

Famatinorthis cf. F. turneri Levy and Nullo, 1973 (Brachiopoda, Orthida) from the Shin Brook Formation (Ordovician, Arenig) in Maine

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other geographical data. Nevertheless, a settlement termed "Ikki" is located some 20 km south of Timatraouine, and the coordinates point to a locality slightly west of the Jbel Arhouri section.

BM 1: Dark olive, phosphatic, sparitic dolostones (bioclastic floatstone) and light brown to olive, slightly limonitic bioclastic rudstone.—Jbel Wawrmast Formation, Brèche à *Micmacca* Member; *Cephalopyge notabilis* Zone.—coll. J. Hindermeyer. IGR.

Tizi n'Telgane

Map sheets Todra-Ma'der 1:200.000 and Alnif 1:100.000. Partial sections about 5 km south of the pass termed Tizi n'Telgane, in the core of the syncline between Jbel Sarhro and Jbel Ougnat.

TNTE-I-49.8: Calcareous, fine-grained sandstone.—Jbel Wawrmast Formation, Brèche à *Micmacca* Member; *Cephalopyge notabilis* Zone. PIW.

TNTE-II-4-6: Lower, about 2 m thick bed of extraordinarily thick (ca. 4 m) echinoderm-trilobite-grainstone with intercalated stromatolitic crusts, close to the base of the formation.—Jbel Wawrmast Formation, Brèche à *Micmacca* Member; *Cephalopyge notabilis* Zone. PIW.

Tarhoucht

Map sheets Todra-Ma'der 1:200.000 and Alnif 1:100.000. At northern slope of the Bou Tiout, about 1 km southwest of the village of Tarhoucht, roughly 13 km south of Tinejdad (Lambert coordinates 536/485). From this section come most of the spectacular commercial giant Cambrian trilobites of Morocco.

TAR-0.7: Grayish to ochre-coloured sandy marlstones, laterally grading into calcareous fine-grained sandstones, 0.7 m above the base of the formation.—Jbel Wawrmast Formation, Brèche à *Micmacca* Member; lower part of *Cephalopyge notabilis* Zone. PIW.

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FAMATINORTHIS CF. *F. TURNERI* LEVY AND NULLO, 1973 (BRACHIOPODA, ORTHIDA) FROM THE SHIN BROOK FORMATION (ORDOVICIAN, ARENIG) IN MAINE

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ABSTRACT—*Famatinorthis* cf. *F. turneri* Levy and Nullo, 1973, is an abundant component of a poorly preserved brachiopod assemblage in volcanoclastic rocks at one locality in the Arenig-age Shin Brook Formation in northeastern Maine. The brachiopod assemblage of the Shin Brook Formation has been classed as a Celtic biogeographic assemblage that is interpreted to have lived in cool water at mid- to high peri-Gondwanan latitudes. *Famatinorthis turneri* sensu stricto is one of the six brachiopod species known from coeval volcanics-rich rocks of continental margin affinities in the Famatina Range of northwestern Argentina; the presence of its congener in Maine supports the Celtic affinities of the Famatina assemblage, but its Ordovician location remains cryptic.

INTRODUCTION

THE PRESENCE in the Precordillera and Famatina ranges of northwestern Argentina of contrasting Early Ordovician (Arenig) brachiopod assemblages of both Celtic and Toquima/Table Head affinities has become important in assessing major questions of the crustal dynamics of that region and beyond (Astini et al., 1995; Thomas and Astini, 1996). The Celtic assemblage of brachiopods has been interpreted to have lived in cool waters of continental margins and intraoceanic sites at mid- to high paleolatitudes, whereas the Toquima/Table Head assemblage is thought to have lived in warm transequatorial waters (Neuman, 1984). The distinctiveness of these assemblages was supported by statistical tests (Neuman and Harper, 1992; Harper et al., 1996). Nearly one-third (7 of 20) of the brachiopod genera listed from the uppermost biozone of the San Juan Limestone of the Precordillera (Herrera and Benedetto, 1991) occur together in Celtic assemblages of the North Atlantic borderlands, indicating approach of the Precordillera to the Gondwanan margin during Arenig/Llanvirn time (Astini et al., 1995). The smaller assemblage (six genera) in coeval rocks of the Famatina Range includes the distinctive brachiopod, *Famatinorthis turneri* Levy and Nullo, previously considered to be endemic (Benedetto, 1994); its identification in the archetypal Celtic assemblage of

the Shin Brook Formation of northeastern Maine as *Famatinorthis* cf. *F. turneri* strengthens the link of the Famatina generic assemblage to the Celtic biogeographic assemblages. Paleogeographic interpretations based on recently obtained paleomagnetic data (Conti et al., 1996) are similar.

