The science of paleontology includes two important components, biostratigraphy and paleobiology. Walcott practiced both, but the emphasis throughout his career was on biostratigraphy. Apart from the Burgess Shale, he collected primarily to interpret the relative ages of rocks in stratigraphic sections that he measured. Furthermore, he identified collections submitted by many others to aid their mapping and structural-geologic interpretations. Taphonomy as a subdiscipline of paleontology had not developed until the latter half of the twentieth century, but Walcott nevertheless developed arguments and conclusions that we could, in retrospect, regard as early taphonomic work (e.g., Walcott, 1898).

Other contributions of Walcott’s that had longstanding effects on the science of geology were removal of “the Taconic period” from the geologic column; clarification and correction of what constituted Lower Cambrian and Middle Cambrian rocks in North America; definition of the base of the Cambrian System in North America at the lowest occurrence of the trilobite Olenellus; and strengthening of a three-fold division of the Cambrian System (see Yochelson, 2001). The practice of using Lower, Middle, and Upper Cambrian was accepted worldwide for more than a century. Ultimately, the tripartite division of the Cambrian System was abandoned (Geyer and Shergold, 2000; Peng et al., 2004; Babcock et al., 2005), in large part because of the addition to the Cambrian of a thick succession of strata below the first appearance of trilobites (Landing, 1994; Palmer, 1998; Geyer and Shergold, 2000; Peng et al., 2004; Babcock et al., 2005).

In 1902, colleagues thought of Walcott as the third most important geologist in America (behind G. K. Gilbert and T. C. Chamberlin; see Yochelson, 2001). Unfortunately, much of the rationale for that view has disappeared from geologic consciousness. The purpose of this paper is to review some of Walcott’s less well remembered contributions to the science of geology in an effort to characterize the man whose work has touched the careers of all sedimentary geologists that have followed him. Walcott’s work as a field geologist was impressive, and his field studies are an appropriate place to begin documentation of his importance.
PHANEROZOIC AND OLDER ROCKS

In 1879, during his first season with the U.S. Geological Survey, C. D. Walcott started with Locke Level and barometer in the Paleogene lake beds of the Bryce Canyon region of southwest Utah and measured downward to the Cambrian, which was exposed near the level of the Colorado Canyon at the mouth of Kanab Canyon. This was 4290 m (13,000 ft) of section!

During 1881 and 1882, Walcott measured sections and collected fossils throughout the Paleozoic section in the Eureka, Nevada, mining district. He published descriptions of the fossils in order to date the various units. All the fossils are reasonably well located stratigraphically, but only the descriptions of the fossils were published (Walcott, 1884). Old though it may be, this monograph is one of the principal sources of information on Paleozoic megafossils from the Great Basin.

In 1882-1883, Walcott “offset” his Kanab, Utah, section, about 70 km to the east and went into the Grand Canyon for 79 days. He began measuring downward at the Cambrian and added another 3960 m (12,000 ft) of sedimentary rocks, plus 330 m (1,000 ft) of volcanics, to his section (Yochelson, 1998). So far as I know, Walcott measured more of a continuous stratigraphic section than anyone, and I am unaware of anyone who measured 8 km (5 miles) of section.

Walcott’s work in the Grand Canyon (Figure 3) serves as an exemplar of intellectual contributions that slip into sedimentary geology literature almost unnoticed. Based on a few scraps of fossils, primarily stromatolites, Walcott originally dated most of the Grand Canyon section as Cambrian (Walcott, 1883). Within a few years, he reconsidered and termed them “pre-Cambrian” (Walcott, 1886a, 1886b). Previous to this time, Archean was the name used for rocks below the Cambrian. Archean strata were metamorphics and intrusive igneous rocks that looked as though they were ancient and highly altered. That a thick sequence of non-metamorphosed sedimentary rocks, preserving stromatolites, mudcracks, and other features typical of Phanerozoic strata could actually exist below the Cambrian was a novel concept for the developing geologic time scale. Within a few years, the time term “Algonkian” was proposed for a large succession of these pre-Cambrian rocks (see for history Van Hise, 1892). A major philosophical advance marks the difference between references to the pre-Cambrian of the late1880s and the current use of the word Precambrian, but nevertheless Walcott’s recognition of a fossiliferous “pre-Cambrian” represented a sea change for the time.

Three less far-reaching examples of Walcott’s contribution to sedimentary geology are discussed below. Unfortunately, just as the significance of his use of pre-Cambrian has been overlooked, these examples also have largely faded from the collective memory of geologists.

