

# THE BASE OF THE CAMBRIAN: TERRENEUVIAN SERIES AND FORTUNIAN STAGE

## History

At the IV International Symposium on the Cambrian System in Nanjing, China, officers of the ISCS (S.C. Peng, M. Moczydlowska-Vidal, G. Geyer, L. E. Babcock) met to discuss names for the lowermost Cambrian series and stage. The proposed global chronostratigraphic names will replace the informal names "Cambrian Series 1" and "Cambrian Stage 1" (Figs. 1, 2). A GSSP for the base of the conterminant series and stage boundary has already been ratified: (Landing, 1994; *Geology*, 22:179–182). This horizon also marks the conterminant base of the Phanerozoic Eonothem, Paleozoic Erathem, and Cambrian System. It is necessary only to select and vote upon names for the series and stage whose bases are marked by the GSSP in the Fortune Head section. The names proposed here were among those briefly discussed in the official ISCS Workshops during the Nanjing and South Australian meetings and during subsequent conversations on Cambrian chronostratigraphic nomenclature.

## Terreneuvian Series

### Proposal

To replace the informal name Series 1, the name "Terreneuvian Series" is proposed. The base has been defined (Narbonne et al., 1987; *Canadian Journal of Earth Sciences*, 24:1277–1293) by a GSSP (FAD of *Trichophycus pedum* and the base of the *T. pedum* Zone [ichnofossils]) in the Fortune Head section, Burin Peninsula, Newfoundland, Canada; Fig. 1A). Its top will be defined by the base of the overlying Series 2, which is presently undefined.

### Etymology

The name "Terreneuvian" is derived from Terre Neuve, the modern French name for the island of Newfoundland. Terreneuvian evokes "Terre Neuffre," which, prior to a spelling reform, was the formal name for the 17<sup>th</sup> century French colony on the island of Newfoundland. Terre Neuffve essentially corresponded to the Burin Peninsula, in the southwest of which is the GSSP. Although the Latinized variant "Terra Nova" has been used as a lithostratigraphic (Terra Nova Group) term, "Terre Neuve" has never been used previously as a lithostratigraphic or chronostratigraphic term. The designation can be pronounced "terr-eh-nov-ee-an."

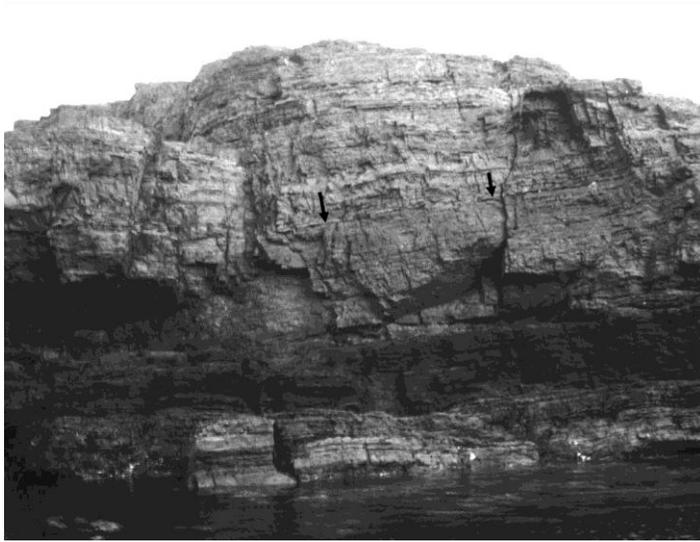


Figure 1A. The GSSP for base of proposed Terreneuvian Series and Fortunian Stage (at black arrow heads) at Fortune Head, SW Burin Peninsula, eastern Newfoundland.

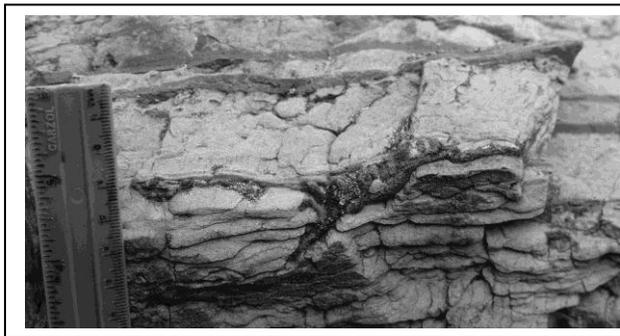


Figure 1B. Lowest occurrence of *Trichophycus pedum* and base of *T. pedum* Zone at the GSSP for base of proposed Terreneuvian Series and Fortunian Stage at Fortune Head, SW Burin Peninsula, eastern Newfoundland.

