

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CONODONT BIOSTRATIGRAPHY AND THERMAL COLOR ALTERATION INDICES
OF THE UPPER ST. CHARLES AND LOWER GARDEN CITY FORMATIONS,
BEAR RIVER RANGE, NORTHERN UTAH AND SOUTHEASTERN IDAHO

by
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Open-File Report 81-740

1981

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ABSTRACT

The contact between the St. Charles and Garden City Formations in the Bear River Range, Bannock thrust sheet in northern Utah and southeastern Idaho, is a diachronous disconformity within the Lower Ordovician. Middle or, possibly, upper Cordylodus proavus Zone (Clavohamulus elongatus to, possibly, C. hintzei Subzones) conodonts indicate that lowermost Canadian Series (Lower Ordovician in North American usage) strata equivalent to the Missisquoia Zone and, possibly, lower Symphysurina Zone (trilobites) are present in the upper part of the St. Charles Formation. The boundary between the Trempealeauan Stage and Canadian Series (Cambrian-Ordovician boundary) is located within the upper part of the St. Charles Formation. Basal beds of the Garden City Formation contain conodonts representing Fauna B (upper part) in two Idaho sections and Fauna C at two Utah localities. At least 12 m (40 feet) of erosional relief was

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developed on the dolostones of the St. Charles Formation prior to deposition of the Garden City Formation. Trilobite Zone A of Ross from the lower part of the Garden City Formation correlates with the upper part of the Symphysurina Zone (S. bulbosa Subzone) and corresponds in its lower and upper parts, respectively, with upper Fauna B and Fauna C (conodonts). Conodont Fauna C occurs with trilobites of upper Zone A through Zone C of Ross. Conodont Fauna D and trilobite Zone D have a lowest occurrence at approximately the same stratigraphic level, although the lower part of trilobite Zone D of Ross lies within the upper part of conodont Fauna C.

Conodont elements from the lower part of the Garden City Formation have a color alteration index (CAI) of low 4, whereas the strongly corroded specimens throughout the St. Charles dolostones have an apparent CAI of 6.5, although associated rarer elements have a CAI=4(low). The color alteration index developed for conodonts from limestones may not apply to samples from dolostones that have had their primary organic matter reduced by leaching during dolomitization.

INTRODUCTION

The contact between the St. Charles and Garden City Formations in the Bear River Range of northern Utah and southeastern Idaho is a striking lithologic break in a miogeosynclinal carbonate platform sequence. Massive dolostones of the St. Charles Formation are succeeded by limestones of the Garden City Formation (Richardson, 1913) containing a trilobite and brachiopod sequence (Ross, 1949, 1951, 1953, 1968) that has come to be regarded as a comparative standard for Early and early

Middle Ordovician faunal correlations in the North American Faunal Province. Shelly faunas have not been recorded from the uppermost part of the St. Charles Formation, and there has been no available macrofossil evidence to support claims that the Garden City Formation conformably (Ross, 1949, 1951) or disconformably (Williams, 1948; Richardson, 1913) overlies the St. Charles Formation.

The present study was initiated to provide a conodont zonation for the upper part of the St. Charles Formation and lower part of the Garden City Formation and to evaluate the conodont evidence for the possibility that the contact between the formations represents a hiatus. The conodont zonation also provides a partial basis for comparison of Ross' (1949, 1951) trilobite Zone A through lowest Zone D with other known conodont and trilobite sequences. The upper 60-75 m (200-250 feet) of the St. Charles and the lower 50 m (165 feet) of the Garden City Formations were sampled for conodonts at four localities in the western limb of the Logan Peak syncline of the Bannock thrust sheet (Richards and Mansfield, 1912; Williams, 1948), Bear River Range, northern Utah and southeastern Idaho (fig. 1). These sections are at or near Ross' (1949, 1951) localities at Franklin Basin and Hillyard Canyon, Franklin County, Idaho, and Blacksmith Fork Canyon and Green Canyon, Cache County, Utah. Associated trilobites, petrographic features, and regional stratigraphy are presently under study by M. E. Taylor and J. E. Repetski. The results reported here apply to the central portion of the Bear River Range, Utah-Idaho, and may or may not be applicable to the

lowest beds of the Garden City Formation in other localities in the northern Great Basin and central Rocky Mountain regions.

The contact between the St. Charles and Garden City Formations is an abrupt change from massively weathering, cliff-forming, locally sucrosic dolostones below, into thin- to medium-bedded limestones above. An interval of thin-bedded, cross-bedded, fine-grained, brownish-grey dolostone with dolomitized intraclasts and sparse quartz sand is generally present above the massive dolostones. This thin-bedded dolostone unit is dissimilar to dolostones in the St. Charles Formation and was assigned to the Garden City Formation in the course of field work. The thin-bedded dolostone unit in the basal Garden City Formation is 0.15 m (0.5 feet) thick and 6.15 m (20.5 feet) thick, respectively, in the well-exposed Franklin Basin and Blacksmith Fork sections. This dolostone unit is 14.8 m (49.3 feet) thick at Hillyard Canyon but is partially repeated by a small fault along the measured traverse. Some fault-related dolomitization may have taken place in the lowermost Garden City Formation at Hillyard Canyon, but thin-bedded dolostone at Franklin Basin and Blacksmith Fork Canyon is not associated with faulting and may be of early diagenetic origin. Finally, considerable tectonic shearing has taken place in the upper St. Charles Formation in the Green Canyon section and appears to be related to an easterly dipping fault zone. However, at least 2.77 m (9.25 feet) of thin-bedded dolostone is present at the base of the Garden City Formation at Green Canyon.