FAMATINORTHIS TURNERI LEVY AND NULLO, 1973, IN ARGENTINA

Famatinorthis turneri occurs in the Molles and Suri formations (Arenig) of the Famatina Terrane of northwestern Argentina. The Famatina Terrane, coextensive with the Famatina Range, is a long, narrow, fault-bounded block whose Ordovician volcanic rocks are interspersed with small amounts of fossiliferous siliceous sedimentary rocks. East of the Famatina Terrane is the Pampeanas Terrane of Precambrian basement rocks; west of it is the Precordillera Terrane that contains Cambrian and Lower Ordovician carbonate rocks of Laurentian affinities and Arenig-age limestone that contains Toquima-Table Head brachiopod assemblages in its lower part followed by a rich and diversified assemblage that contains a significant number of Celtic assemblage genera (Herrera and Benedetto, 1991).

Present knowledge of the stratigraphic and structural relations of the Suri Formation to adjacent units remains uncertain. According to Benedetto (personal commun., 1996), unfossiliferous,

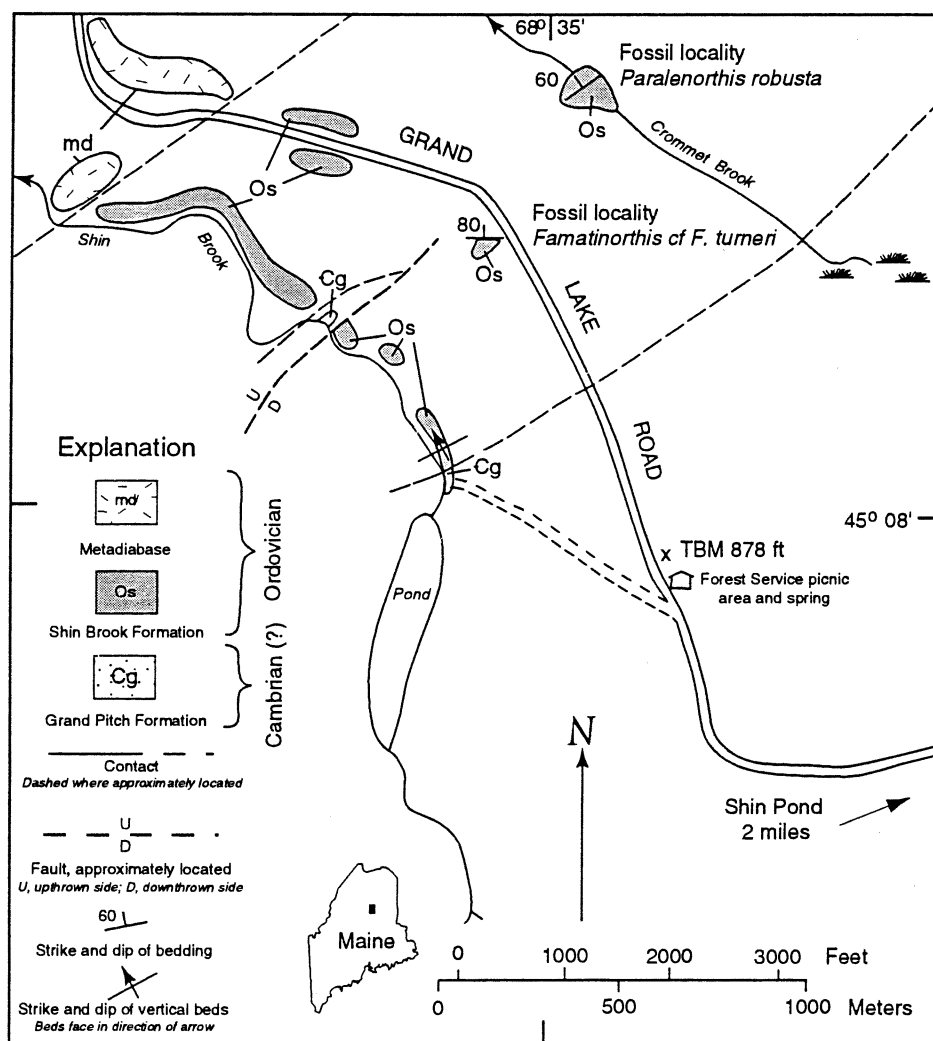


FIGURE 1—Geologic sketch map showing the location of outcrops that yielded *Famatinorthis* cf. *F. turneri* and *Paralenorthis robusta*, Shin Pond Quadrangle, Penobscot County, Maine. The type section of the Shin Brook Formation is along Shin Brook northward from its southern boundary with the Cambrian? Grand Pitch Formation to the upfaulted wedge of Grand Pitch Formation. Patterned areas indicate outcropping bedrock, which elsewhere is covered by glacial drift. Revised from Neuman, 1964, figure 3.

