referred to any one of the following genera: *Cycloceras, Protocycloceras, Perigrammoceras, Spyroceras,* or even *Cyrtoceras* and *Dawsonoceras.* But, in spite of this fact, the species McCoy described are uniform in their general characteristics. They are all annulated straight cephalopods, whose rate of expansion is slow, whose siphuncles are sub-centrad and small, and whose surface markings are limited to transverse striae only. Thus, there seems little reason for choosing *Cyrtoceras* (*Orthoceras*) *rugosum* (Fleming) as the genotype of *Cycloceras* (as

[16] Foerste, August, loc. cit., 226.

Foerste has done), for this species has a submarginal siphuncle, prominent longitudinal markings, is curved rather than straight, and has a relatively rapid rate of expansion. Indeed, it is so radically different from those forms described by McCoy that, though it does somewhat resemble the text figure, to set it up as the type on the mere basis of resemblance to an unlabeled engraving constitutes a questionable precedent. Should it be followed, every investigator might, with equal justification, designate another genotype for *Cycloceras* on the grounds that, in his opinion, McCoy's text figure more closely resembled another form.

To recapitulate, the following facts are apparent:

1. *Cycloceras*, as originally defined by McCoy, was erected for annulated Carboniferous cephalopods. It is possible that the genus encompassed *only* transversely striated forms; it is also possible that, though they were not described, shells with longitudinal striae were also included. It is certain, however, that the genus was not intended for longitudinally striated species *alone*.

2. The *Cycloceras* first described by Hyatt was composed of transversely striated shells *only*. The range was given as Ordovician-Carboniferous. This description of the genus would include the three original species of *Cycloceras* as described by McCoy.

3. The later *Cycloceras* of Hyatt was composed of *only* longitudinally striated forms. The range was given as Ordovician-Carboniferous, ,i.e., the same as for the earlier and diametrically opposed description of the genus.

4. The last named type of shell (longitudinally striated), however, is rare, and possibly does not exist in the Carboniferous.

5. The genus *Protocycloceras* was proposed by Hyatt for species with large siphuncles and with transverse striations *only*. The range was limited to the Ordovician.

6. *Protocycloceras* is essentially the same as Hyatt's earlier *Cycloceras* in which, however, the nature of the siphuncle is not mentioned.

7. Strictly speaking, shells *without* the longitudinal striae are as rare in the Ordovician[17] as forms *with* this feature are rare in the Carboniferous.

8. The genus *Perigrammoceras*, recently erected, is identically the same as the earlier *Cycloceras* of Hyatt except that

[17] Foerste, August, loc. cit., 224.

the range of the latter was given as Ordovician-Carboniferous, while that of the former was given as Carboniferous only. In neither of the descriptions is the nature of the siphuncle mentioned.

9. The genotype of *Perigrammoceras* is a species which probably should be designated as the genotype of the original *Cycloceras* of McCoy.

10. *Cyrtoceras* (*Orthoceras*) *rugosum* can not be regarded as the genotype of the original *Cycloceras*.

11. As a general (and perhaps universal) rule, the older Paleozoic annulated cephalopods have larger siphuncles than similar later Paleozoic shells.

12. All Carboniferous annulated cephalopods have small siphuncles, whose extreme diameter probably never makes up more than one eighth the total diameter of the shell.

With all these points in mind, it is not difficult to understand why there is so much variation in the classification of annulated cephalopods. Moreover, if the cephalopod is preserved as a cast there is little to indicate its correct generic designation, for, in this type of preservation, the surface markings are almost invariably lacking, though the annulations are usually present. In a few cases, however, casts of the interior of this type of cephalopod even fail to show the annulations and hence would be classified as *Orthoceras* unless the mold or portions of the shell material could be discovered.

The situation may be further complicated by the presence of shells belonging to *Dawsonoceras* or *Spyroceras*. Although it is not proposed to indicate the difficulties introduced with these genera, it may be noted, for example, that *Dawsonoceras annulatum* as often figured fails to show the prominently wrinkled growth lines characteristic of the genus, and that *Spyroceras thoas* appears to lack longitudinal ridges in the older portions of the shell, though these markings are supposed to persist into the adult. Another case in point is the fact that in Hyatt's provisional classification of the cephalopods in the collections in the Museum of Comparative Zoology, the specimens labeled *Cycloceras* by him usually lack the longitudinal costae; and those which have this feature developed, in many cases are similar to, if not identical with, *Spyroceras*.

Obviously, with all these difficulties and discrepancies, it is impossible to suggest a classification which will solve the problem to the satisfaction of everyone. Therefore the following redefinitions are proposed merely for what they are worth,

not only because they seem to offer the simplest way out of a complicated situation, but because, from the preceding discussion, it is evident that there is considerable basis for each of the changes involved.

Cycloceras McCoy. Annulated orthoceracones and cyrtoceracones with or without transverse striae, but without vertical striae or ribs. Siphuncle small. Type *C. laevigatum* McCoy. Carboniferous.

Protocycloceras Hyatt. Annulated orthoceracones and cyrtoceracones with longitudinal striations faint or absent after the earlier stages. Siphuncle large. Type *P.* (*Orthoceras*) *lamarcki* (Billings). Ordovician.

Dawsonoceras Hyatt. Annulated orthoceracones and cyrtoceracones whose growth lines are prominently wrinkled. The wrinkles may form longitudinal ridges of more or less prominence. Siphuncle small. Type *D.* (*Orthoceras*) *annulatum* (Sowerby). Silurian-Devonian.

Spyroceras Hyatt. Annulated orthoceracones and cyrtoceracones with persistent longitudinal ridges which become less prominent in the adult. Siphuncle smaller and longitudinal striations more prominent than in *Protocycloceras*. Type *S.* (*Orthoceras*) *crotalum* (Hall). Ordovician-Carboniferous.

Hyatt's later definition of *Cycloceras* is discarded since this description of the genus would not include the three original species. Hyatt's earlier definition of *Cycloceras* and Foerste's *Perigrammoceras* are regarded as essentially synonymous[18] with the original *Cycloceras* of McCoy.

Museum of Comparative Zoology,
Cambridge, Massachusetts.

[18] If *Perigrammoceras* is accepted as a bona fide genus then its genotype, *Cycloceras laevigatum*, cannot be used as the genotype of *Cycloceras* as it has been designated in this paper. In this case one of the two other species described by McCoy under *Cycloceras* is still available as the type of that genus. If either of these is designated, however, it at once becomes apparent that exactly the same type of shell is being used as the genotype for two supposedly different genera. This is perhaps the best proof of the synonymy of *Cycloceras* and *Perigrammoceras*.