CONODONT BIOSTRATIGRAPHY

Remarks.--When present, conodonts are sparsely represented in the upper part of the St. Charles Formation (commonly less than 5 elements per kilogram) and provide a satisfactorily resolved correlation only for the uppermost 6 m (20 feet) of the formation. Diverse and abundant conodont faunas (greater than 500 elements per kilogram) characterize the lowermost dolostone and lower limestones of the Garden City Formation. The observed faunal sequence and the local range zones of selected conodont taxa are recorded in figures 2-5.

St. Charles Formation.--Clavohamulus elongatus Miller, 1969 (=C. elongatus and C. primitivus Miller, 1969), with Cordylodus proavus Müller, 1959, sensu formo (s.f.), Eoconodontus notchpeakensis (Miller, 1969), and Teridontus nakamurai (Nogami, 1967) occur in the uppermost St. Charles Formation at Franklin Basin (upper 7.8 m; 26 feet) and at Hillyard Canyon (upper 3.3 m; 11 feet) in association with Cordylodus intermedius Furnish, 1938, s. f. This assemblage indicates correlation with the uppermost Notch Peak Formation, Ibex area, west-central Utah (Miller, 1969, 1978, 1980; Hintze and others, 1980). A comparable fauna is present in sample D3185-C0 from at least 10.8 m (36 feet) below the top of the St. Charles Formation at Green Canyon.

A highly resolved biostratigraphic correlation of conodont faunas from the uppermost part of the St. Charles Formation is not possible, although an interval in the upper part of the Cordylodus proavus Zone (Clavohamulus elongatus through, possibly, C. hintzei Subzones) is indicated for these Early Ordovician (Canadian)

faunas. Clavohamulus elongatus has been reported to be restricted to the C. elongatus Subzone (middle Cordylodus proavus Zone) in the Ibex area, whereas Cordylodus intermedius s. f. first appears in the superjacent Hirsutodontus simplex Subzone in that area (Miller, 1978, 1980; Hintze and others, 1980). However, Miller (1969) has also noted that the local range zone of C. elongatus overlaps that of C. hintzei, the eponymous species of the uppermost subzone of the Cordylodus proavus Zone, whereas C. intermedius s. f. ranges lower in the Cordylodus proavus Zone.

The biostratigraphic correlation of the uppermost part of the St. Charles Formation at Green Canyon, Hillyard Canyon, and Franklin Basin with the Clavohamulus elongatus Subzone(?) is proposed in this report because conodonts such as Utahconus spp., Hirsutodontus simplex, Clavohamulus hintzei, and Monocostodus sevierensis (Miller, 1969), which first appear in the upper part of the Cordylodus proavus Zone, are not present in the rich collections (more than 1,000 elements) from this interval. This admittedly negative evidence does not rule out the possibility that C. elongatus Subzone(?) of the uppermost part of the St. Charles Formation may actually include upper parts of the Cordylodus proavus Zone.

Samples from the uppermost St. Charles Formation at Blacksmith Fork Canyon yielded C. intermedius s.f. in the absence of Clavohamulus elongatus. The uppermost St. Charles at this

section is lowest Canadian, and there is no evidence for or against a tentative correlation with the middle Cordylodus proavus Zone.

Conodont-based correlation of lower beds in the upper St. Charles Formation are much more problematical. The local range zones of primitive cordylodans extends 13.5 m (45 feet) (sample D3102-CO) and 18 m (60 feet) (sample D3182-CO) below the top of the St. Charles at Blacksmith Fork and Green Canyons, respectively, and indicate that these portions of the section represent the Cordylodus proavus Zone of the uppermost Trempealeauan Stage and lowest Canadian Series. Eoconodontus notchpeakensis in samples D3101-CO and D3179-CO from 45.6 m (152 feet) and approximately 66 m (220 feet), respectively, below the top of the St. Charles Formation at Blacksmith Fork and Green Canyons indicate that these portions of the sections represent strata no older than the middle Trempealeauan Saukiella junia Subzone of the Saukia Zone (middle Proconodontus Zone), although a correlation with any portion of the lower and middle Cordylodus proavus Zone cannot be ruled out on the basis of the sparse faunas. The Trempealeauan-Canadian (Cambrian-Ordovician) boundary is within the lower portion of the documented cordylodan local range zones in these four sections or may be somewhat lower. Minor normal faults and problematical covered intervals in the Franklin Basin and Hillyard Canyon sections that probably contain faults are apparently responsible for the extended local range zones of cordylodans and Eoconodontus at these two localities.

