

THE SIGNIFICANCE OF THE SINAL FORMULA IN DEVONIAN
AND POST-DEVONIAN SPIRIFERS.

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Recent study has brought out the fact that members of the Spiriferidæ, in which the sinus is plicated, are divisible into a series of distinct groups, each of which shows a definite order of appearance of the plications in the sinus of the pedicle valve.

The earliest and perhaps most primitive of these groups, may be designated the *Uniplicate Division*. This is the dominant group in the Middle Devonian, indeed, the only one so far known from that era. It is always characterized by the appearance of a primary median plica in the sinus, which may remain simple, or bifurcate once, or several times. Usually, though not in all cases, a pair of lateral plications appears, one on either side of the median one. These branch from the inside of the bounding plications of the sinus. A second, and sometimes even a third pair, may appear and these may also bifurcate or remain simple.

Examples of this group are:—

Schizospirifer Grabau (Fig. 1)

Plectospirifer Grabau (Fig. 2)

Indospirifer Grabau (Fig. 3)

and such other Spiriferoids as

Spirifer aeneosus

Spirifer divaricatus

all of them belonging to the Middle Devonian.

The only Upper Devonian representatives of this group so far known are *Spirifer* (*Centrospirifer*) *cnani* (Fig. 4) and *Spirifer* (*Centrospirifer*) *heterosinosus* (Fig. 5) of China, and probably *Spirifer mesacostalis* of North America.

The second type of Spiriferoid based on the sinal plication may be designated the *Triplicate Division* and this is most typically represented by the genus *Sinospirifer* (Figs. 6-10) so characteristic of the Upper Devonian of China and Europe and represented in America by *Spirifer whitneyi* (Fig. 9) in the

west, and *Spirifer disjunctus* (Fig. 10) in the east. This always begins with two primary sinal plications, which branch from the bounding plications a short distance below the beak and gradually diverge forward, so as to divide the sinus into three more or less equal portions, a median and two lateral. In the lateral portions, the further development of plications proceeds according to a definite rule. The first pair of laterals branches off from the bounding plications in the same manner as the primary, and usually there is a second pair branching off still further forward, and often a third pair. The primary plicæ remain simple or bifurcate, and the lateral plications likewise may bifurcate, though the last or outermost of these, which is also the shortest, usually remains simple. Again intercalated plicæ may appear, either between the primary and first pair of laterals, or between the laterals themselves.

The median system develops independently from the lateral system and the first pair of median plicæ is always parallel, or nearly so, to the primary plications. It arises independently inside of the primary pair. A second pair is generally formed, this appearing later and inside of the first pair, i.e. nearer to the center of the sinus. A third, and more rarely a fourth pair may appear, successively towards the center. There may or may not be a single central plication but this commonly appears after the first pair of median, or even after later pairs.

The central plica may remain simple or divide once or several times, and some or all of the paired median plicæ may also divide. Intercalated plicæ may also appear in the median system.

This type of Spiriferoid has not yet been found either below or above the Upper Devonian.

A third type of sinal plication may be designated the *Duplicate Division*. This corresponds to the triplicate type in that the primary plicæ develop as a pair by branching off on either side from the bounding plications, but these primary plicæ instead of diverging, remain essentially parallel, and paired plicæ are developed only in the lateral portions. The median part remains without plications in the more primitive forms, but in others a single median plica may appear, which either remains simple or divides once or several times. There are however, no median paired plications as in *Sinospirifer* and this is a distinctive feature of this group. In the more specialized types, the primary,

and one or more of the lateral pairs may bifurcate and more rarely intercalated plicæ may appear.

Another characteristic feature of this group is the frequent bifurcation of the lateral shell plications including the bounding plicæ. In this they again differ from *Sinospirifer*. Sometimes branches may be given off in place of the furcation.

This group is essentially confined to the Carboniferous and Permian, though it has a Devonian precursor in *Platyspirifer*. (Fig. 11). Its most typical representatives are.

1. *Spirifer* Sowerby (sens. strict) Fig. 12
2. *Choristites* Fischer Fig. 13
3. *Spiriferella* Tschernyschew Fig. 14, 15
4. *Brachythyridina* Fredericks. Fig. 16

In the diagrams Figs. 1 to 16 examples of the several groups of sinal plication are given, together with the sinal formula of each. In the latter the reading is always from left to right.—The primary plicæ are designated by I; bifurcation by x, incipient bifurcation by z, and intercalation by y. An undeveloped plica is indicated by o.

UNIPPLICATE TYPES

Fig. 1. *Schizospirifer latistriatus* (Frech) (Ser. No. 657)

Sinal Formula: $1 + 1x + 1x + 1x + 1$

Fig. 2. *Plectospirifer heini* Grabau

Sinal Formula: $1 + I + 1.$

Fig. 3. *Indospirifer padaukpinensis* (Reed) var. *maoerkhuânensis* Grabau

Sinal Formula: $2 + I + 2$

Fig. 4. *Centrospirifer chaot* Gr. (Ser. No. 1520)

Sinal Formula: $3 + I + 3$

Fig. 5. *Centrospirifer heterosinosus* Gr. (Ser. No. 522)

Sinal Formula: $3 + \left(\frac{1x}{1x + 1} \right) + 4$

TRIPLICATE TYPES

Fig. 6. *Sinospirifer subextensus* (Martelli) (*S. sinensis* mut. *bela* Gr.)

Sinal Formula: $2 + I + I + IX + I + I + I$

Fig. 7. *Sinospirifer subarchiaci* (Martelli) (Ser. No. 482)

Sinal Formula: $I + IX + IX + IX + I + \frac{IX}{I + IX} + 2 + IX + IX + I$

Fig. 8. *Sinospirifer pellissarii* Grabau (Ser. No. 597)

Sinal Formula: $(3 + IY + I + IY) + I + I + I + I + I + (IY + I + IY + 3)$

Fig. 9. *Sinospirifer whitneyi* Hall (the holotype)

Sinal Formula: $I + IX + I + I + 2X + 2X + I + I + IX + I$

Fig. 10. *Sinospirifer disjunctus* (Sowerby) (Hall)

Sinal Formula: $2 + IX + 2 + 2 + IX + 2$

DUPLICATE TYPES

Fig. 11. *Platyspirifer subparonai* Grabau (Ser. No. 583)

Sinal Formula: $(2 + IY + I + IY) + I + IY + \left(\frac{IX}{IX + IX} \right) + IY + I + (IY + I + IY + 2)$

Fig. 12. *Spirifer moosakheilensis* Dav. (Ser. C. 242)

Sinal Formula: (B, bounding plications, B' outside branch of same)

$$B' - \left(\frac{Bx}{I + IX} \right) + I + \left(\frac{IX}{IX + IX} \right) + \frac{IX}{IX + IX} + 0 + \frac{IX}{IX + IX} +$$

$$\left(\frac{IX}{I + \left(\frac{IX}{IX + I} \right)} \right) + I + \left(\frac{Bx}{\left(\frac{IX}{IX + I} \right) + I} \right) - B'$$

Fig. 13. *Choristites bisulcatus* (Sow.)

Sinal Formula: $3 + I + I + I + 3$

Fig. 14. *Spiriferella salteri* var. *mongolica* Gr.

Sinal Formula: $I + I + I + I + I$

Fig. 15. *Spiriferella salteri* var. *wimanni* Gr.

Sinal Formula: $2 + IX + I + IX + 2$

Fig. 16. *Brachythyridina strangwaysi* (de Vern.)

Sinal Formula: $I + I + I + I + I$



