A GIANT *RUSOPHYCUS* FROM THE ARISAIG GROUP (SILURO-DEVONIAN) OF NOVA SCOTIA

W. Tansathien and R.K. Pickerill
Department of Geology, University of New Brunswick
Fredericton, New Brunswick, E3B 5A3

Date Received October 16, 1986
Date Accepted December 24, 1986

A unique specimen of the trace fossil *Rusophycus* in the Moydart Formation (Ludlow) of the Siluro-Devonian Arisaig Group of northeastern Nova Scotia is at least 35 cm long, 18 cm wide and 8.5 cm deep. The specimen represents the largest *Rusophycus* yet described and can truly be regarded as a giant. It is speculated that the most likely producer of the trace fossil was a homalonotid trilobite.

La Formation de Moydart (Ludlow) du Groupe siluro-dévonien d'Arisaig, au nord-est de la Nouvelle-Ecosse, a livré un exemplaire unique de l'ichnite *Rusophycus* mesurant au moins 35 cm an de long, 18 cm de large et 8.5 cm de profond. Il s'agit là du plus grand *Rusophycus* jamais décrit et l'on est donc en présence d'un véritable géant. Nous entrevoyons que l'auteur de cette trace a pu être un trilobite homalonotidé.

[Traduit par le journal]

INTRODUCTION

The trace fossil *Rusophycus* (Hall, 1852) is an ichnogenus commonly, if not universally, attributed to arthropods, in particular to trilobites (in marine environments) or isopods or notostracan branchiopods (in non-marine environments) and formed as a result of the producing organism resting, hunting or seeking protection (Osgood, 1970; Bergström, 1973). The trace is bilobate, the overall outline being elliptical, circular, rectangular, heart- or v-shaped and tapering posteriorly (Alpert, 1976). The posteriorly tapering lobes differentiate the ichnogenus from the morphologically similar traces *Cardioichnus* Smith and Crimes and *Chagrinichnites* Feldman, Osgood, Szmuc and Meinke. It ranges in age from Cambrian - Triassic and has been commonly reported from shallow marine and non-marine sequences throughout the world. (See Osgood, 1970; Osgood and Drennen, 1975).

The purpose of this short paper is to record an extremely large example of the ichnogenus recently discovered in the Siluro-Devonian Arisaig Group of Nova Scotia. Indeed, this example is, to our knowledge, the largest *Rusophycus* yet recorded and can be truly regarded as a 'giant'. Despite brief reference to 'worm burrows' by Boucot *et al.* (1974), the trace fossils *Chondrites* and *Arthrophycus* (= *Muensteria*) by Cant (1980) and *Chondrites*, *Skolithos*, *Helminthopsis*, *Planolites*, *Palaeophycus*, *Gordia*, *Scalarituba*, *Teichichnus* and *Linqulichnus* by Pickerill and Hurst (1983) and Hurst and Pickerill (1986), detailed ichnological studies of the sequence have not been attempted and certainly no previous recordings of *Rusophycus* have ever been made from within it. The specimen is currently housed in the Department of Geology, University of New Brunswick.

LOCATION AND STRATIGRAPHY

The Siluro-Devonian Arisaig Group of Nova Scotia is exposed in the Arisaig area of northwestern Nova Scotia on the southern shores of Northumberland Strait (Fig. 1). The succession consists of 1400-1500 m of black to greenish grey mudstone with coarse-grained siltstone and fine-grained sandstone interbeds. The group was subdivided by Boucot *et al.* (1974) into several formations and this study is concerned with the Moydart Formation which occurs near the top of the succession. The Moydart Formation is Ludlow (Upper Silurian) in age and has been subdivided by Boucot *et al.* (1974) into a lower green member, composed of green mudstone and siltstone with an increasing number of calcareous interbeds toward the top, and an upper red member, composed of red marls and concretionary limestones. The specimen described herein was collected from the green member of the Moydart Formation at the base of a small cliff at Moydart Point, approximately 3.3 km southwest of Arisaig Harbour (Fig. 1). Unfortunately the specimen was not found *in situ* but was present in talus material located approximately mid-way (stratigraphically) through the *ca.* 115 m+ of the green member exposed along this section of shoreline (see Boucot *et al.*, 1974).

