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Conodont Zonation of the Early Upper Devonian in Eastern Iowa

GILBERT KLAPPER¹ AND W. M. FURNISH²

Abstract. The type section of the Sweetland Creek Shale in Muscatine County has yielded a sequence of five distinct conodont faunas which correspond almost exactly to a zonation of the Upper Devonian Frasnian Stage by Ziegler (1962 b) in the Rhineland. In addition, the nearby Campbell's Run section has produced the lower three faunas. The Sweetland Creek is equivalent in part to the Independence Formation, and is regarded as representing the southeastern extension of that unit in its true stratigraphic position above the Cedar Valley Formation.

HISTORICAL RÉSUMÉ

Udden (1899) proposed the name Sweetland Creek Shale for about 20 feet of beds overlying the Cedar Valley Formation unconformably; the type section is that shown in text-figure 1. The existing exposure of this section corresponds closely to Udden's original description (1899, p. 68). For brief summaries of later stratigraphic work concerning the Sweetland Creek beds, see Miller & Youngquist (1947, p. 501, 502) and Müller & Müller (1957, p. 1074).

Udden (1899) listed a rather undiagnostic megafauna from the Sweetland Creek, including fish remains and inarticulate brachiopods. Cooper et al. (1942) correlated the Sweetland Creek with formations in an equivocal position at the Devonian-Mississippian boundary; in the absence of significant fossils there was no good basis for assignment. However, conodonts probably collected by A. O. Thomas now available in the S. U. I. collections were examined as early as 1931 by C. L. Copper. These fossils occur in shale slabs lithologically suggestive of the unit which lies 14-17 feet above the base of the formation at the type section and include *Palmatolepis subrecta* Miller & Youngquist.

Branson & Mehl (1938) in a paper on the stratigraphic significance of *Icriodus*, reported two species of the genus, *I. curvatus* and *I. nodosus*, from the Sweetland Creek Shale. The former was listed as occurring in the Sweetland Creek at the type locality. These authors regarded the Sweetland Creek Shale as a synonym of the Grassy Creek Shale of Missouri, and assigned an Upper Devonian age to both.

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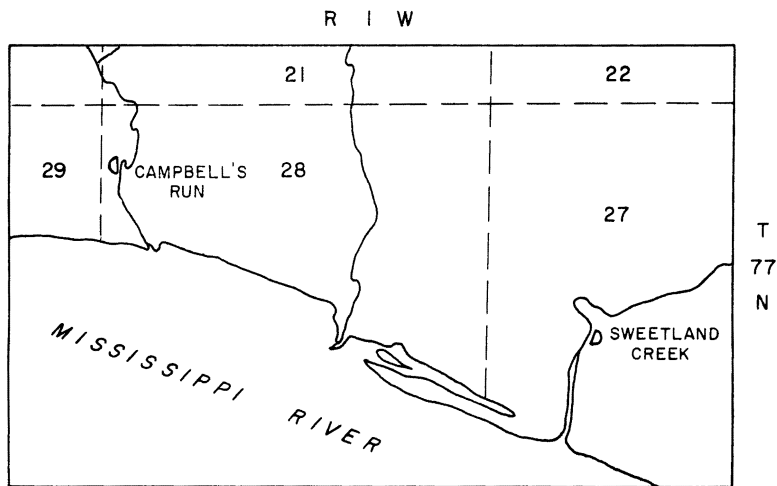
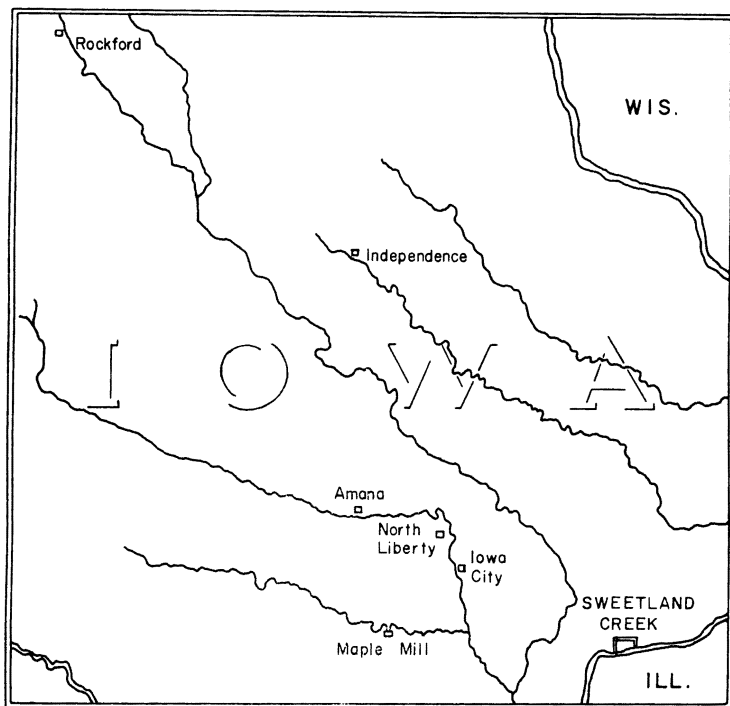


