History of Geology

Paleontological work of Lt. Col. C.C. Grant on the Silurian rocks of the Niagara Escarpment at Hamilton, Ontario

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Abstract
Lt. Col. Charles Coote Grant (1825-1914) organized the collection and donation of Silurian fossils at Hamilton and Grimsby in Ontario, over a continuous period from 1866 to 1914. He was a competent taxonomist and field geologist, who encouraged visits from professional geologists and wrote useful, if repetitive, papers in the 1889 to 1911 volumes of the *Journal and Proceedings of the Hamilton Association*. Grant anticipated a 20th-century trend in which field-oriented paleontologists become concerned with deductions from taphonomy and sedimentology.

Biography
Charles Coote Grant (Figure 1) was born on 15 September 1825 at Mallow in County Cork, Ireland. He was the son of the local protestant rector James Grant and his wife Theodosia Gethin Creagh, the grandniece of Lt. Col. Sir Eyre Coote. Grant joined the 13th (Bedfordshire) Regiment of the British army in 1845. In 1847 he married Asenath Rowswell (1828-1919) and started a family consisting of at least two sons and six daughters. His military life (Duggan, 1967) permitted him to continue a life-long interest in geology and included service in the Mediterranean, West Indies, Ireland, Quebec (1861) and Ontario (1866-1867). He was a short-sighted and absent-minded, kindly eccentric. In 1867, on rising to the rank of Lieutenant Colonel, he was posted from Hamilton, Ontario to the second battalion of the Bedfordshires serving in India. His wife persuaded him to retire on half pay in Hamilton rather than risk their lives in the climate of India. Grant (1910) notes that he was stationed at Fort Erie during the Fenian invasion of 1866 and first visited the Hamilton Niagara Escarpment on court-martial duty:

> "Having an idle day I found my way to one of the shale heaps where I met the late Professor (Rev. W.P.) Wright of Hamilton Ladies College returning from ... collecting some well preserved Clinton shells. What became of the Professor's shells when that institution ceased I do not know."

Spencer (1884) wrote the following acknowledgement to Grant in his description of benthic dendroid graptolites:

> "A Canadian locality was discovered at Hamilton, Ontario, in the Niagara Series, about the year 1868, by Lieut.-Col. Charles Coote Grant (H.P. 16th Reg't H.B.M. service) ... For the large number of specimens herein described, I am indebted to the generosity of the indefatigable worker Col. Grant."

