



Cave millipeds of the United States. VI. *Sequoiadesmus krejcae*, n. gen., n. sp., from Sequoia and Kings Canyon National Parks, California, USA (Diplopoda, Polydesmida, Polydesmidea, Macrosternodesmidae).

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Abstract

Sequoiadesmus krejcae, n. gen., n. sp., a minute, depigmented polydesmidan milliped, is described from caves in Sequoia and Kings Canyon National Parks, Tulare County, California. It is provisionally assigned to the Macrosternodesmidae pending further research on representatives of the polydesmidean superfamilies Polydesmoidea and Trichopolydesmoidea in the western United States. Attributes of Macrosternodesmidae, Nearctodesmidae (Trichopolydesmoidea) and Polydesmidae (Polydesmoidea) are compared and contrasted.

Key words: Trichopolydesmoidea, Polydesmoidea, Macrosternodesmidae, Polydesmidae, Sequoia & Kings Canyon National Parks

Introduction

The composition of the milliped family Polydesmidae (Polydesmida: Polydesmidea: Polydesmoidea) in North America was reviewed by Shelley (2003a), who noted that six genera and 15 species occur west of the Continental Divide. He particularly referenced "micropolydesmids," species less than 6 mm long that typically inhabit soil and litter and are active primarily in cool weather seasons of the year; they are strikingly diverse, differ anatomically from the larger-bodied polydesmids of the Palearctic and eastern Nearctic regions, and exhibit gonopodal patterns that are diagnostic for suprageneric as well as generic taxa. Hoffman (1975, 1980, 1999) noted that the automatic placement of small-bodied polydesmideans in the nominate family was not always supported by the basic gonopodal architecture, and he assigned *Chaetaspis* Bollman, 1887, occurring from the Ozark and Ouachita Plateau Physiographic Provinces of Arkansas and Missouri eastward, to the otherwise European family Macrosternodesmidae Brölemann 1916. Simonsen (1990) and Shelley (1994) noted the similar ground plans of macrosternodesmid and nearctodesmid gonopods, the latter being the dominant polydesmidean family along the Pacific Coast in northwestern North America. Shelley (1993) examined *Harpogonopus confluentus* Loomis, 1960, originally assigned to the Polydesmidae (Loomis 1960), and while uncertain as to its familial position, concluded that it belonged to the superfamily Trichopolydesmoidea, containing the Fuhrmannodesmidae Brölemann, 1916, which is absent from the United States (US), Macrosternodesmidae, and Nearctodesmidae Chamberlin & Hoffman, 1950 (Shelley 2003b). Subsequently, he (Shelley 1994) referred *Harpogonopus* to the Nearctodesmidae as potentially a separate subfamily from the genera in the Pacific Northwest. We believe some small-bodied polydesmideans in the western US that represent undiagnosed genera actually constitute "micronearctodesmids" (Shelley & Shear 2006), and we recently diag-

nosed *Leonardesmus* Shelley & Shear, 2006, from Washington state. Their similar gonopodal structures suggest that Macrosternodesmidae and Nearctodesmidae should be merged as per Hoffman (1982) and Simonsen (1990) (see Shear & Shelley (2007) for discussion), but we concur with Hoffman (1999) that this should not be done until all known genera have been diagnosed and their relationships, clarified. The ultimate objective of our research is to reassess the components of the polydesmidean superfamilies Polydesmoidea and Trichopolydesmoidea and to diagnose potential new families. Accomplishing this task will require several years, during which time we will put on record new taxa from the western US. The first step in this process was our recent revision of *Tidesmus* Chamberlin, 1943 (Macrosternodesmidae) (Shear & Shelley 2007), in which we provided a new, albeit tentative, familial diagnosis.

The ensuing new genus and species was discovered in Hurricane Crawl Cave, Sequoia National Park (SNP), Tulare County (Co.), California, and are diagnosed independently because of urgent conservation concerns regarding caves in SNP and the adjacent "Grant Grove" section of Kings Canyon National Park (KCNP). The caves comprise five subterranean "clusters" in these Parks (Fig. 9). All specimens are housed in the California Academy of Sciences (CAS), San Francisco.