Figure 1. Index map with the type section and the Campbell's Run section of the Sweetland Creek Shale (Independence Formation), Muscatine County, Iowa. The locations of some other important Iowa Devonian conodont localities are shown.

Miller & Youngquist (1947) described a conodont fauna from the Sweetland Creek beds which they stated was secured from the middle part of the formation at the type section. Later, Youngquist & Miller (1948) described essentially the same fauna from three additional Sweetland Creek localities. According to their data, locality (1) is along Campbell's Run a short distance north of the Campbell's Run section described herein; locality (2) is along the small stream between Campbell's Run and Sweetland Creek; and locality (3) is at Sweetland Creek about $\frac{1}{2}$ mile upstream from the type section. Youngquist & Miller (1948) regarded the material from the additional localities as identical, except for minor variations, to the fauna described from the type section. According to our interpretation, the conodonts described in these two papers belong to the same fauna and are referable to the zone reported here from five and a half to thirteen feet above the base of the Sweetland Creek beds at the type section.

Thomas (1950) reported a fauna from the lower shale at the type section of the Sweetland Creek beds and recognized that the conodonts in this unit represented a different zone from the one described by Miller & Youngquist (1947) earlier. Youngquist (quoted in Thomas, 1950) thought that this lower shale fauna was similar to the one found by him in the North Liberty beds, a statement in accord with the findings reported herein. Most of Thomas' list from this lower shale unit have been identified in our collections. However, there are differences in certain details; for example, *Ancyroides uddeni* listed by Thomas has not been found by us in the lower shale unit (below the prominent siltstone) at either Sweetland Creek or Campbell's Run.

Müller & Müller (1957) described conodont faunas from various Iowa localities including the Independence Formation of Buchanan and Benton counties, the Amana beds, the North Liberty beds, and the Sweetland Creek Shale at Campbell's Run. In this group of sediments they recognized three distinct conodont zones, in descending order: the upper part of the Amana beds containing species of "*Ancyroides*" (most of which are referred to *Ancyrognathus asymmetrica* in this and other recent papers) and *Palmatolepis subrecta*; the lower part of the Amana beds containing *Palmatolepis foliacea*; and the part of the North Liberty beds containing *Palmatolepis martenbergensis*. They regarded the younger two faunas as upper Frasnian and the oldest fauna as middle Frasnian. Müller & Müller's zonation (1957, table 2) shows only the youngest of their zones, "*Ancyroides*" — *Palmatolepis subrecta*, present in the Sweetland Creek at Campbell's Run. However, *Palmatolepis* sp. Müller &

Müller (= *P. proversa*) was listed from the lower shale at Campbell's Run. This species is diagnostic of Ziegler's *Ancyrognathus triangularis* Zone, if it is in joint occurrence with the name-bearer of the zone. *Palmatolepis proversa* may occur in the older *Polygnathus dubia* Zone, however. Müller & Müller (1957) listed *Palmatolepis* sp. (= *P. proversa*) in joint occurrence with *Ancyrognathus triangularis* and *Palmatolepis martenbergensis* in the North Liberty beds and in occurrence with the former in the lower shale at Campbell's Run.