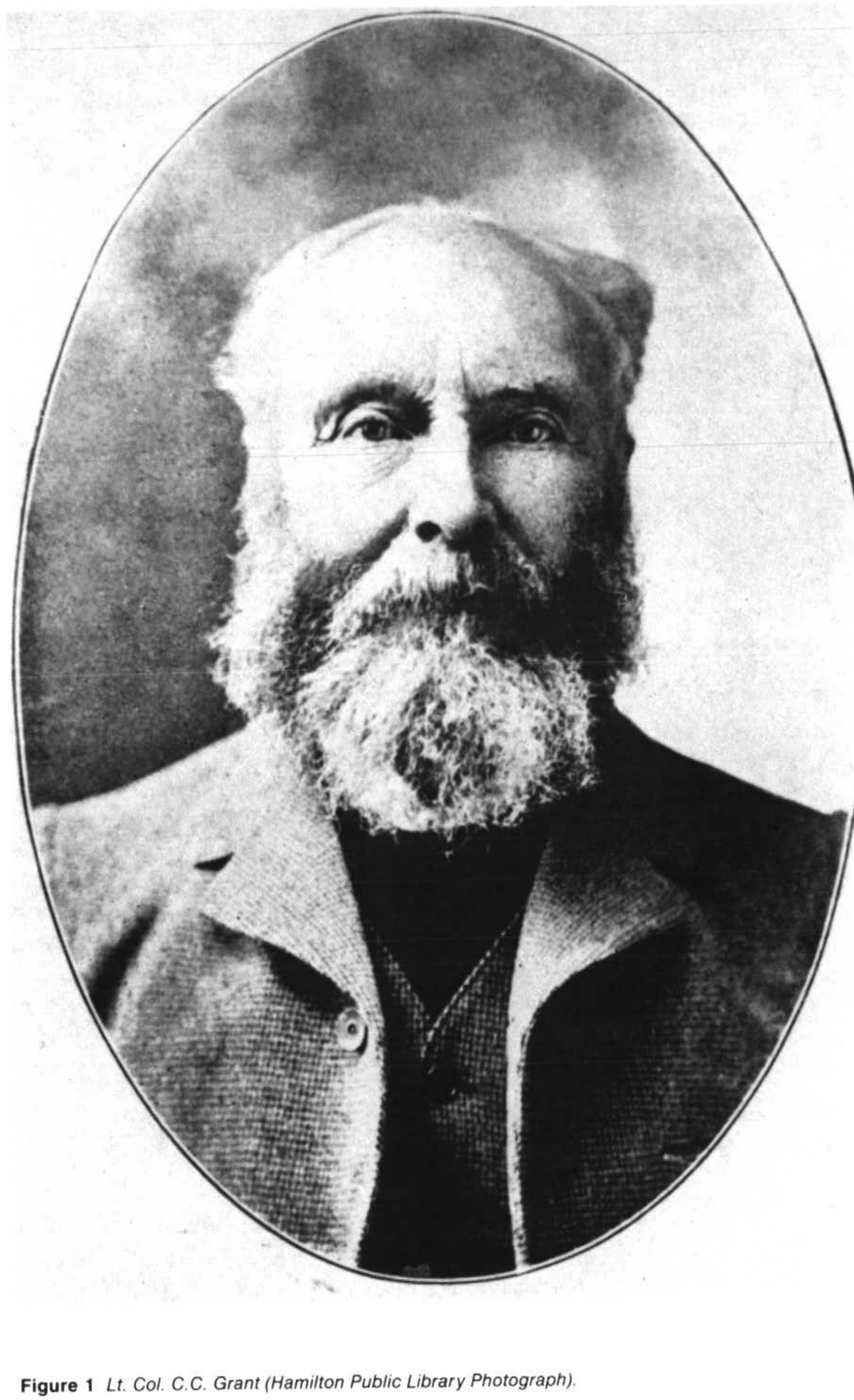


Figure 1 *Lt. Col. C.C. Grant (Hamilton Public Library Photograph).*

Table 1 Changes in lithostratigraphic terminology at Hamilton (not Grimsby) after 1914, based on specimen lithologies labelled by Grant and verified by his published papers and photographs. The modern correlation with New York (right) contains new revisions.

Lithostratigraphy of C.C. Grant	Revised: New York correlations
Upper Barton, Limeridge limestones	Oak Orchard Member (? Ludlow)
Barton Waterlime or new marl	Eramosa Member (Wenlock)
Barton Niagara Shale (8 to 18 m up)	Eramosa Member
Lower Barton Shale (8 m to *Avicula* bed)	U. Goat Island Member
U. or Glaciated Chert Bed	Ancaster Chert Beds of
M. or Main Chert Bed	Goat Island Member in the
L. or Lower Chert Bed	Lockport Dolomite Formation
Niagara Shale/base of chert	Shale marker (0.1 m)
First Niagara limestone below chert	
U. Blue Building Beds (trilobites)	Upper Gasport Member reefs
2nd and 3rd Niagara limestones below chert, L. Blue Building Beds	Gasport Mbr., Lockport Fm. (Lower crinoidal facies)
The Sand Beds, *Strophodonta* and corals	DeCew Member or Rochester
Niagara Shale and thin dolomite beds	Rochester Shale Formation
The Nigger Head	Irondequoit Formation (base of Wenlock Series)
First L. Niagara limestone	Rockway Mbr., Reynales
2nd or *Stricklandia* limestone	Rockway Mbr.
Barren Niagaras	Rockway Mbr. (Clinton)
Pentamerus bed, base of Niagara Series	Merriton Member, R. Fm.
Alga bed (50 mm)	? Neahga Member, R. Fm.
U. Clinton Green Band	Thorold Sandstone Member (upper Medina Formation)
Clinton Iron-Band, U. Red Band	Grimsby Shale Member
L. Clinton Shale or Green Band	Cabot Head Shale Member
Indurated limestone shale	
Clinton Passage Beds	Manitoulin Dolomite Member (absent in New York)
Medina Grey Freestone or Grey Band	Whirlpool Sandstone Member (basal Medina Formation)
Red Medina Shale	Queenston Shale Formation
Hudson River Series (in glacial drift)	Georgian Bay Formation