DEPOSITIONAL ENVIRONMENT

Dineley (1963) studied the red member of the Moydart Formation in some detail concluding that the sequence was fluvial in origin. Boucot *et al.* (1974) and particularly Cant (1980) emphasized that the remainder of the Arisaig Group was shallow marine in origin and formed on a storm-dominated muddy shelf. Integrating both palaeontological and sedimentological data, this conclusion has more recently been reiterated by Pickerill and Hurst (1983) and Hurst and Pickerill (1986) for the Llandovery Beechhill Cove and Ross Brook formations of the Arisaig Group. The green member of the Moydart Formation contains intertidal strata immediately below the contact with the red member

MARITIME SEDIMENTS AND ATLANTIC GEOLOGY
23, 89-93 (1987)

0711-1150/87/020089-5$1.75/0

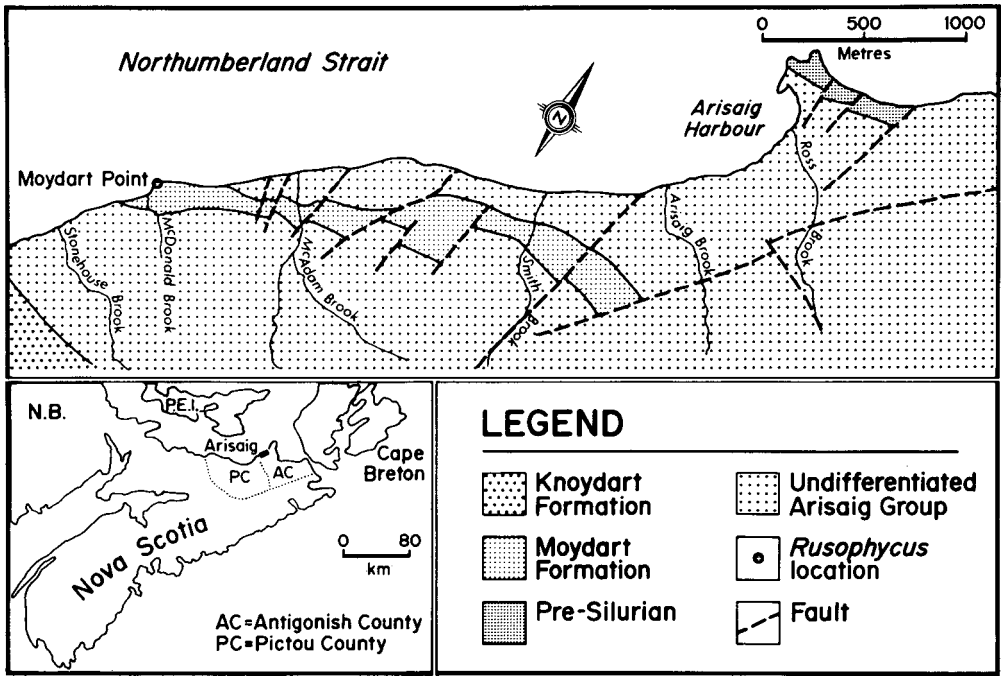

Fig. 1. Location map of the Arisaig Group, northeastern Nova Scotia, illustrating distribution of the Moydart Formation and precise location where the *Rusophycus* described in this paper was collected (modified after Boucot *et al.*, 1974).

(Cant, 1980); the sequence is otherwise interpreted to be shallow subtidal in origin. This is further reinforced by consideration of the total trace fossil assemblage within the formation, which consists of *Cruziana*, *Rusophycus*, *Skolithos*, *Helminthopsis*, *Chondrites*, *Palaeophycus* and *Planolites* (the first three of which are typical members of the shallow subtidal *Cruziana* and *Skolithos* ichnofacies of Seilacher (1964) and abundant and well-preserved shallow subtidal shelly faunal communities (see Watkins and Boucot, 1975) dominated by brachiopods and bivalves.