Section Descriptions

Numbers in parentheses indicate number of well-preserved conodont specimens secured.

Type section, Sweetland Creek Shale.
(N ½, SW ¼, sec. 27, T. 77 N., R. 1 W.,
Illinois City Quadrangle)

	Thickness
Sweetland Creek Shale?	
Unit 6: Shale, dark gray to black, quartzose, micaceous, non-calcareous; no conodonts. Unit is possibly Pennsylvanian in age	2½ ft.
Sweetland Creek Shale	
Unit 5: Clay shale "stringer," greenish-gray, calcareous. Rock slakes and expands rapidly in water, suggesting presence of montmorillonite-like clay mineral. Unit grades laterally into three thin (1-2") shale "stringers" of same character and fauna. Fauna: <i>Palmatolepis triangularis</i> Sannemann-(64); <i>P. marginata marginata</i> (Stauffer)-(11); <i>P. marginata clarki</i> Ziegler-(13); <i>Icriodus</i> sp.-(19); <i>Apatognathus lipperti</i> Bischoff-(1); <i>Palmatodella delicatula</i> Ulrich & Bassler-(1)	1-2 in.
Unit 4. Shale, dark brown to black, quartzose, slightly calcareous. This is the unit from which Udden (1899) identified specimens of <i>Spathiocaris emmersoni</i> Clarke, which are probably to be regarded as anaptychi. Fauna in lower foot of unit: <i>Palmatolepis subrecta</i> Miller & Youngquist-(8); <i>Polygnathus foliata</i> Bryant-(5); <i>Apatognathus lipperti</i> Bischoff-(1); <i>Palmatodella delicatula</i> Ulrich & Bassler-(1)	3 ft.
Unit 3. Clay shale, greenish-gray, calcareous. Rock has same slaking and expanding properties as unit 5. Fauna in upper foot: <i>Palmatolepis subrecta</i> Miller & Youngquist-(57); <i>P. crepida linguiformis</i> (Müller)-(3); <i>Ancyrodella buckeyensis</i> Stauffer-(1); <i>A. lobata</i> Branson & Mehl-(1); <i>Polygnathus foliata</i> Bryant-(3); <i>P. normalis</i> Miller & Youngquist-(3); <i>Nothognathella iowaensis</i> Youngquist-(3). Fauna in lower 7½ feet; <i>Palmatolepis subrecta</i> Miller & Youngquist-(61); <i>P. hassi</i> Müller & Müller-(5); <i>P. gigas</i> Miller & Youngquist-(1); <i>Ancyrognathus asymmetrica</i> (Ulrich & Bassler)-(3); <i>Ancyrodella buckeyensis</i> Stauffer-(21); <i>A. lobata</i> Branson & Mehl-(1); <i>Icriodus symmetricus</i> Branson & Mehl-(1); <i>Polygnathus foliata</i> Bryant-(7); <i>P. normalis</i> Miller & Youngquist-(9); <i>P. unicornis</i> Müller & Müller-(2); <i>Nothognathella brevidonta</i> Youngquist-(1); <i>N. iowaensis</i> Youngquist-(2); <i>Palmatodella delicatula</i> Ulrich & Bassler-(2)	8½ ft.
Unit 2. Siltstone, greenish-gray, quartzose, calcareous, with a shale parting, of same rock type as unit 5, located	

	2½ ft. above base of unit. Siltstone yields a few fragmentary conodonts. Fauna in shale parting: <i>Palmatolepis foliacea</i> Youngquist-(4); <i>Falcodus secundus</i> (Youngquist)-(1)	3½ ft.
Unit 1.	Clay shale, greenish-gray, calcareous. Megaspores visible on rock surface and abundant in residue. Rock has same slaking and expanding properties as unit 5. Fauna: <i>Palmatolepis proversa</i> Ziegler-(13); <i>P. hassi</i> Müller & Müller -(15); <i>P. martenbergensis</i> Müller -(3); <i>P. subrecta</i> Miller & Youngquist-(1); <i>Ancyrognathus triangularis</i> Youngquist-(4); <i>Ancyrodella buckeyensis</i> Stauffer-(2); <i>A. lobata</i> Branson & Mehl -(1); <i>Icriodus symmetricus</i> Branson & Mehl-(3); <i>Polygnathus foliata</i> Bryant-(2); <i>Nothognathella brevidonta</i> Youngquist-(1)	2 ft.
	total thickness	19½ ft.+

Unconformity

Cedar Valley Formation

Dolomite: bed is at creek level.