low-grade metamorphic rocks (i.e., Negro Peinado Formation) are closely associated with the Suri Formation, but all known contacts between them are tectonic. The unfossiliferous rocks may be metamorphosed equivalents of the Suri and Volcancito (Tremadoc) formations, but they may be significantly older (Late Proterozoic–Cambrian).

The association of fossiliferous rocks with abundant volcanic rocks in the Suri Formation (Mangano and Buatois, 1992) led to the suggestion that it represents an island arc environment associated with an active continental margin (Aceñolaza and Toselli, 1988). This is the geological setting of Celtic brachiopod assemblages in North America. Although the generic suite of brachiopods from the Famatina Range was considered too small to support such an assignment (Benedetto, 1994), such an assignment now seems reasonable. The identity of the continent that this arc bordered remains unknown, and its Ordovician paleoposition remains truly “suspect.”

The genus and type species of *F. turneri* was originally described from indifferently preserved specimens in dark-gray siltstone of the Molles Formation of the Famatina Group in La Rioja Province (Levy and Nullo, 1973). Better-preserved spec-

imens from similar rock of the closely related Suri Formation in Catamarca Province (Aceñolaza and Toselli, 1977) permitted revision of the generic diagnosis, more detailed description, and the reillustration of this taxon by Benedetto (1994).

Important features shown in Benedetto's illustrations that are preserved in the specimens from Maine are: the multicostellate ornament of the external molds that is impressed on the internal surfaces at the anterolateral margins of only a few internal molds; in ventral valves, the thickened margin at the front of the pyriform muscle field; in the dorsal valve, a wide, lozenge-shaped notothyrial platform that is elevated at the front and medially where it is joined to the shell floor by a variably thickened median ridge; and the simple cardinal process that extends across the length of the platform. *Doleroides? ponderosus* Cooper (1956), a slightly plicate shell from the early Caradocian Effna Formation in Virginia, has internal features that are more like those of *Famatinorthis* than *Doleroides*, and the species is here reassigned to *Famatinorthis*. The genus is retained in the Plectorthidae with question, pending the establishment of a family that encompasses features of this kind. The Chinese *F. luohensis* new species and *F. sp.* (Liu in Liu et al., 1985; Chinese