Table 2 Index to relevant papers by C.C. Grant listed below.

Topic	Main references
Oak Orchard Mbr.	1895b, 1897c, 1899, 1902b, 1902c
Eramosa Mbr.	1892a, 1894a, 1899, 1905a, 1905b
U. Goat Island Mbr.	1895a, 1898, 1900, 1901a, 1910
U. Chert bed	1889a, 1894b, 1899, 1901a, 1907a
M. Chert bed	1896b, 1900, 1902a, 1903b, 1904
L. Chert bed	1891b, 1892b, 1901a, 1905a, 1906b
Shale marker	1892b, 1896a, 1902a, 1904, 1910
Gasport Member	1894c, 1901b, 1903a, 1908b
Rochester Fm.	1892b, 1896a, 1905b, 1906b, 1907a
Reynales Fm.	1890, 1892b, 1896b, 1899, 1902
Thorold Mbr.	1898, 1899, 1906a
Grimsby Mbr.	1895, 1899, 1901a, 1903b, 1908a
Cabot Head Mbr.	1891a, 1892b, 1893, 1896a, 1910
Manitoulin Mbr.	1892a, 1892c, 1895c, 1906a
Whirlpool Mbr.	1892c, 1893, 1897b, 1900, 1907a
Pre-Medina Fm.	1893, 1897a, 1901d

The North American graptolite memoir of Rudolf Ruedemann (1947) included the following acknowledgement to later collecting, making up for the loss of the Spencer type material by fire at the University of Missouri in 1891:

> "Colonel C.C. Grant made an amazing collection at Hamilton, Ontario; in the Lockport Dolomite, first described by Spencer and revised ... largely from collections in the US National Museum."

Modern students of paleoecology and taphonomy, who wish to know the precise stratigraphical position and history of the largest dendroid graptolites will only find coded information in these and other paleontological papers (e.g. Bassler, 1909). Grant comments:

> "If you are unable to point out the exact position of the beds, I have ever considered it a serious drawback to the pleasure of collecting ... Whenever practicable I trace the layer to its original place. Sometimes the clay resting on it may conceal indication of organic remains, so it may be necessary to put them on the roof of a shed to weather" see also Grant, 1910. In my search for fossils in Europe and this continent ... I have almost invariably found the most likely place to find them was in a thin lime or sandy layer enclosed by shale or mud ... It not only covers dead shells, etc., but entombs animals, also plants, bryozoans and such things as were unable to escape. Thus rivers for example, ... when flooded carry off and convey to the sea, large quantities of silt, depositing it on the sea bed." (Grant, 1892c)

