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Early Cambrian sponge spicules from the Cerro Clemente and Cerro Rajón, Sonora, México

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ABSTRACT

Acid maceration and thin section analysis of archaeocyathan limestones of the Cerro Clemente and Cerro Rajón, Sonora, México, have yielded some of the most ancient sponge fossils reported from the North American Cordillera. The sponge fossils are from Unit 3 of the Puerto Blanco Formation. The fossils include one of the earliest known specimens of *Kiwetinokia* WALCOTT. These new data indicate that diverse archaeocyaths and sponges occur in close association within Lower Cambrian limestones of Sonora. The new specimen of *Kiwetinokia* sp. provides evidence that geometrically complex spicules in Cambrian sponges evolved by the fusion of simpler spicule types. These are among the earliest sponges known to have lived in reef habitats.

KEYWORDS | Sponges. Spicules. Early Cambrian. *Kiwetinokia*. Puerto Blanco Formation.

INTRODUCTION

Although sponges were an important element in Cambrian marine communities, until now Early Cambrian sponge spicules have rarely been reported from the North American Cordilleran rocks, in spite of the fact that several fossil compendia have been published for the Lower Cambrian fossils of these regions (Stewart et al., 1984; Onken and Signor, 1988; Debrenne et al., 1989; McMenamin et al., 1994; Stewart and Poole, 2002). Early Cambrian sponges were reported from Stevens County, Washington, USA by Hampton (1979), but this report was evidently restricted to *Chancelloria* sclerites. With Cambrian sponges beginning to play a key role in our understanding of the early stages of animal evolution (Botting and Butterfield, 2005), it is important to document new sponge occurrences from Cambrian and especially Lower Cambrian strata.

Unit 3 of the Puerto Blanco Formation (Fm) in Sonora, México, is part of a mixed clastic and carbonate platform sequence that is known for its boundstones and small reefs that are dominated by a diverse suite of archaeocyaths (Debrenne et al., 1989). Debrenne et al. (1989) reported sponge spicules present in an irregular patch of lime mudstone from Unit 3 of the Puerto Blanco Fm, in what Debrenne et al. (1989) called the Framework Reef facies Type 1 (Debrenne et al., 1989, plate 4, fig. A). The spicules described by Debrenne et al. (1989) do not appear to be diagnostic for any particular type of sponge. The only other report of Cambrian sponges from México is Middle Cambrian possible sponge spicules that have been reported from the Rancho Sobechi area (Stewart and Poole, 2002).

Figure 1A shows the primary locality plotted on a geologic map of the western edge of the Cerro Clemente.

Like the Cerro Rajón, the Cerro Clemente represents an important stratigraphic section (Fig. 1B) because it represents a fossiliferous and relatively continuous section that includes the Proterozoic-Cambrian boundary. The boundary here is placed at the top of the La Ciénega Fm (McMenamin, 1996), although other researchers have placed the Cambrian boundary within the lower Puerto Blanco Fm (Sour-Tovar et al., 2007). Sour-Tovar et al. (2007) tentatively placed the Proterozoic-Cambrian boundary within Unit 1 of the Puerto Blanco Fm, but they did not demonstrate the presence of diagnostic Proterozoic fossils within the Puerto Blanco Fm. More research is needed on this question, because biostratigraphic control is currently insufficient to resolve the exact position of the boundary in the Sonoran sequence. In any case, the boundary appears to be at or near the boundary between the La Ciénega and Puerto Blanco Fms.

The fossils occur in archeocyath-*Renalcis-Girvanella* boundstones and associated wackestones-packstones. The textures of the archeocyath-*Renalcis-Girvanella* boundstones are complex, and include cavities with multiple rind cements (Debrenne et al., 1989). Scattered sponge spicules occur in these carbonate rocks (Fig. 2).