Campbell's Run Section
(NW ¼, NW ¼, sec. 28, T. 77 N., R. 1 W.,
Illinois City Quadrangle)

Thickness

Pennsylvanian.

Sandstone and shale

Unconformity

Sweetland Creek Shale

Unit 5. Clay shale, greenish-gray, calcareous. Rock has same slaking and expanding properties as unit 5 of previous section. Fauna: *Palmatolepis subrecta* Miller & Youngquist-(9); *Ancyrognathus asymmetrica* (Ulrich & Bassler)-(15); *A. triangularis* Youngquist-(1); *Ancyrodella buckeyensis* Stauffer-(12); *A. gigas* Youngquist-(5); *Polygnathus foliata* Bryant-(8); *P. normalis* Miller & Youngquist-(1); *Nothognathella brevidonta* Youngquist-(3); *N. iowaensis* Youngquist -(1); *Apatognathus lipperti* Bischoff-(2); *Palmatodella delicatula* Ulrich & Bassler-(1)

2 ft.

Unit 4. Siltstone, greenish-gray, quartzose, calcareous, pyritic, blocky weathering. No conodonts

1 ft.

Unit 3. Same rock type as unit 5. Fauna: *Palmatolepis foliacea* Youngquist-(48); *P. gigas* Miller & Youngquist -(5); *P. hassi* Müller & Müller-(2); *P. subrecta* Miller & Youngquist-(2); *P. unicornis* Miller & Youngquist-(1); *Ancyrognathus triangularis* Youngquist-(5); *Ancyrodella buckeyensis* Stauffer-(2); *A. gigas* Youngquist-(3); *A. curvata* (Branson & Mehl)-(1); *A. lobata* Branson & Mehl-(5); *Icriodus symmetricus* Branson & Mehl-(4) *Polygnathus foliata* Bryant-(13); *P. unicornis* Müller & Müller-(6); *Nothognathella brevidonta* Youngquist-(1); *N. iowaensis* Youngquist-(7); *Palmatodella delicatula* Ulrich & Bassler-(1)

1 ft.

Unit 2. Siltstone, greenish-gray, quartzose, calcareous. Not processed

2 ft.

Unit 1. Same rock type as unit 5. At the base of the unit a fish tooth bed is developed which has phosphatic pebbles, pyrite, *Ptyctodus* sp. Abundant megaspores occur in the residue. Fauna: *Palmatolepis proversa* Ziegler-(37); *P. hassi* Müller & Müller-(46); *P. foliacea* Young-