DESCRIPTION

The specimen is preserved on the sole of an 8 cm thick storm-related parallel- to low angle cross-laminated fine-grained sandstone as a large positive feature (positive hyporelief) of broadly convex outline (Fig. 2). Bioclastic material, in the form of disarticulated brachiopods and crinoid columnals, is present in the basal 1-2 cm of the sample, giving it an overall normally graded appearance. The specimen is a posteriorly tapering bilobate trace with a long elliptical outline (Fig. 2). Maximum length is 35 cm but is incomplete; maximum width is 18 cm (9.5 cm right lobe, 8.5 cm left lobe) with a length: width ratio of approximately 2:1. Depth is variable and irregular with a maximum of 8.5 cm observed on the right lobe. Both lobes possess prominent coarse ridges, each 0.2-1 cm in width and relief and oriented anterolaterally with a V-angle of 40-60^{0} with respect to the median (groove) axis. There are 12 and 15 ridges on the right and left lobes respectively, the best preserved occurring in the posterior portion of the specimen. Intervals between adjacent ridges range from 1-2 cm on the right lobe and 1.2-2.3 cm on the left lobe. Delicately preserved fine ridges occur between some of the coarse ridges and extend outward from the median axis parallel to the main ridges for irregular distances of up to 2 cm. Each of these is typically less than 1.5 mm in width and poor-preservation does not allow conclusions on whether or not they are bunched.

REMARKS

Although Seilacher (1970, 1983) united under *Cruziana* both long furrows (= *Cruziana*) and shorter resting impressions (= *Rusophycus*) most subsequent authors, as we do herein, have preferred to retain the two as distinctive ichnogenera (see Crimes *et al.*, 1977 for a detailed review). One of the essential differences between these two ichnogenera is that in *Cruziana* there is evidence of forward movement (Hofmann, 1979), thereby producing a furrow or burrow (Goldring, 1985) whereas in *Rusophycus* no such movement can be demonstrated. The specimen described herein does not indicate any evidence of such movement and its overall outline and convex morphology is typical of many previously described examples of *Rusophycus*. For these reasons we classify the trace as *Rusophycus* though do admit it could possibly be regarded as a transitional form between *Rusophycus* and *Cruziana* particularly as it lacks coxal, hypostome and podomere impressions reported in some, but by no means all, examples of *Rusophycus* (e.g., Osgood, 1970; Baldwin, 1977; Hofmann, 1979; Pickerill and Fillion, 1984). The generally poor preservation of the specimen and lack of diagnostic morphological indicators precludes ichnospecific assignment.

As with other examples of both *Cruziana* and *Rusophycus* (see Seilacher, 1970) it is tempting to interpret the main coarse ridges on the specimen as having been formed by the endopodites and the shorter, finer ridges as scratch marks dug by the