The primary sponge-bearing sample (1 of 12/15/82; Cerro Clemente) also has abundant archaeocyaths, lingulid brachiopod fragments, trilobite fragments, disarticulated echinoderm plates and *Chancelloria* sclerites. The small shelly fossils were recovered from the limestone by acetic acid maceration. The lime mud matrix has abundant *Renalcis* (a calcareous alga that forms a fossil with a clotted texture), and there are thick carbonate overgrowths on the archaeocyaths. The trilobites *Nevadia orbis* (MCMENAMIN) and *Nevadia ovalis* MCMENAMIN both occur stratigraphically higher in the

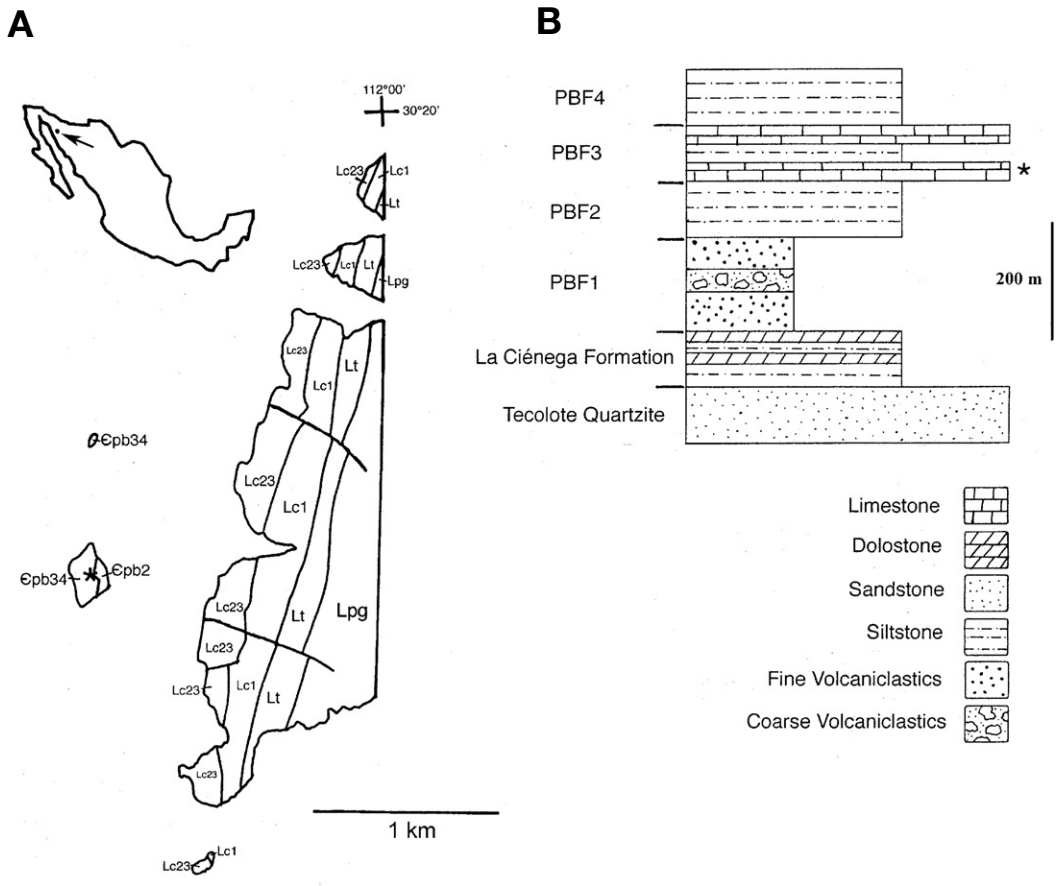

FIGURE 1 | **Geologic map and generalized stratigraphic solumn for the Cambrian sponge fossil locality. A) Geologic map showing the eastern edge of the Cerro Clemente, Sonora. Inset map shows the location of the site (arrow) with respect to the map of México. Geologic mapping refers to bedrock outcrops above the 500-meter contour line on the Hilario Gavilondo H12A76 topographic map (Secretaría de Programación y Presupuesto, 1980). The fossil locality is shown as a star. Rock units on the map are as follows: Lpg, Papalote and Gamuza Formations; Lt, Tecolote Quartzite; Lc1, La Ciénega Formation, Unit 1; Lc23, La Ciénega Formation, Units 2 and 3; Єpb2, Puerto Blanco Formation, unit 2; Єpb34, Puerto Blanco Formation, Units 3 and 4. B) Stratigraphic column of the Proterozoic-Cambrian boundary interval in the Cerro Clemente, Sonora. Thickness data are from Stewart and Poole (2002). The fossil locality is shown as a star. PBF is an abbreviation for Puerto Blanco Formation.**