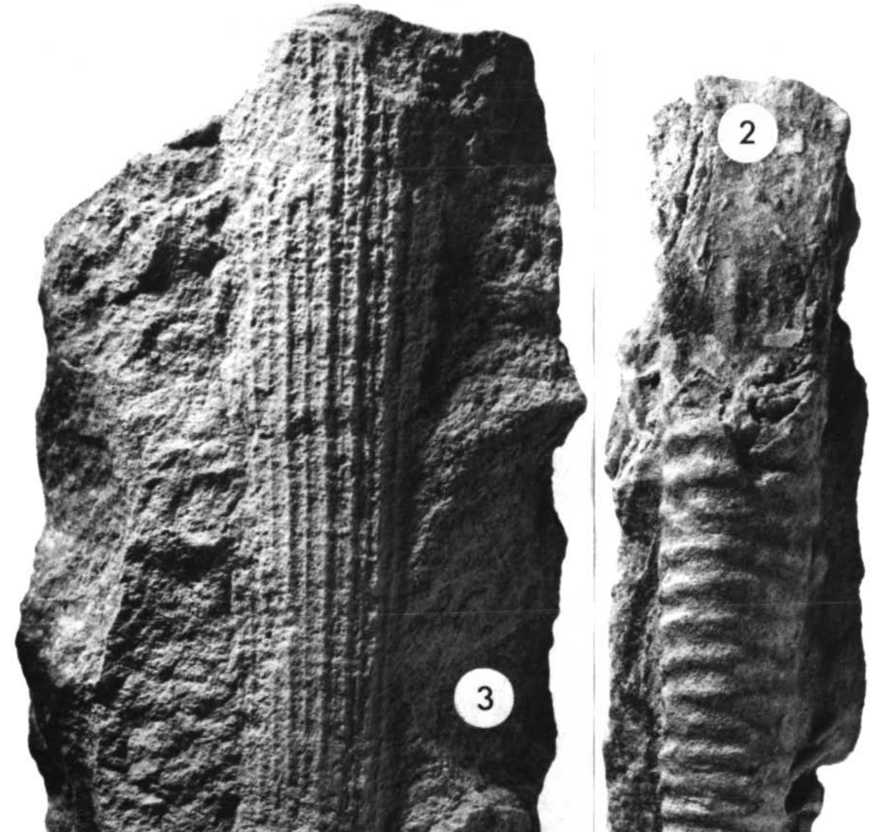
Even by the standards of his own day, Grant would not qualify as a paleontologist; he described no new species and merely glued labels on his specimens to record their names and a consistent, local lithostratigraphy (Tables 1-2). His papers strayed into fields such as sedimentology. Jones (1984) notes that "his views on evolution were not a little suspect in a town with a strong Calvinist tradition". A rather misunderstood "Col. C.C. Grant Soldier, Poet and Geologist" was described in the 10 August 1907 edition of the *Hamilton Herald* by J. Tinsley, and by Child (1932). His only joint paper was based on a visit to Anticosti Island in 1885 (Grant and Dawson, 1887). Grant continued to collect fossils until a few months before he died at 293 Bay Street South, Hamilton, in August 1914.

History of fossil collecting

The succession at Hamilton (Table 1) consists of the red, Richmondian (Ordovician) Queenston Shale Formation (150 m), overlain by imperfectly dated, varied marine rocks of the Medina Formation (30 m). Silurian argillaceous dolomites of the Reynales (3 m), Irondequoit (1 m), Rochester (5 m) and Lockport Formation (Bolton, 1957; Sanford *in* Segell, 1972) are correlated by Rickard (1975). These terms were seldom used before 1914 (Table 1).

When Grant first arrived in Hamilton, a building and grindstone industry had extensively exploited the silica cemented freestones of the Whirlpool Sandstone (Figure 2) for about 15 years. The "real workable beds" averaged 1.5 to 1.8 m in thickness and were exhausted by 1880. Attention shifted to the overlying dolomite freestone and roadstones. Grant soon discovered benthic dendroid graptolites (Figures 4, 6, and 7) within the apparently nonfossiliferous dolomites, most notably in the Merriton Member at the Russell Quarry above Lower James Street and the Lockport Formation at the adjacent Hancock Quarry (beside the modern footpath up the Jolley Cut, 0.8 km further east). They were also worked in the Webber and City Quarries, between the Jolley Cut and Strongmans Drive 0.6 km to the west.

