

CLASSIFICATION OF THE ORDOVICIAN SYSTEM IN NORTH AMERICA

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ABSTRACT

Classifications reflect judgements on completeness of record and complementing relations from faunal and lithic evidence among widely separated sequences. Nomenclature further involves attitudes on magnitudes of time-stratigraphic units and practices regarding priority and revisions.

The system is in North America invariably called Ordovician. European terminology applies to graptolite-bearing sequences; otherwise American terms are used. The lowest series is the Canadian except to a few who classify it as a separate system. Canadian sequences in Vermont, Missouri and Utah are important standards; recently proposed stages are Gasconadian, Demingian, Jeffersonian and Cassinian.

The Chazyan, Blackriveran and Trentonian succeed the Canadian in New York, and are classified as separate series, or as two series (Chazyan and Mohawkian) or as one (Champlainian). The Chazyan has Whiterockian, Dayan, Crownian and Valcourian stages, the Blackriveran has Pamelian, Lowvillian and Chaumontian, and the Trentonian has Nealmontian, Shermanian and Pictonian stages. Chazyan-Blackriveran rocks have also been placed in Whiterock, Marmor, Ashby, Porterfield and Wilderness "stages" that may not be wholly exclusive of one another.

The Cincinnati Series is divided into Edenian, Maysvillian and Richmondian stages, to which some add Gamachian above, and take the Utican (Cobourgian and Collingwoodian) from the Trentonian below.

The Lower Ordovician is generally the Canadian, though Chazyan is sometimes included. Upper Ordovician invariably includes the Cincinnati, and the Trentonian in varying degrees. The intervening rocks are Middle Ordovician.

The term Ordovician (Lapworth, 1879) has been applied quite constantly in North America to the system above the Cambrian since the beginning of the century. Originally, in 1842, the Champlain System of the New York State Survey contained the Ordovician rocks, as well as beds now classed as latest Cambrian (Emmons, 1842). However, the rocks were included in the Silurian by most authors through the nineteenth century. Champlainian (or Champlainic) System as revived and used by some leading American stratigraphers in the early part of the present century (Clark and Schuchert, 1899; Schuchert, 1924), did not gain general approval. Ulrich (1911) placed the lower beds in his Canadian System; the Canadian series of Dana (1874) had somewhat greater span. Flower (1957) suggests that Canadian System has advantages, but the term has not been adopted widely.

The terminology of series for the system has varied. The New York section is the principal one of reference. For more than a century (Emmons, 1842), five main divisions have been recognized, the "Calciferosus" (Beekmantown, Clark and Schuchert, 1899), Chazy, Black River, Trenton, and Lorraine; all but the last are dominantly of carbonate rock, the Lorraine being argillaceous quartz-sandy shale.

Canadian has been rather generally applied as a series name to the lowest division, though the Chazyan is frequently included. The next three have been placed in three series (Chazyan, Blackriveran and Trentonian), in two series (Chazyan and Mohawkian (Clark and Schuchert, 1899)), or in a single series, commonly called "Middle Ordovician", by some Champlainian; the second practice of forming two series, has been most common. Bolarian (Kay, 1947) has been used for rocks correlated with the Blackriveran in the Appalachian region; there is question whether the base is additional to the type Black River, or is equivalent to part of the Chazyan (Kay, 1958). Cincinnati (Meek and Worthen, 1865) is generally used for the upper series, including the New York Lorraine and younger Ordovician strata. The series are bounded somewhat differently by several authors, as will be evident in the following discussion.

The argillaceous sequences with graptolites have not been clearly related to the series names applied to the carbonate rocks. The Deepkill and Normanskill formations in New York have large graptolite faunas; graptolite-bearing units elsewhere frequently are compared with them. Another practice is to use the English series names, Arenigian, Llanvirnian, Llandeilan, Caradocian and Ashgillian, and refer to the zones of Elles and Wood (1905). The classification of these rocks is not only a problem of relating them to carbonate equivalents, but of carrying correlations of the equivalents to reference sections far away and in different province.

The subdivisions of series in chronostratigraphic terms are stages. In North America customarily until recently the series have been divided into provincial groups and formations, properly lithic terms. In some instances, the groups and formations have been considered time-stratigraphic; in others, original time-stratigraphic names have been treated as formational. If organisms in successive units were controlled wholly by time, the biozones would constitute firm bases for stages; as the physical factors controlling lithology may also affect ecology, the evaluation of fossil successions becomes involved and subject to multiple interpretations.