Eoconodontus, Teridontus, and the cordylodans are the eurytopic and geographically widespread components of the conodont faunas from the upper part of the St. Charles Formation. These forms are known from North American peritidal carbonate platform sequences, deeper water limestones and shelf carbonates, and continental slope deposits (Landing and others, 1980).

Hirsutodontus, Semiacontiodus, and Clavohamulus, which dominate samples from the upper part of the St. Charles Formation, are best known from carbonate platform sequences in North America (Miller, 1969, 1978, 1980) and Siberia (Abaimova, 1975; Abaimova and Markov, 1977), and are considered here to be characteristic of shallow marine facies deposited under highly variable environmental conditions. Protoconodonts and paraconodonts are not present in the upper St. Charles Formation, although they may comprise more than half of the conodont elements from coeval deeper water limestones and slope deposits (E. Landing, 1982).

Fauna B (upper part).--Conodonts from the lowest part of the Garden City Formation at Franklin Basin and Hillyard Canyon are considerably younger than those from the underlying uppermost St. Charles Formation and are somewhat older than the lowest Garden City faunas at Blacksmith Fork and Green Canyons. This oldest fauna of the Garden City is comprised of some of the characteristic conodonts reported from conodont Fauna C of Ethington and Clark (1971), although it must be designated as upper Fauna B. Conodont Fauna C was originally defined (Ethington and Clark, 1971, fig. 2) by the association of thirteen form species. The lowest conodont fauna from the Garden City Formation

lacks Oistodus sp. (=oistodiform element of Triangulodis? n. sp. A), Loxodus bransoni Furnish, 1938, Clavohamulus densus Furnish 1938, "Paltodus" spurius Ethington and Clark, 1964, Chosonodina herfurthi Müller, 1964, and Drepanodus spp. s.f. These conodonts appear higher in the Garden City Formation where they are associated with most of the forms first appearing in the lower part of the formation. This lowest fauna of the Garden City lacks a complete component of species comprising Fauna C in its original formulation, and this distinctiveness is here emphasized by its designation as "upper Fauna B". Miller's (1977) definition of the base of an "upper Fauna B" based on the lowest occurrence of Cordylodus angulatus Pander, 1856, s.f. (= C. angulatus s.f. + C. rotundatus Pander, 1856, s.f.) is not appropriate to the Garden City Formation because this form appears only immediately below or within the stratigraphic interval with conodont Fauna C.

The key conodonts comprising upper conodont Fauna B are forms not present in the uppermost St. Charles and include (1) Semiacontiodus iowensis (Furnish, 1938) [= acontiodiform variants termed Acontiodus iowensis s.f. A. propinquus Furnish, 1938, s.f., and an element resembling but not comparable to A. staufferi Furnish, 1938, s.f. plus an unnamed asymmetrical element]; (2) "Oistodus" triangularis Furnish, 1938, s.f.; (3) multielement Acanthodus uncinatus Furnish, 1938, s.f.; (4) Utahconus? bassleri Furnish, 1938 [= Acodus oneotensis Furnish, 1938, s.f., P. bassleri s.f., P. variabilis Furnish, 1938, s.f., Scolopodus sulcatus Furnish, 1938, s.f., S. warensis Druce and Jones, 1971, s.f. (in part)]; (5) rare "Acanthodus" lineatus (Furnish, 1938) s.f.;

and (6) Drepanoistodus? n. sp. A. A dominant component of this fauna is represented by the striated and nonstriated elements, respectively, of Utahconus tenuis Miller, 1980, and New genus A. Cordylodan form species persist from the upper part of the St. Charles and include developmental variants with secondary basal tips [= "Cordylodus lindstromi" Druce and Jones, 1971] in the lower Garden City Formation. Cordylodus angulatus Pander, 1856, s.f., including C. rotundatus Pander, 1856, s.f. as an asymmetrical variant, appears in the upper part of upper Fauna B. Rare elements of New genus B appear through upper Fauna B of the lower part of the Garden City Formation. New genus A and B are also known from lower Fauna B of the Green Point Group, western Newfoundland (Landing in Fortey and others, 1982), but the forms in the Garden City Formation are different species.

Conodont assemblages comparable with upper Fauna B of the lower part of the Garden City Formation are presently incompletely documented. Comparable faunas are known from the Cape Clay Formation, southeast Devon Island, Canadian Arctic Archipelago (Landing and Barnes, 1981), an interval 55-180 m above the base of Member 3 of the Copes Bay Formation, northwestern Devon Island (Nowlan, 1976), the middle part of the House Limestone, west-central Utah (R. L. Ethington and D. L. Clark, 1980, written communication), and lower "conodont complex II", central Siberia (Abaimova, 1975).