Grant refers to three fossil localities found during the construction of the Hamilton and Lake Erie Railway between 1872 and 1875. Articulated starfish (*Promopalaester granti* (Spencer)) and unusually coloured apatite shells of the brachiopod *Lingula* were within a massive sandstone unit of the Medina Formation. Spencer (1884) implies an origin in the red Grimsby Member, although Grant found the type *Promopalaester cataractensis* (Schuchert) in the green Cabot Head Member (S346). Stalked echinoderms known as cystoids occur with interlocked arms on a



Figures 2 and 3 *Bedding plane views of two orthocerid nautiloids collected by Grant at the Jolley Cut.* **Figure 2** *is a ventral view of a cyrtoconic mold of a Richmondian* Gorbyoceras *(length 140 mm). It was collected on the base of a thick sandstone bed, still seen 2.0 m above the base of the Whirlpool Sandstone. Labelled "RM 1108* Orthoceras *sp. Medina — Hamilton, Ontario, Donor Col. Grant".* **Figure 3** *shows a dolomite lithology from the base of a 0.4 m thick biostrome overlying the Gasport crinoidal facies. The 32-ribbed* Kionoceras *was figured by Grant (1910) as "no. 1" (S-319).*

bedding plane 1.2 m above the base of the Rochester Shale Formation. Just south of this site, at the eastern end of Limeridge Road, Grand found *in situ* type specimens of the sponge genus *Aulocopina* (Billings) within the "upper layers" of the Ancaster Chert Beds. Adjacent fields probably yielded the type material (now lost) of another sponge genus, *Astroconia* (Sollas).

Wishing to spare the old gentleman from the Stricklandian demise described by Forbes (1854), the Grand Trunk (Canadian) Railway banned Grant from trespassing on their railway. Childs (1932) notes that:

> "The labourers on the railroad were terribly afraid that he would be run into by passing trains or injured by blasts in the quarry. Such things seemed to be absolutely a matter of indifference to him."

Thus Grant's "glaciated chert bed" shelly fossils came mainly from fields overlying the Ancaster Chert Beds in this Upper Kings Forest district. Spencer (1883) and Hewitt and Birker (1986) discuss his overlying and adjacent Redhill Creek section (Figure 8) and present locality maps.

The collections and fame of Grant were preserved by professional geologists from the United States. They included James Hall, J.M. Clarke and Rudolf Ruedemann of the New York State Museum at Albany; R.A. Bassler and Charles Schuchert from museums in Washington; Charles Doolittle Walcott of the United States Geological Survey and J.W. Spences of King's College (Nova Scotia), who moved to the University of Missouri. Grant organized the Geology Section of the Hamilton Association Museum with A.E. Walker and A.T. Neill. Large collections were also sent to E. Billings at the Geological Survey of Canada at Montreal, J.W. Dawson at the Redpath Museum of McGill University (prefix RM), the British Museum of Natural History (1899 to 1912) and Bristol City Museum (in 1880). Other surviving collections were donated later to the Royal Ontario Museum, McMaster University (prefix S) and the University of Toronto.