The Canadian Series has generally not been assigned formal stage terms, but correlation has been against a standard formational succession, generally that of the Ozark region, Missouri and Arkansas; the formations there are treated as though they were stages. Ulrich (1911; Ulrich and Cooper, 1938) set up a sequence of names of formations that he considered representative of successive times for the whole Ordovician. Some are in local succession, but his practice of selecting units from widely scattered places made it difficult to prove the succession by stratigraphic methods, and reflected his philosophy that difference in organic assemblages are attributable to age rather than environment; regarding "abrupt changes in the fossil content of beds, . . . without exception the faunally distinct though apparently contemporaneous beds have proved to be not only of different ages but . . . represent invasions from different oceanic basins" (Ulrich, 1916, p. 452). The classification is not used.

The faunal succession in the Canadian has been zoned for brachiopods (Ulrich and Cooper, 1938), cephalopods (Ulrich, and others, 1942—1944) and trilobites (Ross, 1951; Hintze, 1952). Flower (1957) suggested a four stage classification into Gasconadian, Demingian, Jeffersonian, and Cassinian, based principally on cephalopod distribution.

The Chazyan Series or "Chazy stage" was divided into three "substages" by

Cushing (1907) that have become the Dayan, Crownian and Valcourian stages (Oxley and Kay, 1959), recognizable in the type area by their distinctive fossil assemblages; perhaps these faunas in the type area are controlled more by environments than by time. Cooper (1956) placed the whole type Chazy in his Marmor "stage", considering the succeeding Ashby and Porterfield "stages" of the southern Appalachians to be post-Chazy and at least partly pre-Black River. But fossils thought diagnostic of the Porterfield "stage" are in argillaceous strata of the type Chazyan (Kay, 1938). Cooper introduced an earlier post-Canadian "stage", the Whiterock, below the Marmor, basing it on faunas found in Nevada; whether these are older than the type Chazyan, or represent different faunal facies or province is difficult to determine because of their isolation. Flower (1957) concurs in believing them younger than Canadian and older than Dayan; the Whiterockian is so-placed in the table. The basal Chazyan (Joins) is Llanvirnian (*Didymograptus bifidus* zone) and the basal Blackriveran-Bolarian (Porterfield) is basal Caradocian (*Nemagraptus gracilis* zone); Canadian trilobite zones are correlated with graptolite zones (Rigby, 1958).

The Black River Group in northern New York can be divided into three formations, the Pamela, Lowville and Chaumont (Young, 1943), which have been treated as stages; they correspond to three biozones of Raymond (1915). The second, the Lowville, was originally the "Birdseye limestone" with prevalence of the coral *Tetradium celluloseum* (Hall); the form was thought distinctive of age by such paleontologists as Ulrich, but experience has shown that it is long-ranging in rocks of pure calcite composition, particularly in calcilitites. Cooper (1956) divided the rocks that he considered younger than the type Chazyan into the Ashby, Porterfield and Wilderness "stages", the latter extending into the lowest Trenton of New York; these stages are in contiguous stratigraphic succession in the Appalachians, but their correlation with New York is uncertain (Kay, 1958). On the other hand, the Pamela, Lowvillian and Chaumontian are quite provincial and relatively sparse in fauna; methods of carrying correlations to them and distinguishing their equivalents are inadequate.

The Trenton Group was divided by Raymond (1916) into a succession of faunal zones that he thought time-stratigraphic, but which he called formations. In time these became the stages of the writer: Rocklandian, Kirkfieldian, Shorehamian, Denmarkian, Cobourgian, Collingwoodian, and Gloucesterian (Kay, 1937, 1943). Critical analysis has been made of the relations between these faunal zones of the type Trenton and the lithologies (Chenoweth, 1951; Lippitt, 1959). The lithic units are also time-stratigraphic, lithic differences reflecting physical conditions that are in turn recognizable in the successive faunas; nevertheless, there are progressive changes in faunas that have time value (Salmon, 1944). Probably the term stage is too high an order for the named divisions of the Trentonian; they can be considered substages of a smaller number of stages. The writer suggests that Nealmontian be applied to the Rocklandian and Kirkfieldian substages (Kay, 1948) and that Shermanian be applied to the Shorehamian and Denmarkian from Sherman Fall, the term originally applied (Kay, 1929) to the interval. The Cobourg-Collingwood-Gloucester seems time-equivalent to the Utica Group (Ruedemann, 1925; Kay, 1943, 1953), but the name Utica is strongly associated with the black shale facies. Hence the uppermost Trentonian stage is designated the Pictonian stage, originally given in a more

restricted sense (Raymond, 1911) and abandoned (Raymond, 1921). The Pictonian stage contains the Utica Group of formations (Kay, 1943, 1953).