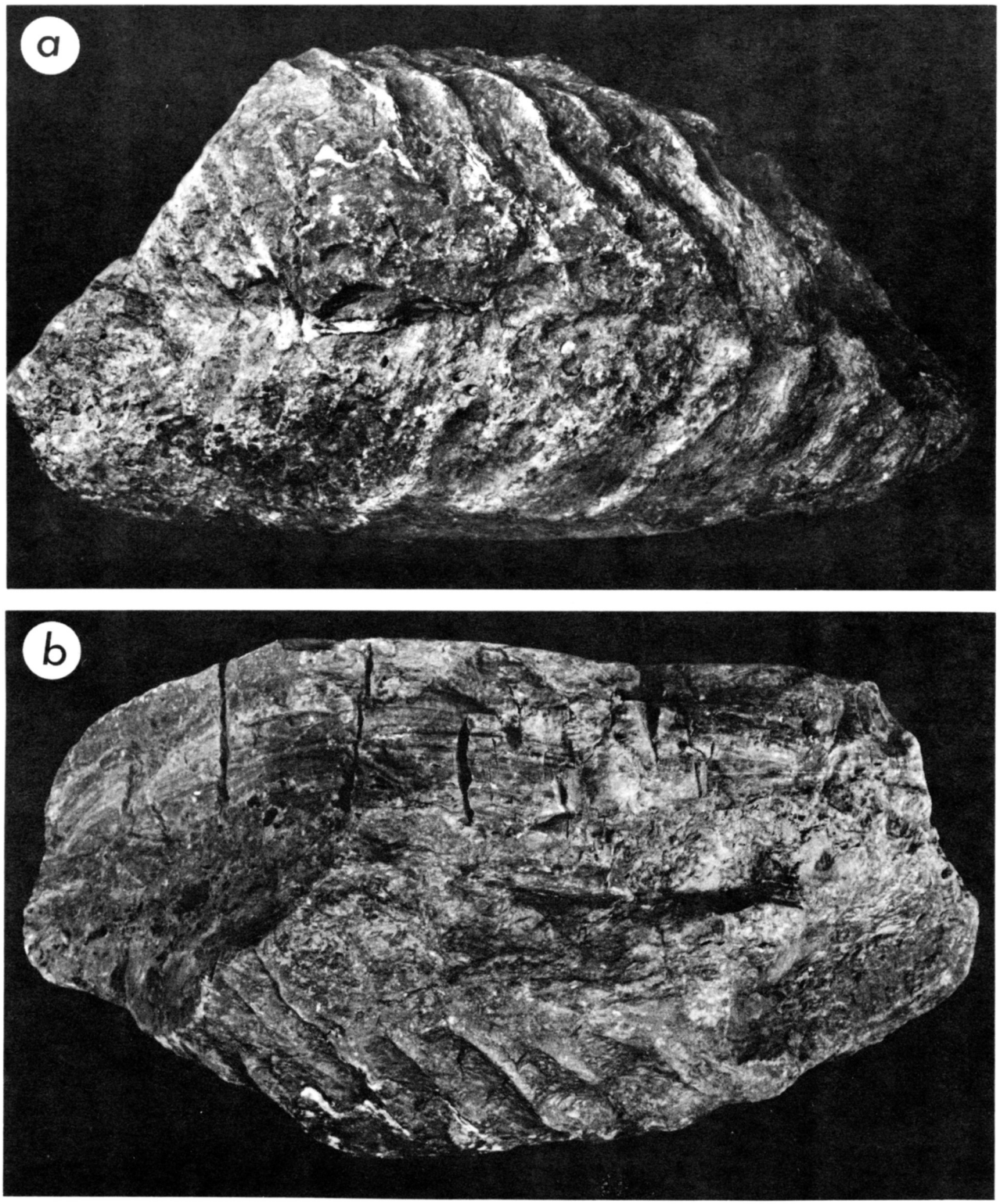

Fig. 2a. *Rusophycus* ichnosp. viewed from above (looking at the lower bedding surface). X 0.46. b. Lateral view of *Rusophycus* (upper portion of specimen as illustrated in a.) illustrating its broadly convex but irregular outline. X 0.46.

exites of the producing organism. In no way, however, can this be established conclusively. As noted above, unfortunately the specimen length is incomplete but by extrapolation is assessed to have been originally 40 cm.

DISCUSSION AND CONCLUSIONS

Despite much palaeontological (e.g., McLearn, 1924; Harper, 1973; Peel, 1977), palaeoecological (e.g., Levinton and Bambach, 1975; Pickerill and Hurst, 1983; Hurst and Pickerill, 1986) and sedimentological (e.g., Lane and Jensen, 1975; Cant, 1980) research on the Arisaig Group, the ichnology has been relatively overlooked. This is in spite of the fact that the succession contains a rich and varied ichnofaunal suite and that bioturbation is in all probability responsible for many of the presently observed sedimentary fabrics, particularly in the mudstones. This report, even though short, therefore represents the first formal account of at least one aspect of the ichnology. The distribution and systematics of the remaining trace fossils are the subject of ongoing study and will be published at a later date.

There have been several previous recordings of large examples of *Rusophycus* but none, to our knowledge, as large as that described herein. According to Seilacher (1970) *Cruziana* and *Rusophycus* are most diversified and largest in Cambro-Ordovician strata and decrease in size and diversity from the Silurian onwards. The majority of previous recordings of large *Rusophycus* would tend to confirm this observation. Thus, for example, Hofmann (1979) has recorded *Rusophycus carleyi* from the Middle Ordovician Chazy Group 31 cm in length and 21 cm in width, and Draper (1980) has recorded forms resembling both *R. dilata* and *R. carleyi* from the Early Ordovician Mithaka Formation of the Georgina Basin (Australia) up to 31 cm in length. It is also noteworthy that Draper (1980) reported several incomplete specimens with extrapolated lengths of up to 36 cm. The previous largest Silurian recording is by Osgood (1970) who noted *Rusophycus* up to 25 cm in length from the Clinton Group in Cincinnati. The giant specimen of *Rusophycus* documented herein suggests that caution must be exercised with respect to Seilacher's (*ibid.*) conclusion on relative size of *Rusophycus* in strata of different ages. This is further reinforced when considering Shone's (1978) recording of giant *Cruziana*, up to 23 cm in width, from the Triassic Beaufort Group of South Africa.