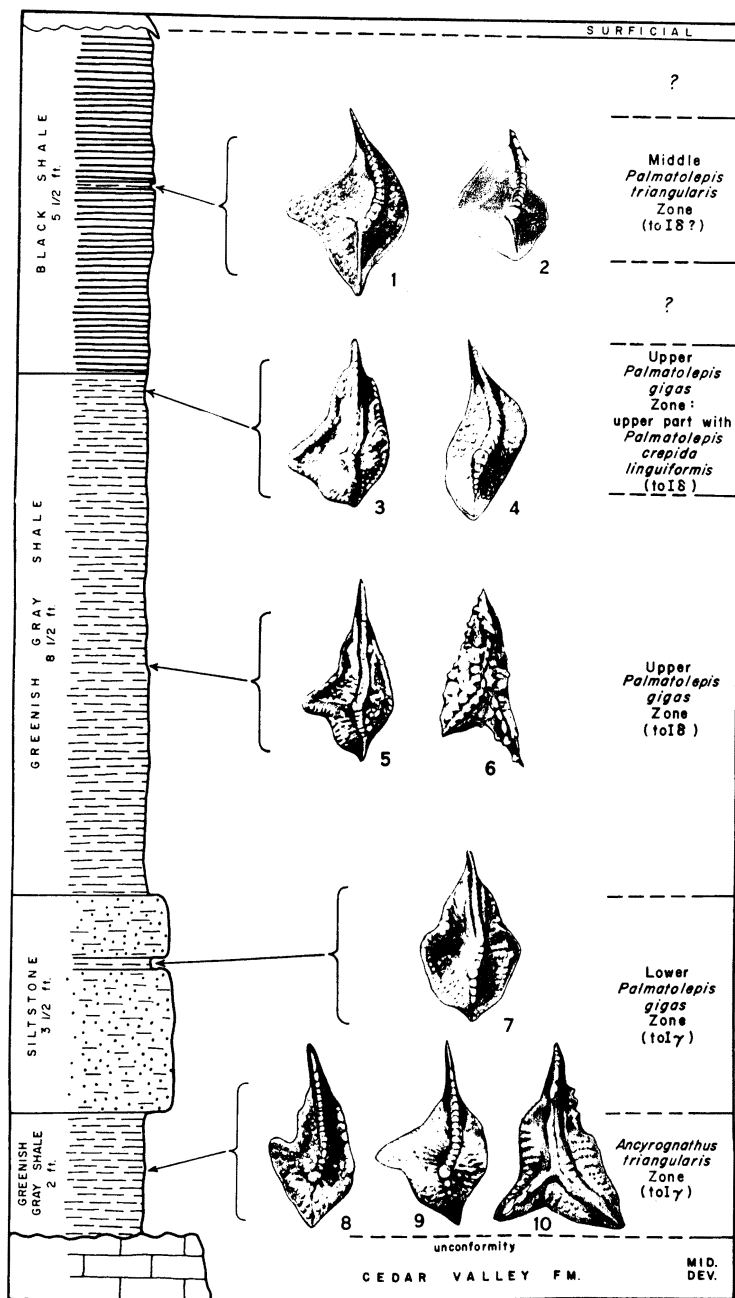


Figure 2. Diagrammatic section of type Sweetland Creek Shale (Independence Formation) with representative zonal conodont species and the German conodont zones to which they are assigned. Individual conodont figures have no uniform magnification.

- Figure 1. *Palmatolepis triangularis* Sannemann, 1955.
- Figure 2. *P. marginata marginata* (Stauffer), 1938.
- Figure 3. *P. subrecta* Miller & Youngquist, 1947.
- Figure 4. *P. crepida linguiformis* (Muller), 1956.
- Figure 5. *P. subrecta* Miller & Youngquist, 1947.
- Figure 6. *Ancyrognathus asymmetrica* (Ulrich & Bassler), 1926.
- Figure 7. *Palmatolepis foliacea* Youngquist, 1945.
- Figure 8. *P. proversa* Ziegler, 1958.
- Figure 9. *P. hassi* Muller & Muller, 1957.
- Figure 10. *Ancyrognathus triangularis* Youngquist, 1945.

quist-(2); *P. martenbergensis* Müller-(1); *P. subrecta* Miller & Youngquist-(1); *Ancyrognathus triangularis* Youngquist-(16); *Ancyrodella buckeyensis* Stauffer-(7); *A. curvata* (Branson & Mehl)-(9); *A. gigas* Youngquist-(14); *Icriodus symmetricus* Branson & Mehl-(65); *Polygnathus foliata* Bryant-(14); *Nothognathella brevidonta* Youngquist-(10); *N. iowensis* Youngquist-(1); Six specimens of *Ancyrodella rotundiloba* (Bryant) are interpreted as reworked because they are worn and rounded and are black (all other conodonts reported in these two sections are the normal, translucent brown color) 2 ft.

total thickness 8 ft.

Unconformity
Cedar Valley Formation
Dolomite

FAUNAL ZONATION

Five distinct conodont faunas have been recognized in the Sweetland Creek beds at the type section (text-fig. 2). These zones can be correlated precisely with a sequence established by Ziegler (1962b) in a comprehensive zonation of the entire Upper Devonian in Germany; zonal terminology in text-figure 2 corresponds to that of Ziegler.