The Cincinnati Series has commonly had three divisions based on the Eden, Maysville and Richmond "groups" near Cincinnati, Ohio. These are so dependent on their faunal associations that they are essentially a succession of biozones. The base of the Edenian is the Fulton Shale, included in the base of the Economy Formation (Sweet and others, 1959). Some have considered a sequence in Anticosti Island, Quebec, the Gamachian, to be post-Richmond Ordovician; its isolation makes precise placement tenuous.

The boundary between the Trentonian and Cincinnati series has been defined variably because of selection of differing horizons in known successions, and varying correlations between the type sections in separated areas. The boundary in North America is taken invariably as separating "Middle" and "Upper" Ordovician, although in European terms, assuming the Caradocian to be "Middle", the American boundary lies within the Cincinnati under any definition of that series (Whittington in Twenhofel, 1954, p. 261). With respect to the base of the Cincinnati or "Upper Ordovician", using the New York stages as applied herein, the boundary has ranged from the base to the top of the Pictonian. The whole Pictonian was "Cincinnati" older than Edenian including Fulton to Ruedemann (1925, p. 149); all but the early Cobourgian (Hallowell) was "Upper Ordovician" to Raymond in 1916 (pl. 8), all but the Gloucester pre-Edenian; but all but the Gloucesterian was placed in the Trentonian by Raymond in 1921. The writer consistently followed this last practice except in including the Gloucesterian in the Trentonian, as it is uppermost Utica-equivalent (Raymond, 1925), and hence the series boundary is placed above *all* the Utica. The Pictonian generally has been placed in the Trentonian and indeed, Cobourgian forms most of the section in the gorge at Trenton Falls (Kay, 1953, p. 26).

These classifications affect the classification of Arctic Ordovician. The Collingwood continues westward into northern Michigan (Groos Quarry of Hussey, 1952) and the uppermost Galena (Dubuque) of Iowa and Minnesota; each succeeds *Maclurites*-bearing beds (Chandler Falls and Stewartville), which thus are Pictonian of Cobourgian substage (Kay, 1935). Recently, conodonts of the Dubuque were found similar to those in basal Cincinnati (Edenian) (Ethington, 1959); so faunas in the late Trentonian are very similar to those in early Cincinnati.

The North American stages, applied particularly to sediments of littoral deposition, are based principally on the sections in New York, and in Ohio for the Cincinnati. There are no serious problems with respect to their stratigraphic order except for the Whiterockian; the stages seem virtually contiguous. They can be used with confidence and precision within a limited province, particularly wherein the continuity can be traced by stratigraphic methods. At distance, where doubt exists as to classification against the primary standard, local sequences of reference are used; for example, the Canadian and Chazy sections of the west can be correlated by means of the trilobite zones of Ross and Hintze (1951; 1952) with reference to the stratigraphic units of western Utah, and eastern Nevada. Authors may agree on the correlation of the middle Montoya of west Texas with a part of the

Fremont of Colorado, but they may differ on the placement of each in the standard sequence of stages. Hence secondary "stages" or standards of reference become useful regionally and provincially.

The following is a classification of the North American Ordovician:

<i>Cincinnatian series:</i>	Richmondian stage	<i>Chazyan</i>	Valcourian
	Maysvillian		Crownian
	Edenian		Dayan
<i>Trentonian</i>	Pictonian		Whiterockian
	Shermanian	<i>Canadian</i>	Cassinian
	Nealmontian		Jeffersonian
<i>Blackriveran</i>	Chaumontian		Demingian
	Lowvillian		Gasconadian
	Pamelian		

The classification is a standard for comparison and correlation. North America has such great area that correlations differ among distant sections. Some are in provinces that were geographically or ecologically isolated. There are many problems that must be solved.

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