Taxonomy

Order Polydesmida Pocock, 1887

Suborder Polydesmoidea Pocock, 1887

Infraorder Polydesmoides Pocock, 1887

Superfamily Trichopolydesmoidea Verhoeff 1910

Family Macrosternodesmidae Brölemann 1916

Diagnosis (adapted from that of Shear and Shelley 2007). Trichopolydesmoidea 6–12 mm long but occasionally growing to ca. 30 mm long, with 20 segments including epiproct; collum narrower than head, not overlapping epicranium; metaterga with transverse sulci and three or four rows of variably rounded to subconical pustules giving rise to clavate setae; paranota small but distinct; male prefemora swollen and convex dorsally; sphaerotrichomes present on at least ambulatory tibiae and tarsi. Gonopodal aperture large, completely filling metazonite, not extending onto prozonite but sometimes spreading caudad between 9th legs. Gonocoxae large, completely filling respective halves of aperture, excavated medially to accommodate telopodites; prefemora horizontal or angling ventromedially, giving rise to acropodite and additional projection homologous to process B of Nearctodesmidae (terminology of Shelley (1994)); distal zone variably configured, sometimes folded, flattened, and not recognizable as such; solenomere long and narrow, arising subterminally, without hairpad and ampulla, prostatic groove opening terminally.

Remarks. Because of the anatomical similarities between Macrosternodesmidae and Nearctodesmidae and the tendency to assign small-bodied forms to the Polydesmidae, it is appropriate to briefly compare and contrast these taxa. This is a purely heuristic enterprise to benefit North American workers who face the practical problem of diagnosing these three families. While the nearctodesmids and macrosternodesmids are presently placed in the superfamily Trichopolydesmoidea and the polydesmids in the Polydesmoidea, the difficulties inherent in separating them are formidable. This serves only to point to the necessity for a complete reexamination of family-level classification in the Infraorder Polydesmoides. Perhaps the greatest problem in such a project will be the vast numbers of described and undescribed genera from the tropics that are now routinely placed in the "wastebasket" taxon Fuhrmannodesmidae.

In nearctodesmids, the gonocoxae are large and globular, closely appressed or fused caudally but narrowly separated anteriorly, and with limited, if any, mobility. The setose basal part of the telopodite (often, and probably correctly, referenced as the **prefemur**) is short, compact, and either angles ventromedial or is oriented transversely. Two elongated processes arise at or near the base of the **acropodite** (*sensu* Shelley 1994 and Shear & Shelley 2007) and are designated **A** and **B**, the former being mesial to the latter. Both may bear teeth and/or subbranches, and A may be absent; we cannot determine whether this is a primitive condition or if the process has been lost. The **prostatic groove** originates in the prefemur, follows a curvilinear course along the acropodal surface, and terminates apically on the **solenomere branch**. Distal to this branch is the apical part of the acropodite, termed the **distal zone**.

The gonopods of North American macrosternodesmids are similar to those of nearctodesmids. All known North American macrosternodesmids lack process A, but possess process B, which is generally longer and broader than in nearctodesmids. Its form and that of the acropodite differ significantly among species presently assigned to *Chaetaspis* (see Lewis 2002), which is probably why Hoffman (1999) contended that more than one genus is covered by this name. Numerous undescribed macrosternodesmids inhabit the Appalachian Mountains and Mississippi Valley; without detailed knowledge of them, Hoffman's suggestion, while plausible, cannot be evaluated. In some males of *Chaetaspis*, the 7th segment is markedly longer (perhaps twice so) than those to the anterior and posterior, and while a slight enlargement is evident in polydesmids, it is never as striking as that in macrosternodesmids.

In polydesmids, the prefemora lie parallel to each other along the body axis; the distal part of the telopodite is not bent, usually constitutes the anterior extremity of the gonopod, and often lies in a prozonal depression that may extend onto the 6th metazonite. Sternal lobes, which are absent from macrosternodesmids, may be present on segments 3–6 of male polydesmids. The prostatic groove, which is actually an internal canal, opens into a small chamber with an outlet pore flush on the acropodal surface that is usually surrounded by fine setae or finger-like cuticular projections, and often subtended by an acute, sometimes branched process.

Sequoiadesmus, n. gen.

Type species. *S. krejcae*, n. sp.

Diagnosis. Metatergal setae acuminate, scattered or in vague, irregular rows, never clavate and in four distinct rows. Process B irregularly laminate for most of length, extending caudad distally, apically expanded and subbifurcate; solenomere long and curvilinear, becoming progressively narrower distad, with shorter, sub-acuminate basal branch.