CONGLOMERATES, BRECCIA, AND LIMESTONE

During 1882 and 1883, Walcott made two, short, intensive trips to examine the Cambrian around York, Pennsylvania (Walcott, 1892). One result was his observation of limestone conglomerates and breccias within the early-middle Cambrian limestone sequence (Walcott, 1894). A prevailing view in stratigraphy at the time was the importance of an unconformity. If an angular unconformity could not be observed, a conglomerate was commonly interpreted as evidence of a significant time break in the geologic history of an area.

By documenting the presence of conglomerates and breccias within a sequence of apparently continuous sedimentation, Walcott was directing caution to interpretation of one of the basic tenets of field geology. Following his publication (Walcott, 1894), there was no obvious discussion either for or against the concept that a conglomerate or breccia necessarily indicates a major unconformity. If an angular unconformity could not be observed, a conglomerate was commonly interpreted as evidence of a significant time break in the geologic history of an area.

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In regard to the far smaller chips of limestone, Walcott had a simpler mechanism. He observed on a Rhode Island beach that modern sediments could form a hard crust rapidly which would then be broken into pieces and transported by the incoming tide (Walcott, 1895). The implication that limestone could form in exceedingly shallow water, harden rapidly, and be broken and transported was not pursued by him, nor did it register with other geologists of the time. In terms of understanding the formation of limestones, however Walcott’s casual observation was decades ahead of its time.

**GEOLOGIC TIME**

Thanks to the efforts of Lord Kelvin, the age of the Earth was a major concern from the 1860s onward. Kelvin’s ever decreasing time scale caused serious problems for the geologic community. Geologists had notions of rates of deposition and erosion, but as an eminent physicist, Kelvin had real numbers and formulas to bolster his arguments. Walcott (1893) approached the problem by considering in detail how much limestone, shale, and sandstone, was deposited in the western United States during the Paleozoic and proceeding from there. The method was not unique, but his analysis was the most sophisticated in this particular line of inquiry. He gave no details on where he obtained data for the Cenozoic and Mesozoic, although it can be assumed that his measurements came from his 1879 work on the Colorado Plateau.

Walcott’s (1893) suggested age was a minimum of 25 to 30 million years, and a maximum of 60 to 70 million years for the post-Archean interval. “In conclusion, geologic time is of great but not of indefinite duration. I believe that it can be measured by tens of millions, but not by single millions or hundreds of millions, of years.” This seemed to generate no discussion in literature from geologists, but Ulrich’s insistence on a still older “system” and his attacks on other worker effectively doomed his efforts.

Walcott’s was essentially the only prominent geologist who used both of the proposed systems in his publications. One may guess that throughout his career he was attuned to ever finer divisions of geologic time and thus was of an open mind in further dividing the Paleozoic.

One aspect of Ulrichian geology was that it was based on “layer cake” stratigraphy. Strata were presumed to remain essentially unchanged in sedimentary character throughout the length of their outcrop. The notion of a facies change in sedimentation of a stratigraphic unit was not acceptable. In Ulrich’s view, seas from one direction deposited sediment and then withdrew, to be followed by seas from another direction depositing a different type of sediment. It was in this manner that a change along strike from limestone to shale could be explained away. Ulrich’s prose was not easy to comprehend. What may be the best exposition of Ulrichian notions is presented in a summary paper by Walcott (1927). Like many of the other examples of Walcott’s work given above, one cannot judge what effect, if any, it had at the time, but Ozarkian and Canadian have disappeared as geologic periods.

**LEGACY AND CONCLUSIONS**

Charles Doolittle Walcott was a workaholic who never paused between manuscripts. In terms of volume of paleontological publication, he probably ranks among the three most productive paleontologists of the nineteenth or twentieth centuries (together with Joachim Barrande and James Hall). His laboratory investigations were closely linked to his field work. In the years since Walcott’s work was published, stratigraphic investigations have been refined, with new terms added, but the subdivisions he identified and the thicknesses he measured remain virtually unchanged. Likewise his paleontological work has been closely reexamined, yet the basic structure of his conclusions remain little changed. Despite my investigations, I am still unable to fully explain how he was able to publish so much research of such a high quality.

**ACKNOWLEDGMENTS**

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Figure 2: Slab of Burgess Shale (Cambrian) showing two trilobites, Olenoides serratus Walcott, both retaining their calcified exoskeleton and their nonbiomineralized (originally chitinous) appendages. Exoskeleton of the specimen at lower right = 8 cm. Photograph by Chip Clark.


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