Seilacher (1970) has summarized the arguments for and against a trilobite origin for marine examples of *Cruziana* and *Rusophycus*. While there is still controversy as to whether trilobites were responsible for producing marine examples of *Cruziana* (see Whittington, 1980) it is universally accepted that they were reponsible for producing most *Rusophycus*. The discovery of trilobites preserved *in situ* within *Rusophycus* (Osgood, 1970; Draper, 1980) together with the closely comparable morphological features preserved in some *Rusophycus* when compared to the ventral morphology of trilobites leaves little doubt that trilobites were responsible for their production. Although most trilobites were small, some gigantic forms more than 20 cm in length (*Uralichas* attained a length of 70 cm) are known from Cambrian to Devonian strata (Shone, 1978). Assuming, therefore, a trilobite origin for the *Rusophycus* described herein, what was the likely culprit? It is of course dangerous to speculate on producers of trace fossils when no positive evidence is preserved. Nevertheless it is noteworthy that the Moydart Formation has only revealed two groups of trilobites, the Dalmanitidae and Homalonotidae. The low length: width ratio of the body and generally low convexity of the former group is suggestive of a benthic mode of life (Thomas and Lane, 1984) and the thoracic morphology and smooth and wedge-shaped cephalon of the latter group suggests adaptation to burrowing (Gill, 1949). Thus, either of these groups could have been responsible for the production of the *Rusophycus*. It is notable, however, that dalmanitid trilobites are numerically dominant in offshore shelf facies (Thomas and Lane, 1984) whereas homalonotid trilobites prefer inshore coarse clastic facies (Thomas *et al.*, 1984). Furthermore, homalonotid trilobites are considerably larger and in the Arisaig Group have been recorded up to 10.5 cm in width (McLearn, 1924). It is tempting to suggest, therefore, that a homalonotid trilobite was in fact responsible for the production of the giant *Rusophycus* though this conclusion must be regarded with caution. Notably, however, Osgood and Drennen (1975) interpreted *R. bilobatum*, an ichnospecies morphologically similar to the specimen described herein, as having been produced by homalonotids.

ACKNOWLEDGEMENTS

We thank Rose Northrup who typed the manuscript and Bob McCulloch and Paul Chenard for technical assistance. Careful reviews of the preliminary manuscript by Guy Narbonne and Denis Fillion greatly improved the content. Financial support for this and ongoing research on the Arisaig Group was provided from a CIDA No. 7282-84-1 scholarship to the senior author and an NSERC Grant A 3857 to the second author, both of which are gratefully acknowledged.

ALPERT, S.P. 1976. Trilobite and star-like trace fossils from the White-Inyo Mountains, California. Journal of Paleontology, 50, pp. 266-240.

BALDWIN, C.T. 1977. *Rusophycus morgati*: an asaphid produced trace fossil from the Cambro-Ordovician of Brittany and northwestern Spain. Journal of Paleontology, 51, pp. 411-425.

BERGSTRÖM, J. 1973. Organization, life and systematics of trilobites. Fossils and Strata, 2, pp. 1-69.

BOUCOT, A.J., DEWEY, J.F., DINELEY, D.L., FLETCHER, R., FYSON, W.K., GRIFFIN, J.G., HICKOX, C.F., MCKERROW, W.S. and ZIEGLER, A.M. 1974. Geology of the Arisaig Area, Antigonish County, Nova Scotia. Geological Society of America, Special Paper 139, 191 p.

CANT, D.J. 1980. Storm-dominated shallow marine sediments of the Arisaig Group (Silurian-Devonian) of Nova Scotia. Canadian Journal of Earth Sciences, 17, pp. 120-131.

CRIMES, T.P., LEGG, I., MARCOS, A. and ARBOLEYA, M. 1977. ?Late Precambrian-low Lower Cambrian trace fossils from Spain. *In* Trace fossils 2. *Edited by* T.P. Crimes, and J.C. Harper. Geological Journal, Special Issue 9, Seel House Press, Liverpool, pp. 91-138.

DINELEY, D.L. 1963. The "Red Stratum" of the Silurian Arisaig Series, Nova Scotia. Canada Journal of Geology, 71, pp. 523-524.

DRAPER, J.J. 1980. *Rusophycus* (Early Ordovician ichnofossil) from the Mithaka Formation, Georgina Basin. BMR Journal of Australian Geology and Geophysics, 5, pp. 57-61.

GILL, E.D. 1949. Paleozoology and taxonomy of some Australian homalonotid trilobites. Proceedings of the Royal Society of Victoria, New South Wales, 61, pp. 61-73.