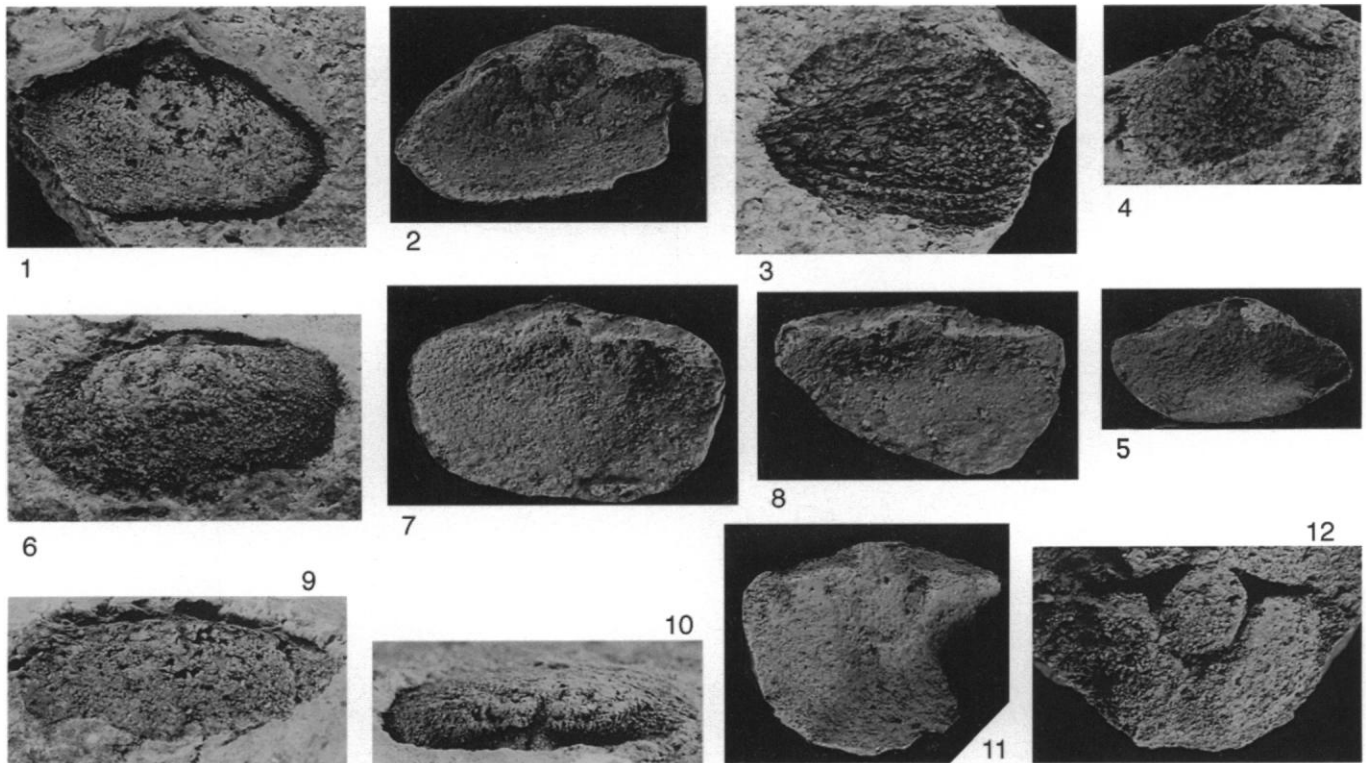


FIGURE 2—*Famatinorthis* cf. *F. turneri*, $\times 2$. 1–3, obliquely compressed ventral valve of common large size, USNM 489926, internal mold, internal cast, external mold preserving remnant of radial and concentric ornament; 4–5, obliquely compressed, small ventral valve, USNM 489928, internal mold, internal cast; 6–7, longitudinally compressed dorsal valve, USNM 489923, internal mold, internal cast, showing impressions of adductor scars and skewed cardinalia; 8–10, longitudinally compressed dorsal valve, USNM 489924, internal cast, dorsal and posterior views of internal mold showing part of cardinalia folded under shell floor; 11–12, ventral valve, USNM 489927, internal cast, internal mold showing the muscle field and the faintly impressed proximal parts of the *vascula media*.

text translated by Rong Jia-yu, personal commun.) are rejected from this genus because they lack its essential features.

FAMATINORTHIS CF. *F. TURNERI* IN MAINE

Context of the collection.—Twenty-six poorly preserved specimens of brachiopods identified here as *Famatinorthis* cf. *F. turneri* were recovered, together with specimens of three better-known brachiopods, from samples of highly strained conglomeratic volcanoclastic sandstone of the Shin Brook Formation at one locality in northeastern Maine (Figure 1; see Appendix). The specimens of *Famatinorthis* remained unclassified when the three other brachiopods (*Orthambonites robustus* [20 specimens], *Productorthis mainensis* [12 specimens], and *Platystro-*

phia sp. [20 specimens]) were identified, despite deformation of shapes and obliteration of many details (Neuman, 1964); these three taxa were known also from better preserved specimens from other localities of the Shin Brook Formation, some nearby. Among these is the fine-grained volcanic sandstone 600 m [1,800 ft] to the northeast (Figure 1; U.S. Geological Survey Locality CO-3725) that yielded abundant specimens of *Orthambonites robustus* Neuman, 1964, reclassified as *Paralenorthis robusta* (Neuman) in a comprehensive restudy of *Orthambonites* and related genera (Jaanusson and Bassett, 1993). Because the newly established criteria that distinguish the genera of this group of coarsely costate brachiopods are not preserved in specimens that are associated with *F. cf. F. turneri*, they are here referred to as “*Orthambonites* sp.”

Most of the specimens of *Famatinorthis* cf. *F. turneri* from USGS Locality CO-3607 are considerably deformed; the five that are least deformed are shown in Figure 2.