Upper conodont Fauna B was recovered from laterally equivalent dolostones and limestones at Hillyard Canyon and Franklin Basin, respectively, and is not strongly lithofacially

associated in the lower Garden City Formation. Upper conodont Fauna B is present in the lower 4.5 m (15 feet) of the Garden City Formation at Franklin Basin, whereas trilobite Zone A of Ross is known to occur from 0.6 m (2.0 feet) to at least 5.7 m (19 feet) above the base of the Garden City Formation in this section (R. J. Ross, Jr. and M. E. Taylor, unpub. data). The correlation of trilobite Zone A of Ross has long been problematical. Winston and Nicholls (1967) compared trilobite Zone A with their concept of the Missisquoia Zone in the Llano area of Texas, whereas Norford (1969) compared it with both the Missisquoia and Symphysurina Zones of Winston and Nicholls (1967). Stitt (1977) proposed a somewhat younger equivalency with the Symphysurina Zone of Stitt (1971). Conodont data from the present study indicate that strata equivalent to the Missisquoia Zone, and, possibly, lower Symphysurina Zone are present below trilobite Zone A in the upper part of the St. Charles Formation, whereas trilobite Zone A of Ross corresponds to upper conodont Fauna B and lower conodont Fauna C. These conodont assemblages are younger than those from the Symphysurina brevispicata Subzone, which is equivalent to the upper part of the Cordylodus proavus Zone and the lower part of conodont Fauna B (Miller, 1980), while examination of trilobites indicates that trilobite Zone A is the zone most comparable to the Symphysurina bulbosa Subzone (M. E. Taylor, 1980, oral commun.). Strata equivalent to the upper Cordylodus proavus Zone and the

lower part of conodont Fauna B of the House Limestone of the Pogonip Group west-central Utah, are not present in the Bear River Range, Utah-Idaho.

Fauna C.--The base of Fauna C of Ethington and Clark (1971) is recognized herein at the lowest occurrence of Triangulodus? n. sp. A in the Garden City Formation. Triangulodus? n. sp. A was descended from Utahconus tenuis and differs primarily by the presence of an oistodiform element [=Oistodus sp. of Ethington and Clark, 1971]; it has been illustrated in Iran as Oistodus parallelus s.f. and Acodus oneotensis s.f. by Müller (1973), and in Queensland as O. lanceolatus s.f. and A. oneotensis by Druce and Jones (1971). Representatives of most of the taxa from the upper part of Fauna B persist into conodont Fauna C of the Garden City Formation. "Acanthodus" lineatus (Furnish, 1938) s.f. is extremely abundant in Fauna C, whereas rare specimens of Loxodus bransoni Furnish, 1938, s.f. and common specimens of "Paltodus" spurius Ethington and Clark, 1964, s.f. occur above or at the lowest occurrence of T.? n. sp. A at Franklin Basin and Hillyard Canyon, respectively. Protopanderodus asymmetricus (Druce and Jones, 1971), presently described only from the upper Ninmaroo Formation, Queensland, Australia, and Walliserodus n. sp. A are abundant in conodont Fauna C in the Garden City Formation. Cordylodans are sparsely represented in the upper part of conodont Fauna C. Where abundant, they display a wide range of morphologic variability, and separation of form species becomes subjective in the large collections. Rare Cordylodus proavus s.f. elements in Fauna C either represent the persistence of this form species or

are indistinguishable variants of C. intermedius s.f. with an anteriorly convex basal cavity. Drepanodus concavus (Branson and Mehl, 1933) and Scolopodus rex Lindström, 1955, sensu stricto appear in the upper part of Fauna C but are rare.

Conodont Fauna C occurs with upper trilobite Zone A and Zone B of Ross at Franklin Basin and Blacksmith Fork and Zones B and C at Hillyard Canyon. Conodont Fauna C undergoes little change through this interval.

Conodont Fauna C appears in abundantly fossiliferous limestones 4.5 m (15 feet) above the base of the Garden City Formation at Franklin Basin, and only 0.6 m (2.0 feet) above the base of the formation at Blacksmith Fork Canyon in cross-bedded, linguloid-bearing dolostones. These data support three conclusions: (1) conodont Fauna C is not strongly lithofacially controlled in the Garden City Formation and occurs in laterally equivalent dolostones and limestones; (2) unless all of upper conodont Fauna B as represented at the Franklin Basin and Hillyard Canyon sections is condensed into 0.6 m (2.0 feet) at Blacksmith Fork Canyon, the base of the Garden City at the latter section is younger than in the northern sections; and (3) trilobites from Zone A of Ross at Blacksmith Fork Canyon occur with conodont Fauna C and are younger than lower Zone A at Franklin Basin, which contains upper Fauna B conodonts. Conclusion 2 provides some information about the relief of the erosional surface developed on the St. Charles Formation prior to deposition of the Garden City Formation in the Bear River Range. The 4.5 m (15 feet) of section with upper conodont Fauna B at Franklin Basin is not present at

Blacksmith Fork Canyon. Upper Fauna B is present at least through the lower 11.7 m (39 feet) of the Garden City at Hillyard Canyon. Although boundary beds of the St. Charles and Garden City Formations are not exposed at Green Canyon, conodont Fauna C occurs 3.9 m (13 feet) above the highest outcrop of St. Charles Formation. A sub-Garden City Formation surface with approximately 12 m (40 feet) of relief is present in the Bear River Range, Utah-Idaho. The surface is a diachronous disconformity with older units present at the base of the Garden City in the northern sections.