Distribution. At present known only from a single species found in limestone caves in Sequoia National Park, Tulare Co., California; may also occur in adjacent Kings Canyon National Park.

Etymology. The generic name reflects the form's occurrence in SNP near Giant Sequoia trees, *Sequoiadendron giganteum*, the world's largest living organisms.

Sequoiadesmus krejcae, n. sp.

Figs. 1–8

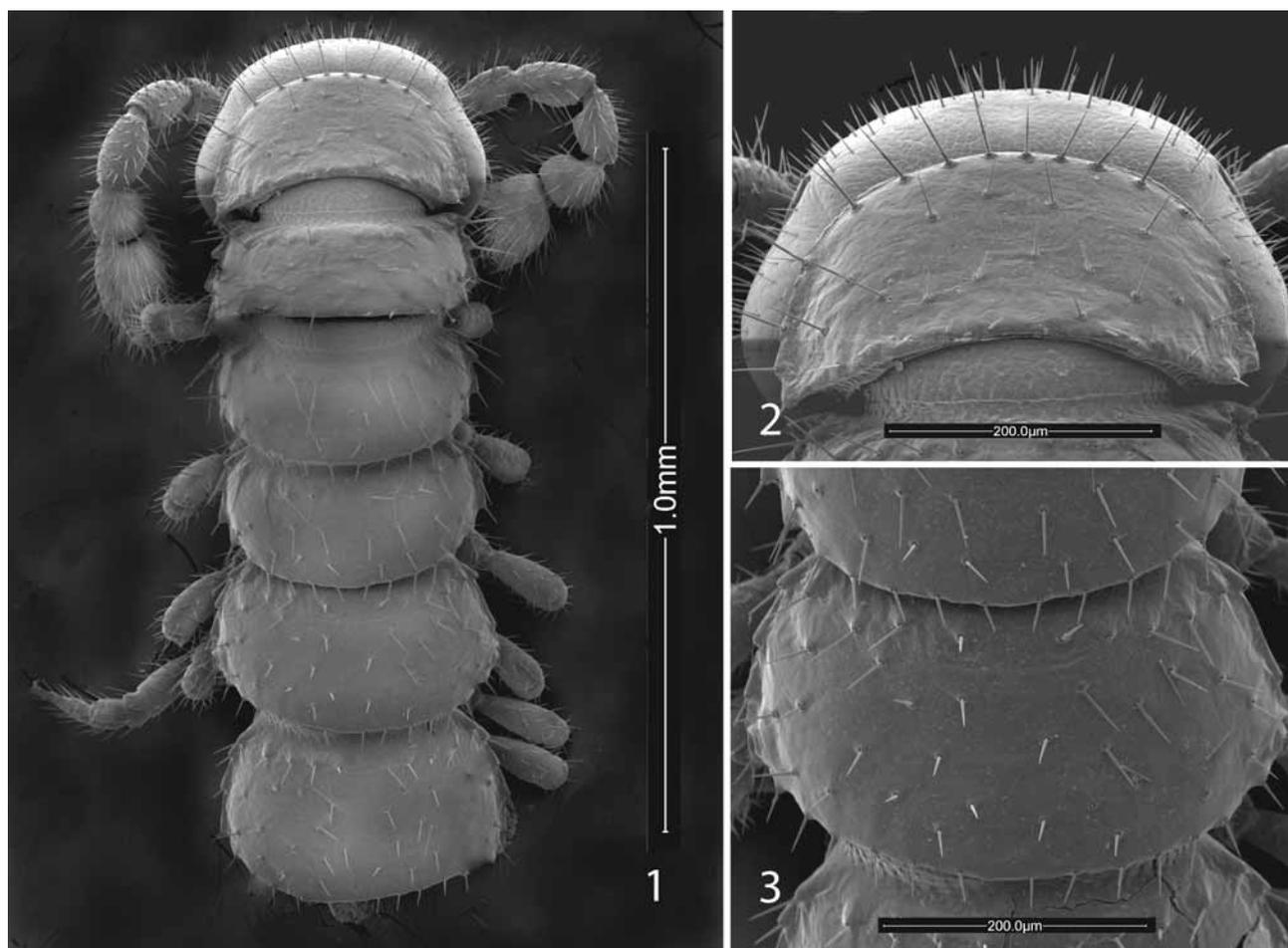
Type specimens. Male holotype and one male and one female paratype (CAS) collected by J. Krejca, A. Gluesenkamp, C. Walk, J. Despain, & N. Barth, 9 July 2004, in Hurricane Crawl Cave, SNP, Tulare Co., California.