GOLDRING, R. 1985. The formation of the trace fossil *Cruziana*. Geological Magazine, 122, pp. 65-72.

HALL, J. 1852. Palaeontology of New York 2. C. van Benthuysen, Albany, 362 p.

HARPER, C.W. 1973. Brachiopods of the Arisaig Group (Silurian-Lower Devonian) of Nova Scotia. Geological Survey of Canada Bulletin, 215, 163 p.

HOFMANN, H.J. 1979. Chazy (Middle Ordovician) trace fossils in the Ottawa-St. Lawrence Lowlands. Geological Survey of Canada Bulletin, 321, pp. 27-59.

HURST, J.M. and PICKERILL, R.K. 1986. The relationship between sedimentary facies and faunal associations in the Llandovery siliciclastic Ross Brook Formation, Arisaig, Nova Scotia. Canadian Journal of Earth Sciences, 23, pp. 705-726.

LANE, T.E. and JENSEN, L.R. 1975. Stratigraphy of the Arisaig Group. *In* Ancient sediments of Nova Scotia. *Edited by* I. Mck. Harris. Eastern Section, Society of Economic Paleontologists and Mineralogists. Field trip guidebook, pp. 75-96.

LEVINTON, J.S. and BAMBACH, R.K. 1975. A comparative study of Silurian and recent deposit-feeding bivalve communities. Paleobiology, 1, pp. 95-124.

MCLEARN, F.H. 1924. Paleontology of the Silurian rocks of Arisaig, Nova Scotia. Geological Survey of Canada, Memoir 137, 180 p.

OSGOOD, R.G., JR. 1970. Trace fossils of the Cincinnati area. Paleontographica Americana, 6, pp. 281-444.

OSGOOD, R.G., JR. and DRENNEN, W.T. III. 1975. Trilobite trace fossils from the Clinton Group (Silurian) of east-central New York State. Bulletin of American Paleontology, 287, pp. 299-348.

PEEL, J.S. 1977. Systematics and palaeoecology of the Silurian gastropods of the Arisaig Group, Nova Scotia. Biologiske Skrifter Kongelige Danske Videnskabernes Selskab, 21, 80 p.

PICKERILL, R.K. and FILLION, D. 1984. Occurrence of *Rusophycus morgati* in Arenig strata of Bell Island, eastern Newfoundland. Journal of Paleontology, 58, pp. 274-276.

PICKERILL, R.K. and HURST, J.M. 1983. Sedimentary facies, depositional environments and faunal associations of the Lower Llandovery (Silurian) Beechill Cove Formation, Arisaig, Nova Scotia. Canadian Journal of Earth Sciences, 20, pp. 1761-1779.

SEILACHER, A. 1964. Biogenic sedimentary structures. *In* Approaches to Paleoecology. *Edited by* J. Imbrie and N.D. Newell. John Wiley and Sons, New York, pp. 296-316.

SEILACHER, A. 1970. *Cruziana* stratigraphy of non-fossiliferous Palaeozoic sandstones. *In* Trace fossils. *Edited by* T.P. Crimes and J.C. Harper. Geological Journal, Special Issue 3. Seel House Press, Liverpool, pp. 447-476.

SEILACHER, A. 1983. Upper Paleozoic trace fossils from the Gilf Kebir-Abu Ras area in southwestern Egypt. Journal of African Earth Sciences, 1, pp. 21-34.

SHONE, R.W. 1978. Giant *Cruziana* from the Beaufort Group. Transactions of the Geological Society of South Africa, 81, pp. 327-329.

THOMAS, A.T. and LANE, P.D. 1984. Autecology of Silurian trilobites. *In* Autecology of Silurian organisms. *Edited by* M.G. Bassett and J.D. Lawson. Special Papers in Palaeontology, 32, pp. 55-69.

THOMAS, A.T., OWEN, R.M., and RUSHTON, A.W.A. 1984. Trilobites in British Stratigraphy. Special Report of the Geological Society of London, 16, 72 p.

WATKINS, R. and BOUCOT, A.J. 1975. Evolution of Silurian brachiopod communities along the south-eastern coast of Acadia. Geological Society of America Bulletin, 86, pp. 243-254.

WHITTINGTON, H.B. 1980. Exoskeleton, moult stage, appendage morphology, and habits of the Middle Cambrian trilobite *Olenoides serratus*. Palaeontology, 23, pp. 171-204.