Conodont Fauna D.--The distinctive conodont assemblage representing Fauna D of Ethington and Clark (1971) first appears at approximately the same level as the base of the range zone of trilobite Zone D of Ross at Franklin Basin, Hillyard Canyon, and Blacksmith Fork Canyon. "Acanthodus" lineatus (Furnish) s.f., A. uncinatus Furnish s.f., Scolopodus? parallelus (Branson and Mehl), S. rex Lindström, and Drepanodus concavus (Branson and Mehl) are among the few euconodonts to persist from Fauna C. Acanthodus uncinatus persists into the lowest part of conodont Fauna D at Franklin Basin, whereas "A" lineatus s.f. persists into the lower 66 m (200 feet) of conodont Fauna D in the Garden City Formation. Abundant elements of multielement Scolopodus filiosus Ethington and Clark, 1964, and Scalpellodus n. sp. A [= Protopanderodus? n. sp. 1 and P.? n. sp. 2 of Repetski (1975)], mark the base of Fauna D in the Garden City Formation. Rare elements of Scolopodus gracilis Ethington and Clark, 1964 [= S. gracilis s.f. and S. triangularis Ethington and Clark, 1964, s.f.] and S. quadruplicatus Branson and Mehl 1933 [= S. quadruplicatus

s.f., S. robustus Ethington and Clark, 1964, s.f., Acontiodus staufferi Furnish, 1938, s.f., and S. triplicatus Ethington and Clark, 1964, s.f.] first appear in lower Fauna D. Lower Fauna D conodonts are also present in the lower Fillmore Formation of the Pogonip Group, west-central Utah (Ethington and Clark, 1971; Ethington, 1979), in the lower part of the El Paso Group, west Texas (Repetski, 1975), and in upper "conodont complex II" through "conodont complex IV" in central Siberia (Abaimova, 1975).

The base of conodont Fauna D may lie slightly above the base of trilobite Zone D of Ross. Conodonts tentatively referred to upper Fauna C are associated with trilobites of Zone D of Ross in the basal bed of the Highgate Formation of Landing (1979) in northwestern Vermont.

COLOR ALTERATION INDICES

Conodont elements from the base of the Garden City Formation at Blacksmith Fork and Hillyard Canyons and Franklin Basin have a color alteration index (CAI; see Epstein and others, 1977) corresponding to low 4. This index has been associated with the upper thermal limit for dry gas production (Epstein and others, 1977, p. 24), and can be attributed to a normal thermal gradient at the base of known overburden [Lower Ordovician through Pennsylvanian, 4,920 m (16,400 feet)] in the Bannock overthrust (Mansfield, 1927).

Conodont elements from the underlying St. Charles Formation at Blacksmith Fork and Hillyard Canyons and Franklin Basin include rare specimens with a comparable CAI of low 4. However, most elements from all samples from the stratigraphic interval

investigated seem to have an anomalously high index of 6.5, and are an opaque greyish-white. This greyish-white color is tentatively considered to be due to a leaching of organic matter from most conodont elements during the dolomitization of the St. Charles. If the interstitial fluids responsible for dolomitization can reduce the proportion of organic matter in conodont elements after burial and prior to heating, then the color alteration index determined for conodont elements from limestones (Epstein and others, 1977) may not be applicable to specimens from some dolostones. Such specimens may not become opaquely black (CAI=4) at elevated temperatures because of the reduction in original organic material. Similarly, the volatilization of fixed carbon would produce grey and opaquely white specimens (CAI=6 and 7) at somewhat lower temperatures and/or over shorter periods of heating than those required for a comparable color alteration of conodonts from limestones that did not undergo leaching.

Conodont elements from the upper St. Charles Formation have intensely corroded surfaces, and denticles and cusps are occasionally deeply pitted and secondarily reduced in size. Specimens from the thin-bedded dolostone forming the lowest part of the Garden City Formation are weakly corroded by comparison, and have a color index that is fully comparable to that of specimens from the overlying limestones. These differences are regarded as circumstantial evidence that corrosion and leaching of the St. Charles conodont elements are unrelated to and temporally antecedent to diagenesis of the Garden City Formation.

An anomalously high index of 5.5 is present in conodont elements from the upper part of the St. Charles Formation and lowest Garden City Formation at Green Canyon. These specimens come from the eastward-dipping shear zone in the bleached dolostones of the upper St. Charles and adjacent beds of the Garden City. Elevated CAI and bleaching in this section could be explained by the passage of hot fluids along the fault zone.

ACKNOWLEDGMENTS

This study was undertaken during the tenure of a U.S. Geological Survey-National Research Council Postdoctoral Associateship in 1979-1980, and is part of a multidisciplinary study of the paleontology, stratigraphy, and magnetostratigraphy of Cambrian-Ordovician boundary beds in the Western United States being conducted by S. L. Gillett, J. E. Repetski, and M. E. Taylor.

A thesis by J. L. Mason [1975, Conodont biostratigraphy of the lower Garden City Formation (Lower Ordovician) of northern Utah: Salt Lake City, Univ. of Utah, unpubl. M. S. thesis] contributed to the early stages of this study. Unpublished data of Lower Ordovician conodont sequences of the El Paso Group west Texas, by J. E. Repetski, and at the Pogonip Group, west-central Utah, by R. L. Ethington and D. L. Clark were made available to the author in the course of this study.