Diagnosis. With the characters of the genus.

Holotype. Length, 5.4 mm, maximum width 0.6 mm. Head (figs. 1, 2) smooth but with moderately dense pilosity. Antennae short, clavate, and densely pilose, reaching back to caudal margin of 2nd tergite, relative lengths of antennomeres $6 > 2 = 3 = 4 > 5 > 7 > 1$, articles 2–4 twice as long as wide and slightly clavate, 5 slightly wider than long, 6 subovoid and swollen. No accessory sensory areas detected. Collum (figs. 1, 2) small and subovoid, overlapping epicranium, with acute posteriolateral angles and indistinct lateral teeth; surface smooth, with anterior-anteriolateral row of 15 long, acute setae, posterior row of 11 similar setae, and ca. 15 additional, scattered, dorsal setae. Metaterga of succeeding segments (fig. 3) smooth, virtually without paracosta, with 3 acuminate lateral setae anterior to ozopores subtending small marginal teeth, about 15 setae on caudal margins posterior to ozopores, 10–13 setae in anterior rows, and ca. 15–22 scattered dorsal setae. Caudal segments with dorsal setae arranged in 3 transverse rows. Limbi smooth. Ozopores (fig. 3) with slightly raised rims. Epiproct setose and subtriangular, sides tapering evenly to tip; spinnerets not set in depression.

Sterna unmodified. Legs moderately long; prefemora of pregonopodal legs not swollen. Gonopodal aperture (fig. 6) broadly ovoid, occupying entire breadth of metazonite but not extending onto prozonite. Gonopods (figs. 4–8) with coxae globular, completely filling respective halves of aperture, narrowly segregated anteriorly, contiguous, deeply excavated anteriorly; prefemora moderately transverse, setose. Process B with two unequal distal branches, lateral one short and blunt, mesial branch longer and expanding apically into shallowly indented, "T-shaped" termination. Acropodite with long, distally curved solenomere giving rise to short, apically blunt distal zone at 1/3 of length. 9th legs unmodified.

Female paratype. Length, 5.7 mm, width 0.6 mm. Nonsexual characters as in male.