### **Correlations and chronostratigraphic range**

The base of the Terreneuvian Series can be correlated both biostratigraphically and geochemically: 1) at the FAD of *Trichophycus pedum* and the base of the *T. pedum* Zone [ichnofossils] (Fig. 1B), and 2) near the onset of the dramatic fall in  $\delta^{13}\text{C}$  values at the Ediacaran–Cambrian boundary (e.g., Amthor et al., 2003; *Geology* 31:431–434) (Fig. 2). The latter standard is the BACE Excursion (Basal Cambrian Carbon isotope Excursion; Zhu et al., 2006: *Palaeoworld* 15:217–222).

The Terreneuvian Series replaces the regional (Avalonian) Placentian Series (Landing et al., 1989; *Journal of Paleontology*, 63:739–769), and is roughly equivalent to the regional (Gondwanan) Cordubian Series in Iberia (see Geyer and Landing, 2004; *Acta Geologica Polonica*, 54:179–218). Maintenance of “Placentian” for this lowest Cambrian interval with the earliest diverse trace fossils and the oldest small shelly fossil assemblages (Landing et al., 1987) would ultimately lead to an “undesireable restriction” and creation of an objective homonym. This is a likely development if the base of the second series of the Cambrian were to be based on

an FAD that uses trilobites. Indeed, the upper Placentian, though lacking trilobites, likely correlates with such trilobite-bearing intervals as part of the Siberian lower Atdabanian Stage. Thus, formalization of a second Cambrian series would truncate the top of the previously established Placentian).

### **Biostratigraphic significance**

As the Terreneuvian Series brackets several key events in the Cambrian evolutionary radiation, its interregional correlation between Cambrian paleocontinents is readily accomplished in marine successions by traditional biostratigraphic and non-conventional (geochronologic and chemostratigraphic) techniques. The fossilizable faunas of the Terreneuvian Series appear with the extinction of Ediacaran acritarchs and most Ediacaran-grade organisms.

Terraneuvian Series organisms equate to those of the Placentian Ecologic Evolutionary Unit—the initial stage of the Cambrian Evolutionary Fauna (Landing and Westrop, 2004; *Paleontological Society Papers*, 10:93–105). This Placentian EEU includes the appearance and diversification of coelomate burrowers followed by the appearance of diverse skeletalized metazoans, and means that assemblages below Cambrian “Series 2” with diverse metazoan burrows at least through the lower range of diverse skeletalized metazoans are Terreneuvian.

### **Geochronology**

The Terreneuvian Series comprises a significant part of the lower Cambrian. Preliminary geochronologic work in the Avalon continent demonstrates that the earliest trilobite-bearing strata in southern Wales have a U-Pb volcanic zircon age of 519 Ma (Landing et al., 1998; *Canadian Journal of Earth Sciences*, 35:329–338). Thus, with a Cambrian base at 543 Ma, the duration of the Terreneuvian could reach somewhat over 40% of the Cambrian.

Middle Terreneuvian strata in New Brunswick, Canada, have a U-Pb zircon age of 530 Ma (Isachsen et al., 1994; *Geology*, 22:496–498). Numerous ashes occur in the lower Fortunian Stage (Landing, 2004; *Journal of Geodynamics*, 37:411–435), and will likely provide dates on the lowest occurrence of diverse small shelly fossils and the pace of the Cambrian radiation (E. Landing and S.A. Bowring, unpub. data).

### **Preservation and accessibility**

The Fortune Head stratotype was designated a geologic preserve in 1994, and will remain preserved and accessible.