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Figure Captions

Figure 1. Index map of northern Utah and southeastern Idaho showing location of stratigraphic sections, sampled for conodonts.

Figure 2. Correlation and local range zones of selected euconodonts from the upper St. Charles and lower Garden City Formations at Franklin Basin, Franklin County, Idaho.

Figure 3. Correlation and local range zones of selected euconodonts from the upper St. Charles and lower Garden City Formations at Hillyard Canyon, Franklin County, Idaho.

Figure 4. Correlation and local range zones of selected euconodonts from the upper St. Charles and lower Garden City Formations at Green Canyon, Logan County, Utah.

Figure 5. Correlation and local range zones of selected euconodonts from the upper St. Charles and lower Garden City formations at Blacksmith Fork Canyon, Logan County, Utah.

Figure 1

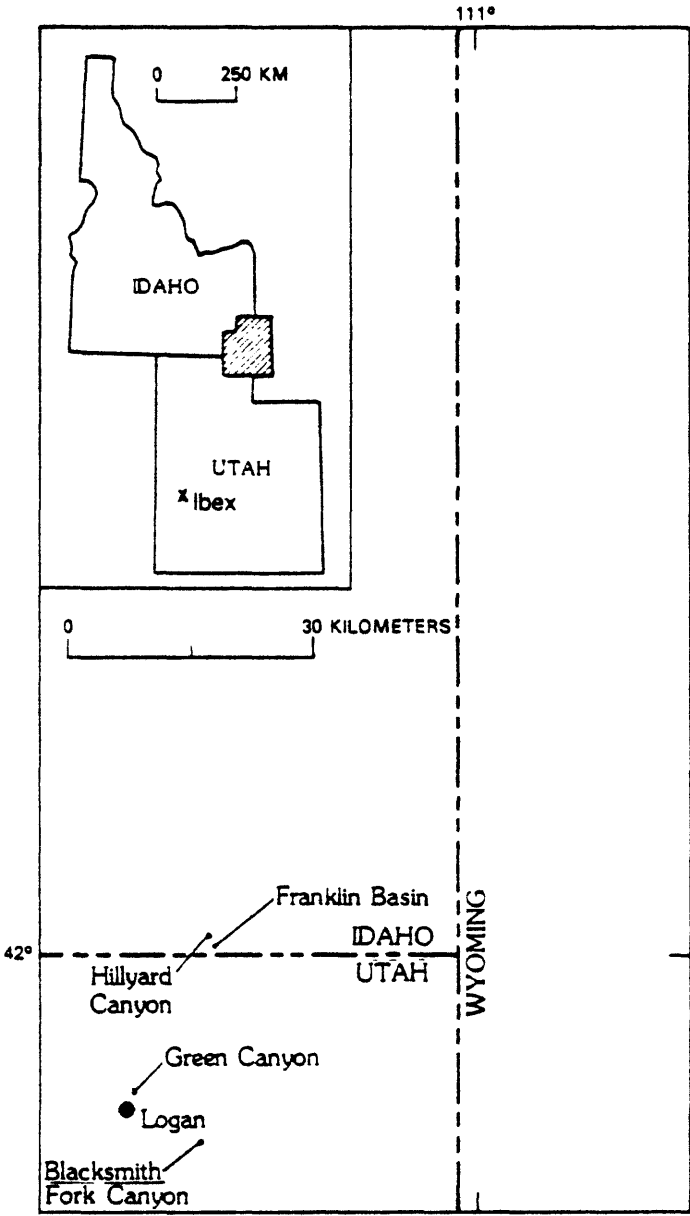


Figure 2

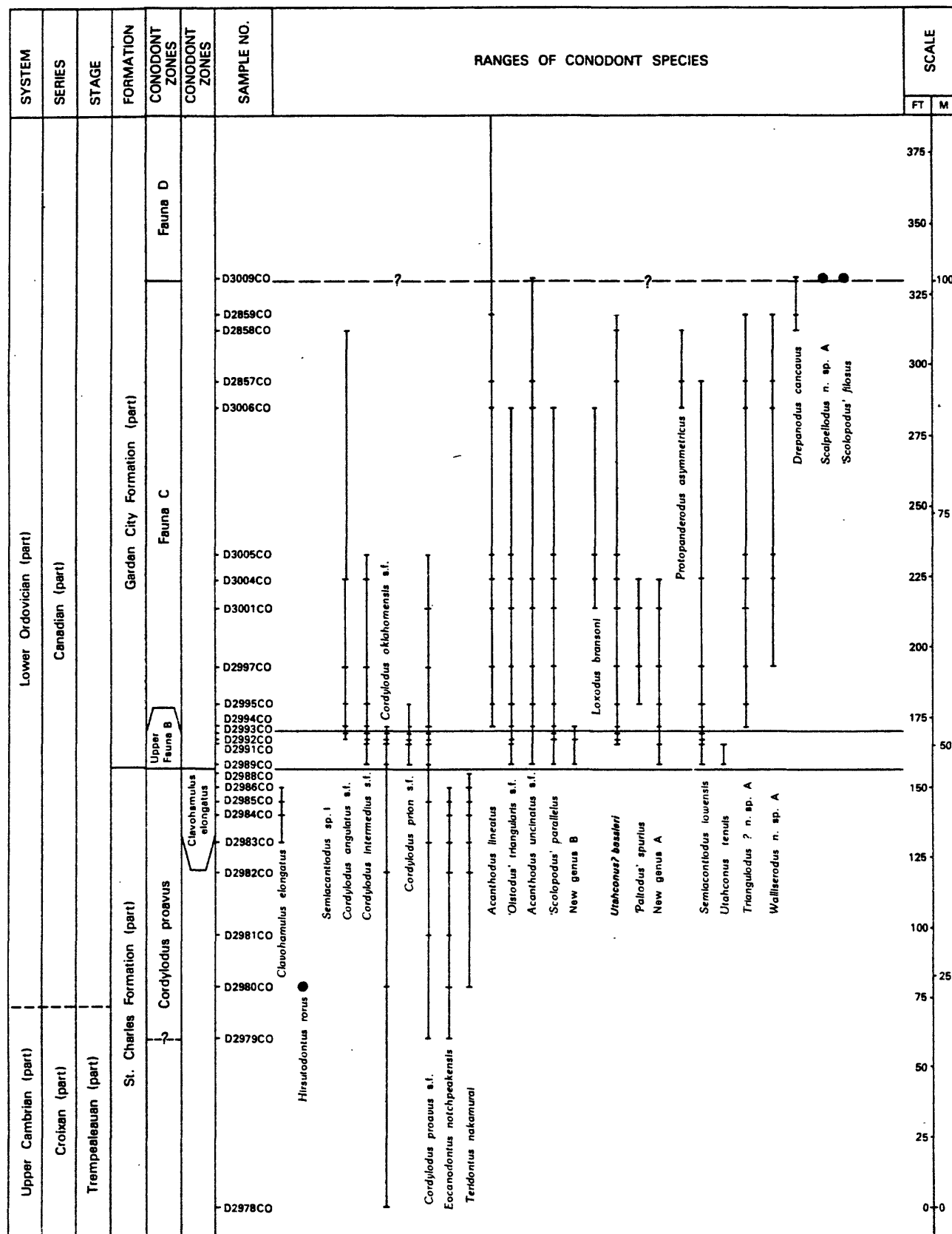


Figure 3

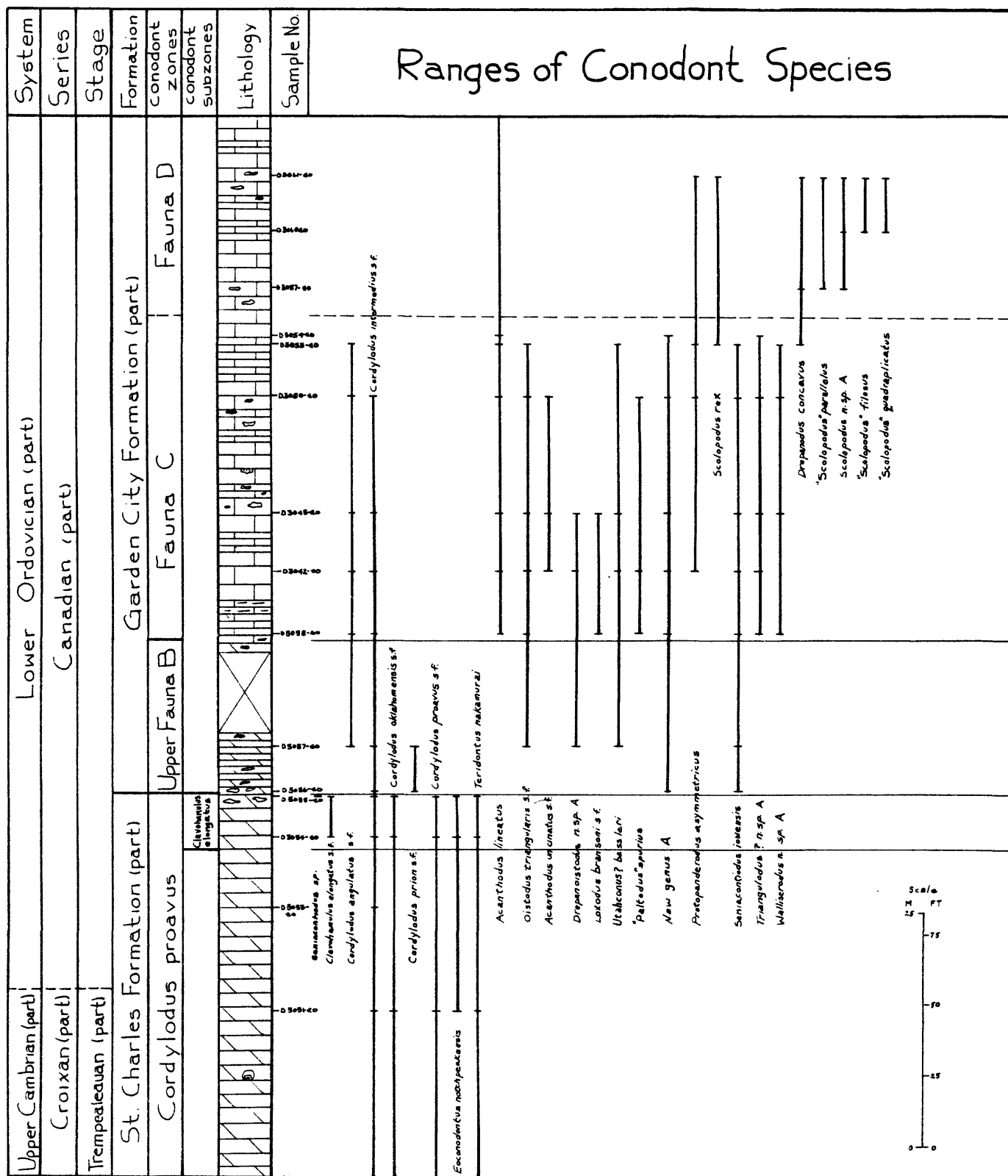


Figure 4

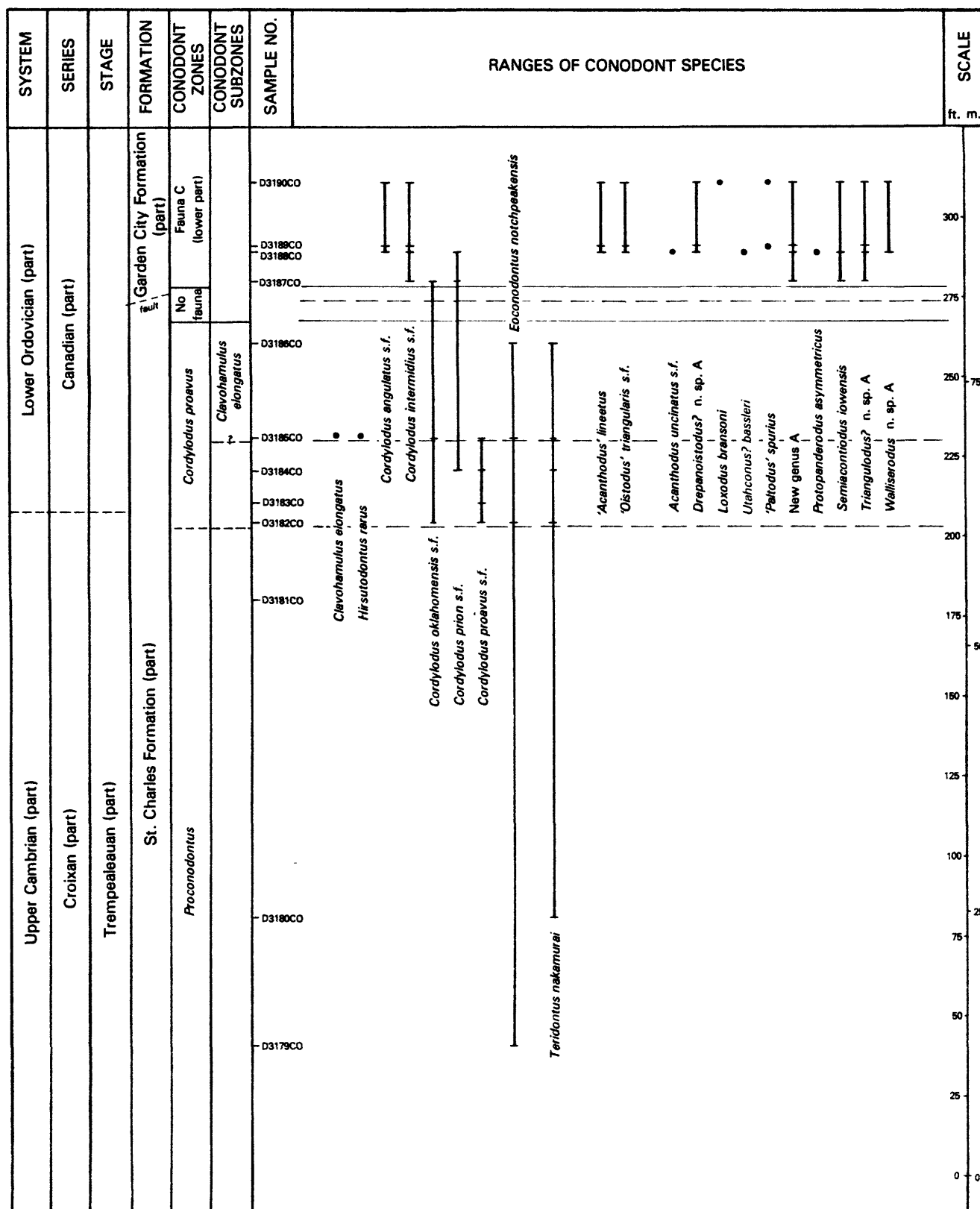


Figure 5