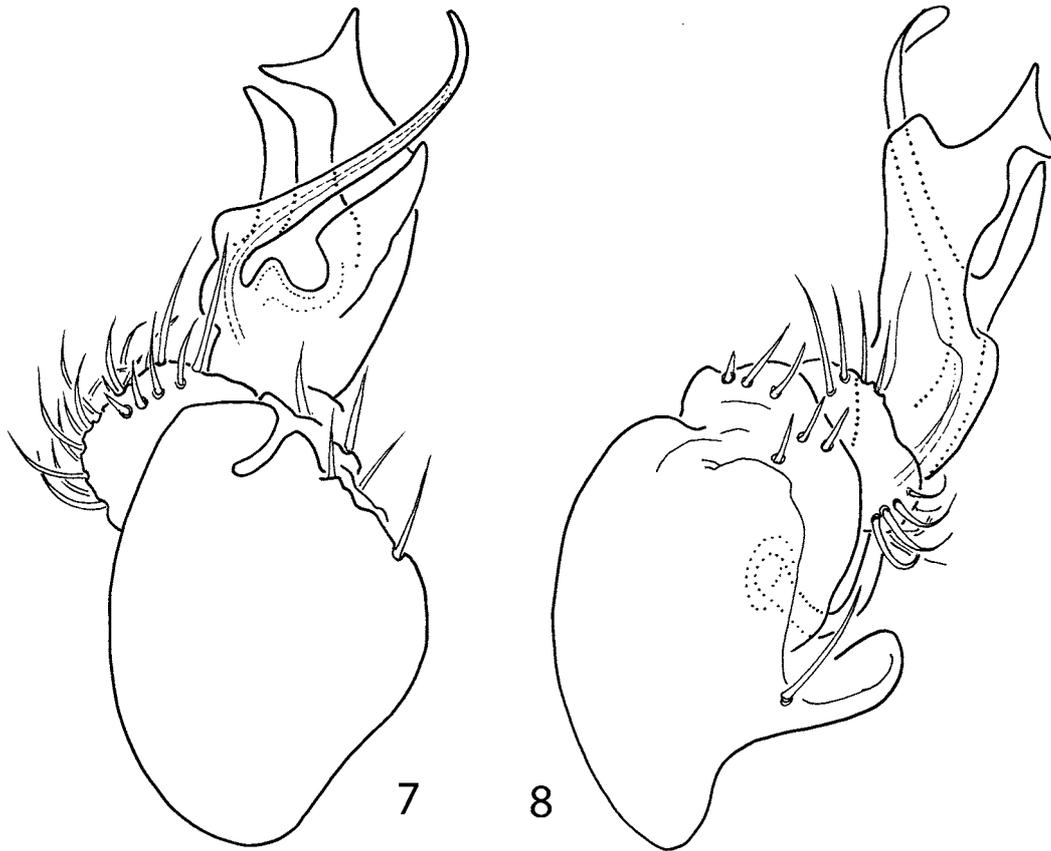


FIGURES 1–3. Scanning electron micrographs of *S. krejcae* holotype. 1, head and segments 1–6, dorsal view. 2, head and collum, dorsal view. 3, segment 5, dorsal view.



FIGURES 4–6. Scanning electron micrographs of gonopods *in situ* of *S. krejcae* holotype. 4, posterior view. 5, lateral view. 6, anterioventral view.

Distribution. The following female specimens are consistent with the female paratype but cannot be authoritatively assigned to *S. krejcae* given the difficulties in distinguishing species in female and juvenile polydesmideans.



FIGURES 7–8. Line drawings of dissected *S. krejcae* left gonopods. 7, lateral view. 8, mesial view.

CALIFORNIA: *Tulare Co.*, SNP, Clough Cave, f, 27 April 2004, J. Krejca, P. Sprouse, B. Fryer, D. Ubick, P. Paquin (CAS); KCNP, Grant Grove Section, Lilburn Cave, ff, 30 July 2003, J. Krejca, V. Loftin, S. Fryer, J. Snow, A. Snow, B. Oost (CAS).

The caves in SNP and KCNP comprise five clusters (fig. 9); Hurricane Crawl Cave, the type locality, is in cluster 2. Lilburn Cave is in cluster 1, about 5 miles (8 km) north-northwest of cluster 2, and Clough Cave is in cluster 5, about 14 miles (22.5 km) south of cluster 1. Adult males are needed to determine whether forms in these caves are conspecific with *krejcae*. The presence of more than one species is a definite possibility, since clusters 2 & 5 harbor distinct species of the troglophilic milliped genus *Amplaria* Chamberlin, 1941 (Chordeumatida: Striariidae) (Shear & Krejca 2007).

Etymology. The species name honors Jean K. Krejca, who organized and led the several expeditions to the caves of Sequoia National Park, and participated in collecting this and other species.

Remarks. At this point it is not possible to assess the ecological status of *S. krejcae*. Is it a troglobite, a troglophile, or an edaphobite to be found only occasionally in caves? Both troglotic and edaphobitic minute polydesmidans tend to be depigmented, and of course, all polydesmidans are eyeless. Figs. 1–3 show that the legs and antennae of the species are not elongated nor attenuate, and the cuticle is well-calcified. Since very little collecting has been done outside caves in the region, we are not at all confident that *S. krejcae* is cave-limited.

Our assignment of *S. krejcae* to the Macrosternodesmidae is somewhat tentative since not all the diagnostic familial characters are evident and others are equivocal. The distal zone could be interpreted as homologous to the process close to the pore of the prostatic groove in the Polydesmidae, and what we label as process B, which is characteristic of macrosternodesmids, could also be a polydesmid “tibiotarsus”; finally, the pregonopodal legs lack the dorsally inflated prefemora that occur in other macrosternodesmids. Some gonopodal

features of *Sequoiadesmus* are similar to those of the Californian “polydesmid” genus *Bidentogon* Buckett and Gardner, 1968, which is atypical within Polydesmidae, and may require a new family. We therefore hypothesize the present assignment pending further research toward our aforementioned goals with the Polydesmoidea and Trichopolydesmoidea.