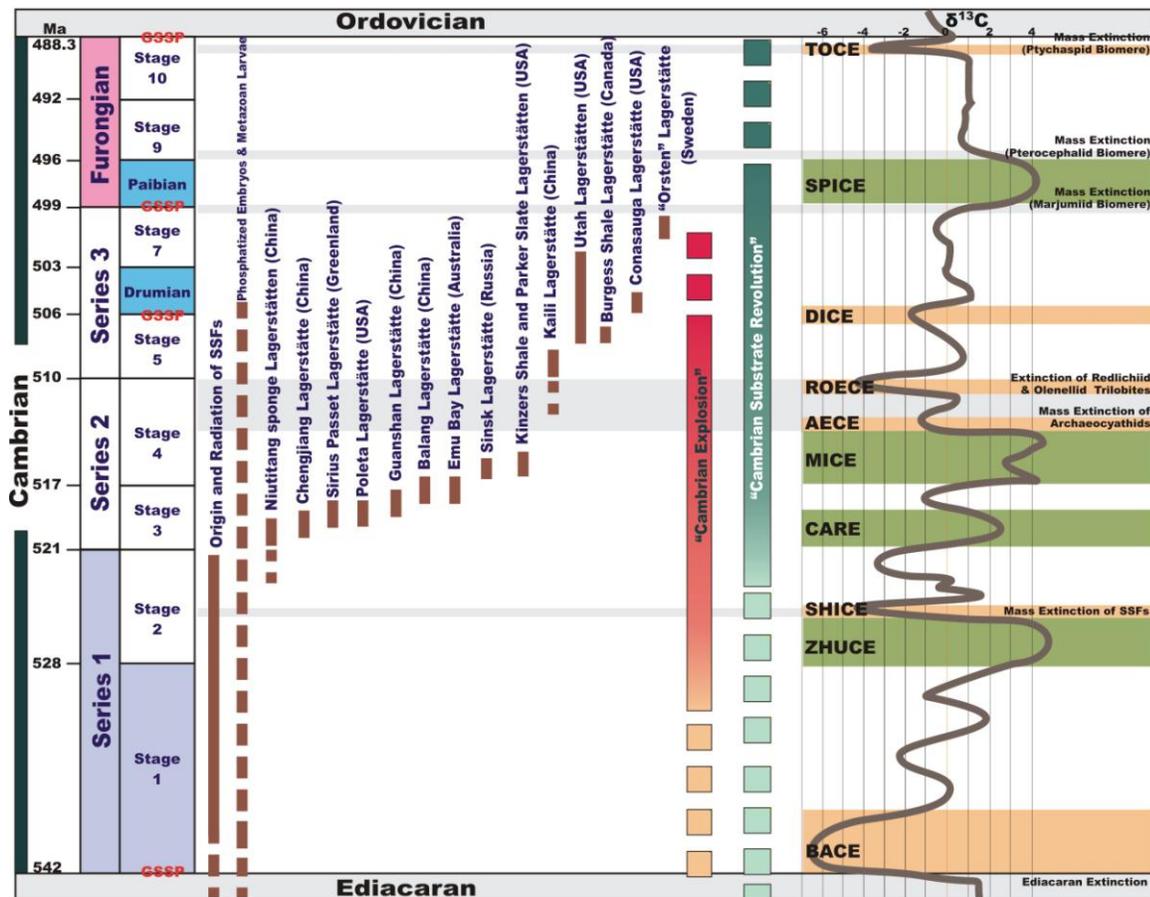


Figure 2. Relationship of BACE Excursion to base of proposed Terreneuvian Series (“Series” 1 of figure) and Fortunian Stage (“Stage 1” of figure). From Zhu et al. (2006: Palaeoworld 15: fig. 1).

## Fortunian Stage

### Proposal

To replace the informal name “Stage 1,” the name “Fortunian Stage” is proposed as the lowest stage of the Cambrian and the lower part of the proposed Terreneuvian Series. The base of the Fortunian Stage corresponds to the defined GSSP for the base of the Cambrian (FAD of *Trichophycus pedum* and base of the *T. pedum* Zone [ichnofossils] in the Fortune Head section, Burin Peninsula, Newfoundland, Canada; Fig. 1). Its top will be defined by the base of the overlying stage, which is presently undefined.

### Etymology

The name Fortunian is derived from the Grand Bank 1 M/4 Canadian national map area in the Burin Peninsula, Newfoundland, Canada. The name Fortunian denotes Fortune Head, Newfoundland, Canada, the site of the stratigraphic section containing the GSSP. It also evokes the village of Fortune, just east of the GSSP, as well as Fortune Bay immediately to the west.