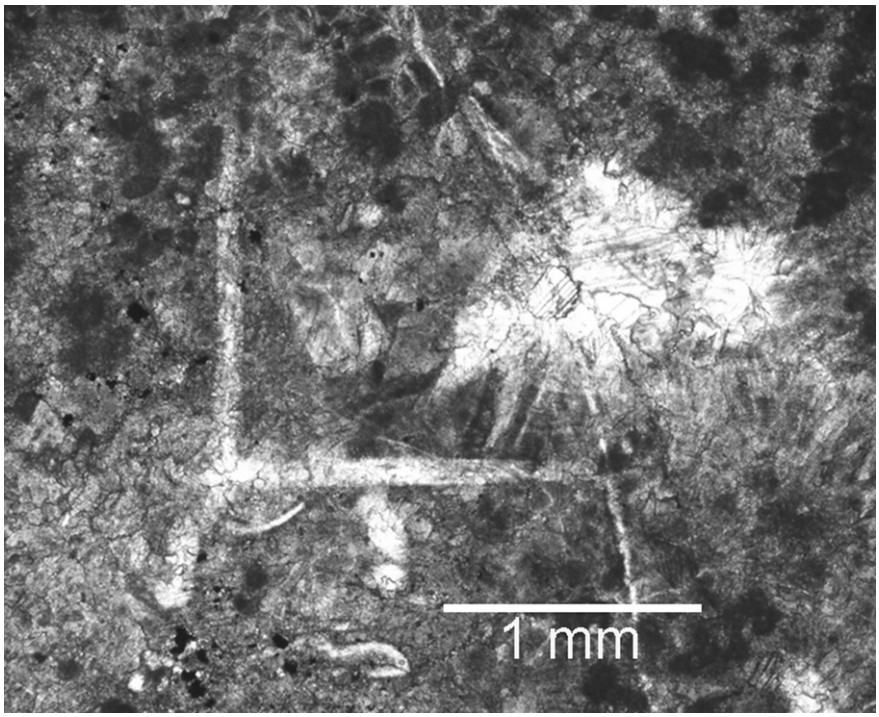

FIGURE 2 | **Probable stauractine spicule from the base of Unit 3, Puerto Blanco Formation, Cerro Rajón. Note trilobite 'shephard's hook' below spicule. Sample 9 of 3/23/90; IGM 7450b.**

section within the medial clastic facies of Unit 3 of the Puerto Blanco Fm, indicating a lower *Nevadella* Zone age (Botomian age) for Unit 3 of the Puerto Blanco Fm (McMenamin, 2001). All samples are deposited in the Institute of Geology Museum (IGM), Departmento de Paleontología, Instituto de Geología, Ciudad Universitaria, Delegacíon de Coyoacán, 04510, México, D. F.

SYSTEMATIC PALAEONTOLOGY

Phylum: Porifera GRANT, 1836

Class: Hexactinellida SCHMIDT, 1870
Order: Reticulosa REID, 1958
Family: Protospongidae HINDE, 1887

GENUS ***Kiwetinokia*** WALCOTT, 1920

Kiwetinokia sp.
Figures 3, 4, 5

The genus *Kiwetinokia* is characterized here by the presence of spicules where two or more spicules are