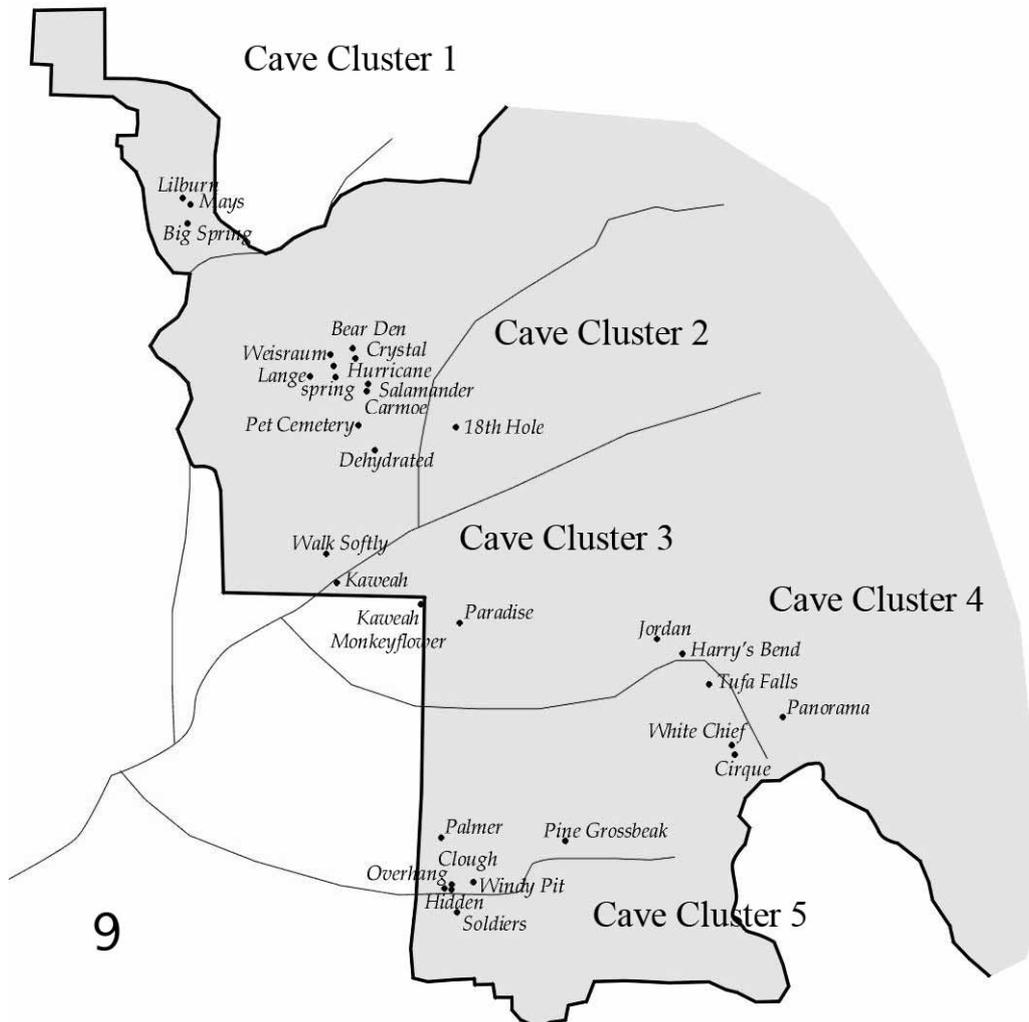


FIGURE 9. Map of parts of Sequoia and Kings Canyon National Parks, Tulare Co., California, showing locations of caves studied in 2003–2004 by Jean K. Krejca and associates. Note that some of the cave names are shortened for ease of viewing on the map, typically the word Cave is left off. See text for the full names of caves in which *Sequoiadesmus krejcae* specimens were collected.

Acknowledgments

We thank Jean Krejca, Zara Environmental LLC, 118 Goforth Rd., Buda, Texas 78610 USA, for sending the specimens initially to RMS. A National Park Service (NPS) grant that funded the collection trips was written by Danny Boiano and Joel Despain, who along with NPS personnel Annie Esperanza and Shane Fryer assisted with logistics and participated extensively in the study. Scanning electron microscopy was done at East Carolina University; thanks are due to Jason Bond, for arranging use of the instrument by WAS, and to Matt Walker and Paul Marek, for technical assistance. The map was contributed by Joel Despain. This paper is published under the auspices of National Science Foundation PEET grant (DEB05-29715) to WAS, Jason Bond and Petra Sierwald, and with the help of a Faculty Development grant from Hampden-Sydney College. Asa Kreevich and anonymous reviewers made valuable suggestions on the manuscript.

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