“Fortune” constitutes one of the few unused geographic names that is available for use as a chronostratigraphic term in the Fortune Head area. A “Fortune Formation” had been proposed (Heyl, 1936; Newfoundland Department of Natural Resources, Geological Section Bulletin 3, 66 p.) in distant, north-central Newfoundland for Ordovician trench-fill deposits, but has been abandoned (see Lexicon of Canadian Geologic Units, [http://cgkn1.cgkn.net/weblex/weblex\\_list\\_e.pl](http://cgkn1.cgkn.net/weblex/weblex_list_e.pl)) as a formation “defined inadequately, commonly not recognizable as he recognized them, or ambiguous in sequence, and contradicted by the mapping of various workers” (Helwig, 1969; American Association of Petroleum Geologists Memoir, 12:408–413; also Horne and Helwig, 1969; American Association of Petroleum Geologists Memoir, 12:388–407.). Thus, “Fortune” is available for use as a chronostratigraphic unit that comprises the lowest Cambrian stage.

### **Correlations and chronostratigraphic range**

As for the base of the Terreneuvian Series, the base of the Fortunian Stage can be correlated regionally on the basis of biostratigraphic and geochronologic standards: 1) at the FAD of *Trichophycus pedum* and the base of the *T. pedum* Zone [ichnofossils]), and 2) near the onset of the dramatic fall in  $\Delta^{13}\text{C}$  values at the Ediacaran–Cambrian boundary (e.g., Amthor et al., 2003; *Geology* 31:431–434). The latter standard is the BACE Excursion (Basal Cambrian Carbon isotope Excursion of Zhu et al., 2006; *Palaeoworld* 15:217–222; Fig. 2).

The basal Cambrian GSSP, the base of the proposed Terreneuvian Series, and the base of the proposed Fortunian Stage at Fortune Head lie in the southwest part of the Grand Bank map area. The sea cliffs southeast of Fortune Head expose all of the strata (Chapel Island through Random Formation) that comprise much of the interval that will likely constitute a lowest Cambrian stage. This completely exposed succession extends from the base of the *T. pedum* Zone through the lowest local occurrence of diverse small shelly fossils (e.g., Fortune North section of Landing et al., 1989; *Journal of Paleontology*, 63:739–769).

In addition, a short reference section that exposes the base of the proposed Terreneuvian Series and Fortunian Stage lies just northeast of Fortune Head and immediately east of Grand Bank village on Grand Bank Head (Narbonne et al., 1987; *Canadian Journal of Earth Sciences*, 24:1277–1293; Landing et al., 1989). Finally, a long reference section through the Fortunian Stage that extends up through the oldest small shelly fossil assemblages lies in the section in the sea cliffs north of Little Danzig Cove in the Lamaline 1 L/13 map area just southwest of the Grand Bank map area (Landing et al., 1989; *Journal of Paleontology*, 63:739–769).

### **Biostratigraphic significance**

As the base of the Fortunian Stage at its type section marks an important event in the Cambrian evolutionary radiation—i.e., the appearance of coelomate burrowers—its interregional correlation between Cambrian paleocontinents is readily accomplished in marine successions by traditional biostratigraphic techniques. The fossilizable faunas of the Fortunian Stage equate at least to the early part of the Placentian Ecologic Evolutionary Unit—the initial stage of the Cambrian Evolutionary Fauna (Landing and Westrop, 2004; *Paleontological Society Papers*, 10:93–105). This early part of the Placentian EEU includes the appearance and diversification of coelomate burrowers. At least part of the subsequent appearance of diverse skeletalized metazoans may be referable to the Fortunian Age.

### **Geochronology**

As outlined above for the Fortunian Series, volcanic ashes are particularly well developed in the lower part of the Fortunian Series (unpublished work of E. Landing and S.A. Bowring) on the

Avalon continent. A U-Pb volcanic zircon date of 530 Ma (Isachsen et al., 1994; *Geology*, 22:496–498) was determined from an ash a relatively short distance above the lowest occurrence of diverse small shelly fossils in southern New Brunswick.

**Preservation and accessibility**

As noted above, the basal Cambrian GSSP and, thus, the base of the proposed Fortunian Stage at Fortune Head was designated a geologic preserve in 1994, and will remain preserved and accessible.

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