The five zones of the Sweetland Creek beds represent only a part of the Frasnian (*Manticoceras* Zone). Apparently lacking is the conodont zone representing Frasnian *toIα* and *toIβ* (sensu Wedekind, 1913), i. e., the *Polygnathus dubia* Zone. The lowest zone at Sweetland Creek and at Campbell's Run is the *Ancyrognathus triangularis* Zone (*toIγ*). This zone, according to Ziegler (1958, table 10, and 1962b), is characterized in Germany by the first occurrence of *A. triangularis*. *Palmatolepis proversa* and *P. martenbergensis* occur also in this zone. *P. subrecta* and *P. hassi* occur below, in and above the *A. triangularis* Zone. Beginning near the top of this zone, *P. foliacea* also appears.

The *Ancyrognathus triangularis* Zone in the Sweetland Creek beds agrees in all the critical occurrences. The dominant species of *Palmatolepis*, are *P. proversa* and *P. hassi*. Only two specimens of *P. foliacea* were recognized. *P. proversa* and *P. martenbergensis* do not range above this zone in the Sweetland Creek beds.

The *Palmatolepis gigas* Zone is divided into two parts, with the upper subzone also subdivided. *Palmatolepis gigas* is now

regarded as a senior synonym to *P. rhenana* (personal communication, Dr. W. Ziegler, 1962). Consequently *P. gigas* is used here as the zonal name-bearer instead of *P. rhenana* which was employed by Ziegler (1962b). Ziegler plans to present a paper on the synonymy of American and European conodont species based on his study in this country in 1961.

The Lower *Palmatolepis gigas* Zone (*toIy*) is characterized in Germany by the first occurrence of the name-bearer. *P. foliacea* also occurs in this subzone and does not range above it. *P. hassi*, *P. subrecta*, and *Ancyrognathus triangularis* continue from the zone below. The Lower *Palmatolepis gigas* Zone at Sweetland Creek and Campbell's Run agrees with the typical occurrence. The fauna is much better developed at the latter locality, however. *P. foliacea* is the most abundant palmatolepid and does not occur above this level.

The Upper *Palmatolepis gigas* Zone (*toIδ*) in Germany is characterized by the first occurrence of *Ancyrognathus asymmetrica*. The name-bearer, as well as *Palmatolepis subrecta*, also occurs. *Ancyrognathus triangularis* occurs, but makes its last appearance near the base. In the Sweetland Creek and Campbell's Run sections, the same situation is found; *Palmatolepis subrecta* is the dominant palmatolepid. This is the highest zone recognized at the Campbell's Run section.

The upper part of the Upper *Palmatolepis gigas* Zone (*toIδ*) is characterized in Germany by *P. crepida linguiformis* which is restricted to this occurrence. *P. subrecta* is also present. In the Sweetland Creek beds, at the type section, the same association is found with *P. subrecta* the dominant palmatolepid.

The next higher zone in Germany is the *Palmatolepis triangularis* Zone. The lower part of the zone is characterized by the first occurrence of the name-bearer (for a clarification of the concept of this species, see Helms, 1959, and Ziegler, 1962a). This part of the *P. triangularis* Zone has not been recognized at the Sweetland Creek type section but may possibly be present in the upper part of the black shale, lying between 14-17 feet above the base of the formation, which has so far yielded few conodonts and has been a difficult lithology to process.

The Middle *Palmatolepis triangularis* Zone (*toIδ?*) is characterized by the first appearance of *P. marginata marginata* and *P. marginata clarki* in association with the name bearer. This joint occurrence is present at the Sweetland Creek type section. It occurs in several green shale "stringers" about 17 feet above the top of the Cedar Valley Formation. All three of these palmatolepids occur at this horizon. No other palmatolepids are present.

CORRELATION IN IOWA AND OTHER AREAS

The Independence Formation of the type area in Buchanan and Benton counties includes beds equivalent to the lower three zones at Sweetland Creek and the three zones at Campbell's Run. The Independence Formation at Müller & Müller's (1957) locality 4 in Benton County, contains *Palmatolepis proversa*, and is here referred to the *Ancyrognathus triangularis* Zone. The formation at locality 1 (Müller & Müller, 1957) in Buchanan County includes *Palmatolepis foliacea* and is referred to the Lower *Palmatolepis gigas* Zone. The beds at their locality 2 (Buchanan County) contain *Ancyrognathus asymmetrica* and are regarded as equivalent to the Upper *Palmatolepis gigas* Zone.