The graptolite succession

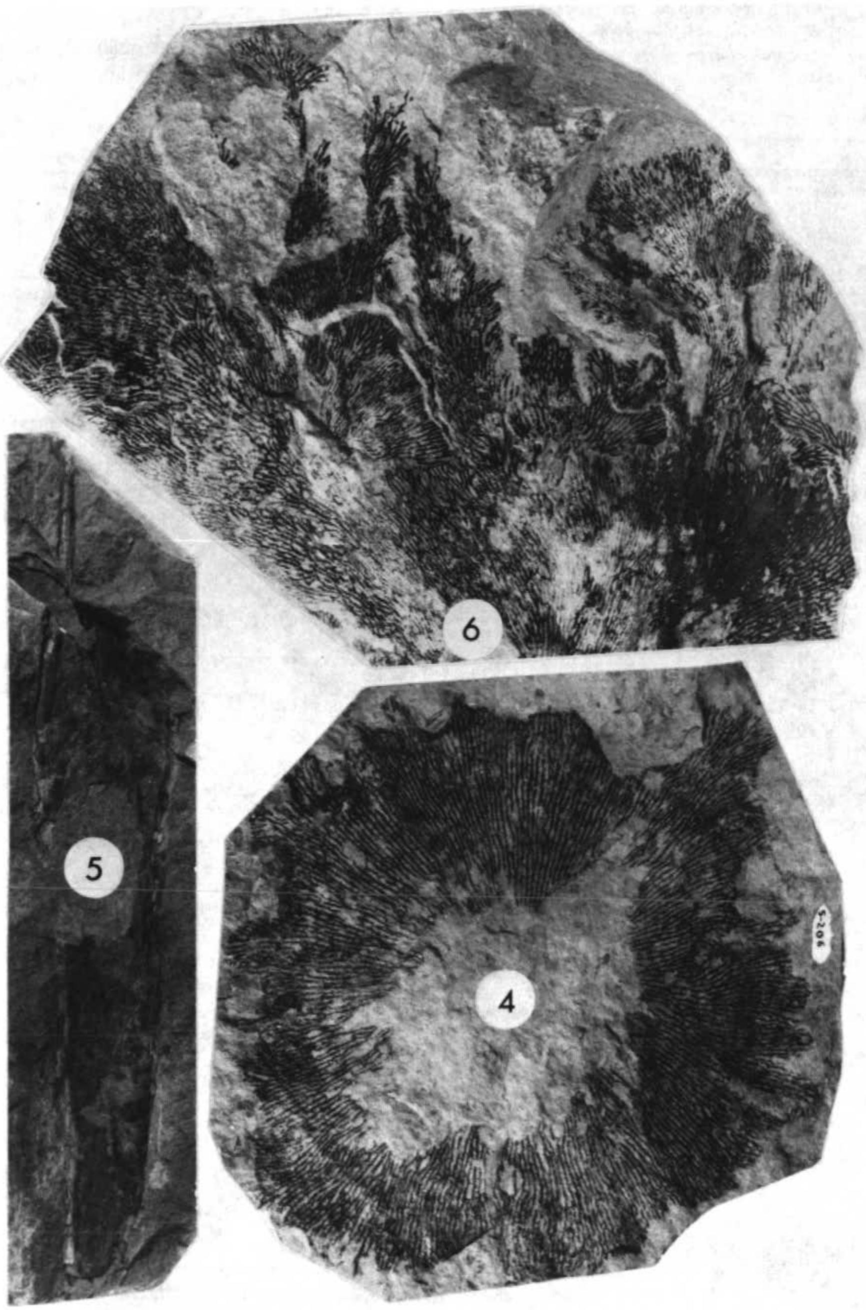
Grant reported a *Dictyonema*-bearing "graptolite bed" in the Cabot Head Member and found similar small dendroid graptolites in the lower Rochester Formation. But only two of the described graptolite type specimens did not originate from the Lockport Formation of the Jolley Cut and Redhill Creek. They are the type *Cyclograptus rotadentatus* (Spencer) and the type *Desmograptus micronematoides* (Spencer), which Spencer (1884) identifies as having come from a lower assemblage of seven so-called species reported by Grant from the Merriton Member. The origin of genuine Lockport (Wenlock) graptolites at the Jolley Cut was discussed by Spencer (1884):

> "[The] beds in which they are principally found are those about six feet above the base of the chert beds, and in the more shaly dolomites underlying (i.e. 1.8 m apart)."

Grant (1907a) describes the existing adjacent cliff at Strongman Drive in his own terminology:

> "In a recent visit I noticed that a shot had been fired in the blue building beds at the base of the chert, which disturbed the thin limestone layer at the top, which contains fucoid impressions."