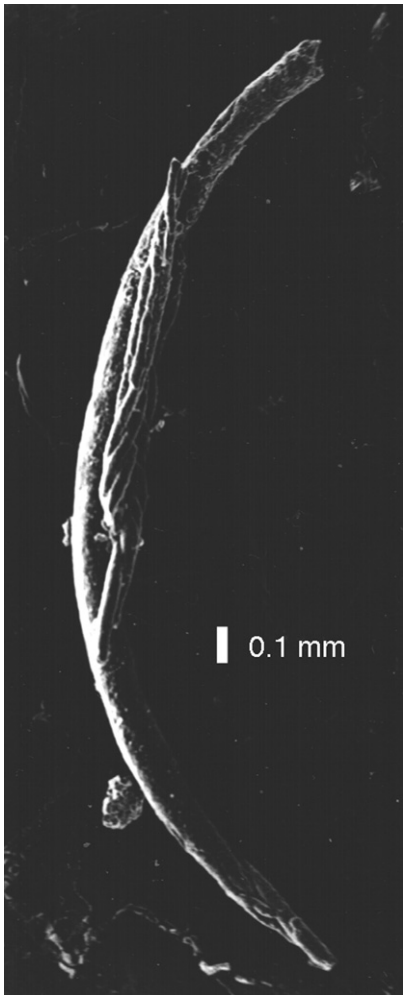

FIGURE 3 | ***Kiwetinokia*** **sp. Several twisted and fused spicules are visible. The specimen has been phosphatized, the phosphate probably replacing calcium carbonate. Lower Unit 3, Puerto Blanco Formation, Cerro Clemente, Sonora, sample 1 of 12/15/82, IGM 3614.**

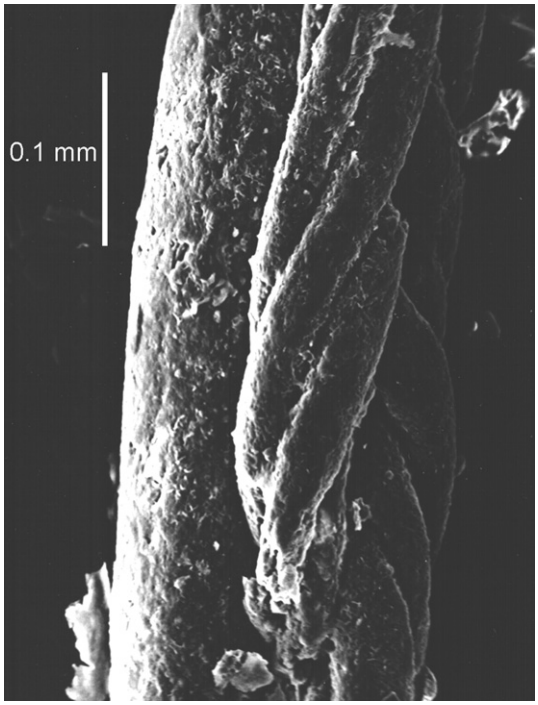

FIGURE 4 | ***Kiwetinokia* sp. Enlargement of the twisted spicule cluster seen in Figure 3. Lower Unit 3, Puerto Blanco Formation, Cerro Clemente, Sonora, sample 1 of 12/15/82, IGM 3614.**

twisted around each other. A single spicule was recovered by acid maceration from Unit 3 of the Puerto Blanco Fm in the Cerro Clemente, and shows the rope-like twisting characteristic for the genus (Rigby, 1983). The Y-shaped prodiaene spicule seen in a thin section in Fig. 5 may belong to this genus as well, as spicules of this shape are a distinctive part of the *Kiwetinokia* assemblage (Walcott, 1920; Beresi, 2003). Beresi and Rigby (1994) assigned a Y-shaped prodiaene from the Lower Cambrian La Laja Fm, Chica de Zonda Range, of the Argentine Precordillera to *Kiwetinokia utahensis*?, but the spicule assemblage of which it was a part did not include twisted, rope-like spicules (Beresi and Rigby, 1994).