The beds at Middle Amana correlate with the Independence Formation also, as pointed out by Müller & Müller (1957), as follows: the lower part of the Amana section correlates with the Independence Formation at Müller & Müller's locality 1 in Buchanan County; and the upper part of the Amana section with the Independence at their locality 2, also in Buchanan County.

The significance of the above correlations seems clear. The Amana and Sweetland Creek beds are both stratigraphically higher than the Cedar Valley Formation. In contrast to the Frasnian age of the conodonts in the Amana and Sweetland Creek beds and in the Independence Formation in Buchanan and Benton counties, the Cedar Valley yields diagnostic Middle Devonian conodonts (Downs & Youngquist, 1950, and Müller & Müller, 1957). In the light of present information concerning the Middle Devonian of Germany, the age assignment made by the above authors based on Cedar Valley conodonts seems fully confirmed. In addition, carbonate samples from the type Solon Member and the Rapid Member of the Cedar Valley at the River Products Quarry near Iowa City, collected by Mr. Verne E. Dow and examined by us, have yielded well preserved Middle Devonian conodont faunas. This conclusion agrees, therefore, with the age assignment of the Cedar Valley Formation based upon its brachiopod fauna (Cooper & Warthin, *in* Cooper, et al., 1942, p. 1750, 1751).

Thus, the Sweetland Creek and Amana beds represent the Independence Formation in its true position above the Cedar Valley Formation. The Independence of Buchanan County, e. g., Stainbrook's locality near Quasqueton (1945, p. 75, fig. 2), lies apparently below the Cedar Valley, but this anomaly is the result of either stratigraphic leak into solution cavities or sedimentation in sinks after a karst terrain had been developed on the Cedar Valley, or both. Numerous authors have presented versions of

this explanation before (for historical review of the problem, see Stainbrook, 1945). Stainbrook's interpretation, however, was diametrically opposed to this view, for he believed that the Independence Shale's true stratigraphic position lay below the Cedar Valley. More recently, recognizable solution cavities have been found higher in the Cedar Valley section, e.g., in the type Coralville Member at the River Products Quarry and at the Iowa City Hillcrest Dormitory excavation. These cavities are filled with shale which yields Frasnian (Independence) conodonts.

For the beds at Amana, at Sweetland Creek, and at North Liberty, the name Independence Formation is applied, following the practice of Müller & Müller (1957). Independence has priority over other names for these units. Stainbrook's contention (1945, and earlier) was that a Frasnian shale lies in normal position below a carbonate formation which is now known to contain diagnostic Middle Devonian conodonts as well as brachiopods. This interpretation plus the idea that the Amana beds and the Independence Formation of Buchanan County are not exact correlatives is no longer tenable in the light of present knowledge.

The Frasnian part of the Upper Devonian sequence in north-central Iowa is represented by the Lime Creek Formation. The conodont zonation in this province is now being studied by Wayne I. Anderson.

The Sylamore Sandstone of Illinois (Collinson, 1961, and Collinson et al., 1962) can be correlated with the lowest zone in the Sweetland Creek, because of the mutual occurrence of *Palmatolepis proversa*. The Sylamore of their usage may also include higher correlatives of the type Sweetland Creek section.

The Dowelltown (lower) Member of the Chattanooga Shale of the Eastern Interior (Hass, 1956) carries a conodont fauna, according to more recent systematics, that includes *Palmatolepis proversa*, *P. subrecta*, *P. gigas*, and *Ancyrognathus triangularis*, indicating a positive correlation with the Sweetland Creek beds. This association occurs throughout most of the Dowelltown Member.

The third zone from the base of the Sweetland Creek can be correlated with Cooper's Chemung Stage and the overlying Dunkirk Shale Member of the Perrysburg Formation in New York which contain *Palmatolepis subrecta* and *Ancyrognathus asymmetrica*, according to Hass (1959) who dated this association as Frasnian, *to*18.

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