These *Chondrites* are 130 mm below the top of a shale marker used here to define the base of the Ancaster Chert Beds (upper chert bed of Laird (1935); same usage as Bolton (1957) in his type section). They correspond to the level yielding type graptolites in "shaly dolomite". This shale is seen for 15 km along the escarpment, from West Flamborough and Ancaster to Upper Kings Forest.



Figures 4, 5 and 6 *Bedding plane views of suspension feeding fossils in the Goat Island Member.* ***Figure 4*** *is labelled "S-206* Dictyonema crassibasale, *Lockport Hamilton" and is specimen "no. 3" of Grant (1904). It originated from below the shale marker. The type* Dawsonoceras *(Hyatt) (Foreste, 1928) also came from this tabular bed (0.2 m).* ***Figure 5*** *was labelled by Grant* "Conularia sp. Niag. Chert Mid. Sil. Hamilton, Ont." *(RM 14778). The 0.5 mm thick francolite welts separate from 12 to 20 mm in 130 mm as in* Sphenothallus corrugatus *(Ruedemann) from the Rochester Formation.* ***Figure 6*** *shows a small fragment resembling the delicate graptolite colonies in the highest chert bed (e.g. "Calyptograptus" of Grant (1907b), "no. 3"). Dimensions 205 mm × 135 mm. Labelled "S-201* Callograptus, *Hamilton, Lockport".*

Grant (1892b) therefore implies that five and a half feet (1.7 m) of "Blue Building Beds" extended downward from the 0.1 m thick shale. They included 0.9 m of the basal Goat Island Member of J.T. Sanford (*in* Segell, 1972) and one metre of Lower Gasport Member crinoidal bar facies (Crowley, 1973). They are correlated with the Gasport here. Grant cites an interval of 17.5 feet plus 5.5 feet (7.0 m) between the top of his "Blue Building Beds" and the well-defined top of the 1.4 m thick Irondequoit Formation. He indicates that only the upper Blue Building Beds with trilobite heads and tails were fossiliferous. This so-called Niagara limestone contains, orthocones (*Dawsonoceras*), trilobites (*Bumastus, Encrinurus*), conical *Dictyonema* (Figure 4) and conulariids (Dyer, 1921). It is an 0.6 m thick carbonate build-up (Armstrong, 1953), capped by a tabular bedded crinoidal dolomicrite (0.2 m). Grant (1896b) also went to the Hancock Quarry and

> "carefully noted the *in situ* position of the different graptolites in the Niagara Chert. The richest layer of rock which contained them was noted as occurring exactly six feet below the glaciated chert of the upper bed" (i.e. 1.8 m down the 3.6 m thick unit).

Ecological notes on the Ancaster Chert Beds

Grant made the important observation that only benthic graptolites, inarticulate brachiopods, an 80 mm long epifaunal bivalve (*Cornellites*) and a few other suspension feeders were widespread and unstunted in the Goat Island Member at Hamilton. For example, the trilobite *Bumastus* declined in width from 80-100 mm in the Gasport to 20-30 mm in the so-called glaciated chert bed.

The graptolite fauna shows an upward decrease in diversity at the Jolley Cut quarries, six new species being first described

Figure 7 *S-199 A fragment labelled "*Inocaulis plumulosus *Hall, Lockport, Hamilton".*

Figure 8 *A largely bedding parallel* Armenoceras *(75 mm long) found by the author on a loose block of massive and bituminous dolomite in March 1985. It was beside Upper Ottawa Street, 800 m east of a 4.6 m section on Red Hill Creek (first Carpenter or mineral quarry; Spencer, 1883, p. 137 and 162). The specimen is of particular interest since it enabled Dr. P.M. Clifford (McMaster University) to cite it as evidence of 95% dolomite loss by pressure solution in one bituminous layer (Oak Orchard equivalent). This new application of fossil collecting was not missed by Grant (1897c) when he recalled a visit to the working quarry: "I noticed there an unusual number of crushed cephalopods so completely flattened by overpressure that it was altogether impossible to form any idea regarding the species whenever four or five were massed together irregularly".*