Description of *F. cf. F. turneri*.—The specimens are large, oval in outline, variably wider than long (Table 1). Maximum width is 10 to 20 percent greater than hinge width. A ventribiconvex profile is inferred from comparison of thicknesses of disarticulated ventral and dorsal valves (ventral valves—3 mm near mid-length, dorsal valves—1.5 mm at about one-quarter length). Neither fold nor sulcus is present on either valve. A vestige of multicostellate ornamentation is preserved on the external mold of only one specimen (USNM 489926; Figure 2.3) at its front where there are 12 costae per 10 mm; it is not evident on internal surfaces (internal molds). The ventral interarea of large specimens, determined from casts of two ventral valves (USNM

TABLE 1—Measurements (in mm) of selected specimens of *Famatinorthis* cf. *F. turneri* Levy and Nullo, 1973, from the Shin Brook Formation. Figures in parentheses are estimates of total values following measurements of preserved parts.

Specimen no. USNM	Figure no.	Length	Width	
			Hinge	Maximum
Dorsal valves				
489923	2.6–2.7	12	16	20
489924	2.8–2.10	9	17	18 (22)
489925	—	10	17	22
Ventral valves				
489926	2.1–2.3	16	15	18 (22)
489927	2.11–2.12	15	15 (18)	20
489928	2.44–2.5	8	11	13

489926 and 489927, Figure 2.2, 2.11), is about 3.5 mm long, apsacline, and slightly concave; the dorsal interarea (USNM 489923, Figure 2.6, 2.7) is about 1.5 mm long and anacline. Both delthyrium and notothyrium appear to be open and unmodified.

Inside dorsal valves the lozenge-shaped notothyrial platform is short, wide, and concave; its posterolateral sides are joined to the notothyrium, and its anterolateral sides are elevated above the shell floor except medially where it is underlain by a broad median ridge. The brachioophore bases rise from its lateral apices. The cardinal process is a thin blade in most specimens (swollen in USNM 489923, Figure 2.7) that extends along the full length of the platform. The median ridge extends to about one-fourth the shell length as a myophragm separating the shallow oval excavations of the adductor muscle scars. Mantle canals and external ornament are unknown in dorsal valves.

Inside ventral valves the bases of the teeth are stout; the dental plates are thick, widely divergent, and extend onto the shell floor to form the posterolateral sides of the delthyrial cavity. The muscle field, rimmed by thickened shell, is large; its sides are widely divergent and slightly elevated above the shell floor; its front is sharply rounded and more highly raised than the sides. The adductor scars extend beyond the diductors, and occupy about three-quarters of the width of the field at its midlength. The saccate mantle canal system is preserved in one specimen (USNM 489927, Figure 2.12) as a pair of parallel broad trunks of the *vascula media* that extend from a low ridge at the front of the muscle field to near the anterior shell margin where they diverge and run parallel to the shell margin, enclosing the large *vascula genitalia*. Lack of callosities of the muscle field and the shell floor of the smallest specimen (USNM 489928, Figure 2.4) suggests that it was an immature individual.

DISCUSSION AND CONCLUSION

Despite poor preservation, the generic affinities of the specimens from the Shin Brook Formation of Maine identified here as *Famatinorthis* cf. *F. turneri* with typical Argentine *F. turneri* are strong. Neither has a plicate profile like that of *F. ponderosus* (Cooper) from slightly younger carbonate-rich rocks in Virginia. No other occurrence of the genus can be verified. The similarity of the Argentine and Maine species, the co-occurrence of both with other components of Celtic brachiopod assemblages in Argentina and Maine, and the occurrence of both in rocks that are parts of continental margin sequences whose paucity of carbonate rocks suggests that they shared cool-water, mid- to high latitude environments, but the distance that separated relevant parts of Maine and Argentina remains unknown.

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APPENDIX

Description of the locality that yielded *Famatinorthis* cf. *F. turneri*: U. S. Geological Survey Locality CO-3607 = Locality D of Neuman, 1964, p. E12: T. 6 N., R. 7 W., Penobscot County (Shin Pond 15-minute quadrangle), *roche moutonnée* about 8 m (25 ft) south of the Grand Lake road, 4 km (2.5 miles) northwest of Shin Pond, just southwest of the point where the road curves from N. 40° W. to N. 80° W. About 6 m (18 ft) of beds are exposed, consisting of fine- to coarse-grained conglomeratic tuff in graded beds, 12–65 cm (0.5–2 ft) thick. Fossils are scattered throughout these beds, but are most abundant in the uppermost exposed layer. Bedding strikes east, dips 80° N; cleavage strong, strikes N. 55° E., dips 75° NW.