The twisting and fusion of three to four spicules seen in Figs. 3 and 4 is reminiscent of the twisted bundles of spicules in *Kiwetinokia spiralis* WALCOTT. However, in the Mexican specimen the twisting is much less regular. Furthermore, the twisted spicules are seen adhering to a large, curved tusk-shaped spicule that shows evidence itself of fusion of twisted spicules at its tapered end. This latter observation is in accord with the fusion of twisted spicules (Walcott, 1920) as seen in the Middle Cambrian sponge *Kiwetinokia utahensis*. One might argue that the control of biomineralization in the Early Cambrian Mexican species was less morphologically regularized than in subsequent species of the genus. Furthermore, it seems plausible that all *Kiwetinokia* spicules with multiple rays

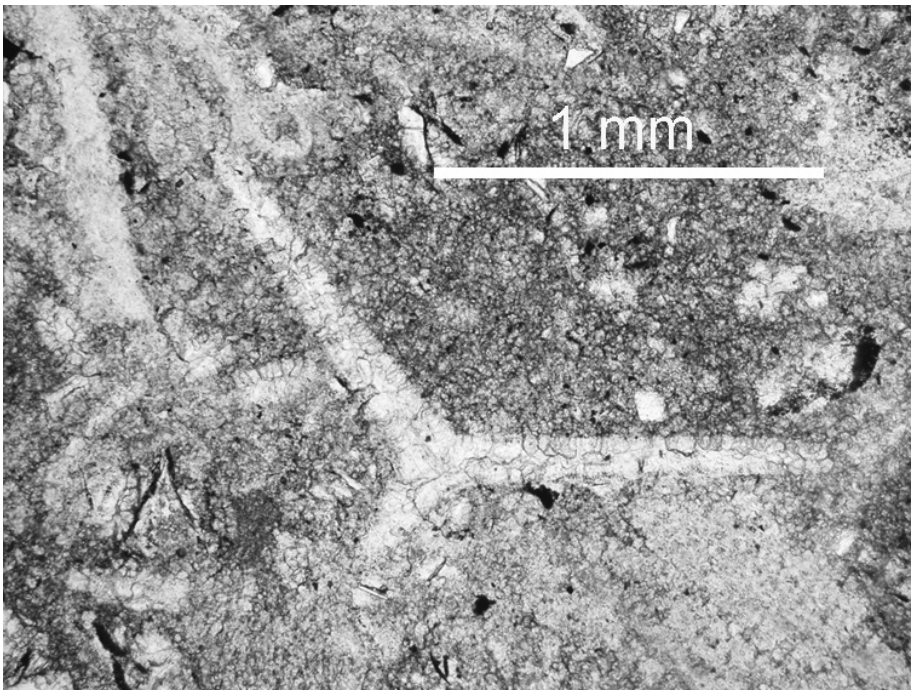

FIGURE 5 | ***?Kiwetinokia* sp. Y-shaped calcareous spicule in petrographic thin section. Lower Unit 3, Puerto Blanco Formation, Cerro Clemente, Sonora, sample 1 of 12/15/82. IGM 7450a.**

may be thought of as geometrically regular clusters of fused spicules; see in particular the Y-shaped spicule in plate 89, fig. 1b and 1d of Walcott (1920), where spicules of *Kiwetinokia utahensis* appear to be built up by fusion of monaxial spicules.

This specimen of *Kiwetinokia* is from the lower *Nevadella* Zone, and is thus likely to be the oldest known representative of this genus, if we assume as seems reasonable that it is slightly older than the sponges occurring stratigraphically downward from trilobites of the *Plagiura-Poliella* zone in the Soldano Member of the La Laja Fm of the Argentine Precordillera (Beresi, 2003).

Stauractines

Figure 2

A single stauractine spicule has been seen in a limestone thin section from the base of Unit 3 of the Puerto Blanco Fm in the Cerro Rajón, Sonora. Similar spicules are known from several different orders of sponges (Beresi, 2003).

CONCLUDING REMARKS

Kiwetinokia sp. from the Cerro Clemente shows characteristics considered here to be primitive, such as the tendency for irregular spicular twisting and fusion. This Early Cambrian sponge may therefore represent a stem group taxon. *Kiwetinokia* sp. provides evidence that geometrically complex spicules in Cambrian sponges evolved by the fusion of simpler spicule types. More information is needed about the morphology of these sponges in order to fully assess their importance for our understanding of early poriferan evolution. These Mexican sponges evidently lived in a close ecological association with reef-forming archaeocyaths, and are thus among the first North American sponges known to have lived in reef habitats.

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