from the "glaciated chert bed", compared with nine from the "main chert bed" and thirty from the "Niagara limestone" (excluding Reynales). The lower 0.55 m of the Ancaster Chert Beds is a relatively massive and unbioturbated dolomicrite with some sponge debris. Grant implies that fragments of the large calcified arthropod *Pterygotus canadensis* (Dawson)(Copeland and Bolton, 1960) came from "two feet" above the shale marker (0.6 m) in the base of his "chert macademising beds". His overlying "main chert bed" yielded the largest known specimens of *Inocaulis plumulosus* (Hall) (Figure 7), the 210 mm long syntype of *Pseudoconularia magnifica* (Spencer) figured by Sinclair (1941), the widest known worm tubes of the basal Cambrian to middle Jurassic Torellellidae (30 mm in RM 20.4477 and Figure 5), the infaunal brachiopod *Lingula ingens* (Spencer) and 30 mm wide *Thallasinoides* burrows. The burrows are still seen *in situ*; they are defined by manganese-stained lower surfaces (1.9 m above the shale datum) and chert-replaced shell lenses (2.4 m level). It is suggested that this giant biota formed a canopy to two lithified erosion surfaces in the Hamilton to West Flamborough area.

The highest or "glaciated" chert bed (3.3-3.6 m level) overlies a third interval of relatively bioturbated and irregularly jointed dolomicrites. Overlying red cherts with sponge spicules, bryozoan and trilobite debris, yield concave-down valves of the brachiopod *Coolinia subplana* (Hall), manganese-coated benthic graptolites and rolled heads of the bryozoan *Monotrypa*. The latter attains a length of 100 mm and was interpreted by Grant as a tabulate coral ("*Callopora*") grown within the photic zone. The associated fauna included 25 mm diameter cones of *Cornulites*, large bryozoa (*Fenestella, Lichenalia*) and hexactinellid sponges. In addition to the three graptolites listed by Bassler (1909), this "glaciated chert" is the source of the type *Acanthograptus* (Spencer), type *A. pulcher* (Spencer), type *Calyptograptus radiatus* (Spencer) and larger undescribed specimens.

Grant knew that Recent hexactinellid sponges lived at depths of over 100 m and interpreted the morphology of trilobites as functionally analogous to that of deep-water crustacea. Since he interpreted many of the burrows as algal impressions and misidentified some bryzoans as corals with photosynthetic algae, he was forced to postulate that the disarticulated trilobites were swept onshore by storms and that the Silurian sponges lived over a wider depth range. He noted rightly that Recent brachiopod genera live over a wide depth range and suggested that they were poorly correlated with bathymetry in the Silurian. His more direct evidence of shallow water — the winnowing of the relatively large and dense shell debris in the micritic Ancaster Chert Beds — can be supported by noting the extensively regenerated growth ridges of the bryozoan *Lichenalia* and benthic *Conularia* from his collection. The development of lithified and scoured dolomicrite surfaces, provides an explanation for the wave resistance of the large benthic suspension feeders and for the survival of micritic sediment below lenses of storm deposited shell debris.

If Grant had worried about the implications of the Darwinian theory of gradual morphological change, he might have made a major contribution to the descriptive paleontology and stratigraphy of the Niagaran dolomites. As it was he was content to let professional paleontologists describe over 70 new species and seven new genera from the Silurian of Hamilton without much regard for his detailed stratigraphical knowledge. The emphasis on bed-by-bed collecting was intended to aid the reconstruction of facies, rather than to add biostratigraphical or phylogenetic detail to a regional synthesis. Today the majority of North American sedimentary geologists have returned to the research perspectives of Grant, regarding fossil species as real entities and facies analysis as the main goal of field work. His largely irreplaceable fossil collections have still not been fully described and remain as his most lasting contribution to geology.

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