

CAMBRIAN STRATIGRAPHY AND PALEONTOLOGY OF NORTHERN ARIZONA AND SOUTHERN NEVADA

THE 16TH FIELD CONFERENCE OF
THE CAMBRIAN STAGE SUBDIVISION WORKING GROUP
INTERNATIONAL SUBCOMMISSION ON CAMBRIAN STRATIGRAPHY
FLAGSTAFF, ARIZONA, AND SOUTHERN NEVADA, UNITED STATES

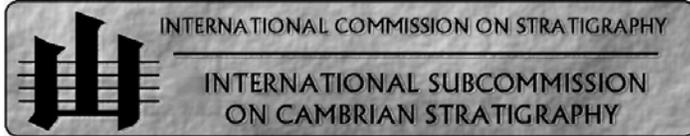


Edited by
J. Stewart Hollingsworth
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STOP 6B

**UPPER DYERAN AND LOWER DELAMARAN LITHOSTRATIGRAPHY AND
BIOSTRATIGRAPHY OF THE NORTHERN GROOM RANGE, NEVADA**

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INTRODUCTION

UPPER DYERAN through Delamaran strata are well exposed on the western flank of the northern Groom Range, Lincoln County, Nevada (Fig. 1). The Groom Range occupies a key geographic location between outcrop areas of age-equivalent strata that have been mapped as the Pioche Formation to the east (Stops 5A-D, 6A) and as the Carrara Formation to the west and south (see Webster, Article 7, this volume, fig. 2). Careful study of strata in the Groom Range is therefore critical to our understanding of lithofacies and biofacies relationships between these formations around the Dyeran-Delamaran stage boundary interval.

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REGIONAL SETTING AND GENERAL STRATIGRAPHY

Upper Dyeran and lower Delamaran strata of the Groom Range were deposited in an inner-to-middle shelf setting. Groom Range strata of the upper Dyeran *Bristolia insolens*, *Peachella iddingsi*, and lowermost *Bolbolenellus euryparia* zones (as defined by Webster, Article 7, this volume) are carbonate-rich and lithologically more similar to the Thimble Limestone and Echo Shale members of the Carrara Formation than to the correlative Delamar Member of the Pioche Formation. However, higher Dyeran and Delamaran strata in the Groom Range are lithologically much more similar to the Combined Metals, Comet Shale, Susan Duster Limestone, and Log Cabin members of the Pioche Formation than to correlative members of the Carrara Formation. Historically, upper Dyeran and lower Delamaran strata of the southern Groom Range were mapped as the “Pioche Shale” by Humphrey (1945), but were assigned to the Carrara Formation by later workers (Barnes and Christiansen, 1967; Palmer and Halley, 1979) following the formal naming of that unit by Cornwall and Kleinhampl (1961). For ease of discussion, Pioche Formation nomenclature is applied herein to the northern Groom Range succession (see also McCollum and McCollum, Article 8, this volume).

This paper focuses on biostratigraphic details of the Pioche Formation in the northern Groom Range. Lithologic and sequence stratigraphic details of the Pioche Formation are presented by Webster (this volume, Article 7; this volume, Stops 5A, 5B, 6A), McCollum et al. (Stops 5A-D, 6A, this volume), and McCollum and McCollum, Article 8, this volume).

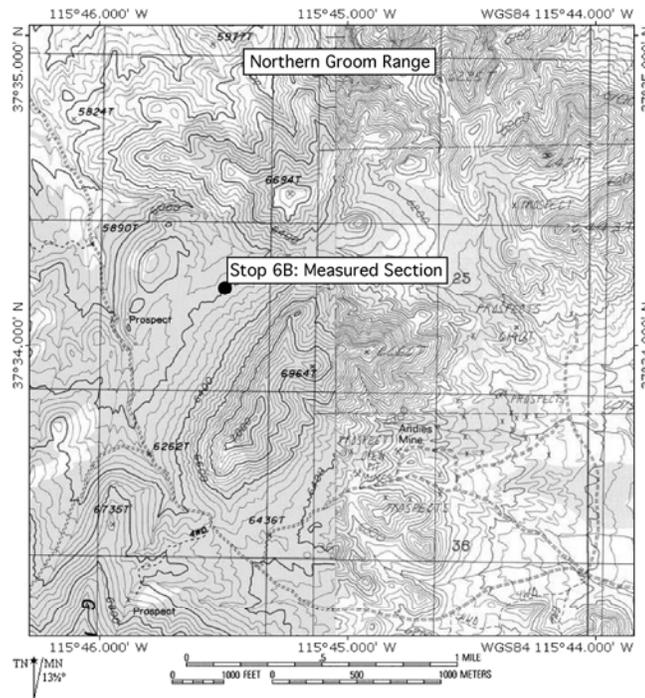


FIGURE 1.—Map of the western flank of the northern Groom Range, Lincoln County, Nevada, showing the location of the measured section (Stop 6B). Map created with TOPO! software (© National Geographic, 2002).

HISTORY OF RESEARCH

The first geological survey of the Groom Range (formerly considered part of the Timpahute Range) was published by Gilbert (1875). Walcott (1886, 1890, 1910) illustrated olenelloid trilobites collected by Gilbert from the Groom Range (cataloged as USNM locality 313g). Later survey work resulted in more detailed descriptions of the Cambrian stratigraphy of the southern Groom Range by Humphrey (1945; subsequently slightly modified by Wheeler, 1948), Barnes and Christiansen (1967), and Palmer and Halley (1979). The Groom Range was incorporated into regional biostratigraphic and geologic syntheses by Spurr (1903), Mason (1938), Tschanz and Pampeyan (1970), Stewart (1970), and Palmer (1971). Access to the southern part of the Groom Range has been restricted as the result of expansions of Nellis Air Force Range in the mid-1970s and again in the mid-1990s. However, the

northern part of the range remains outside this restricted zone and is accessible to the public via unimproved dirt roads.

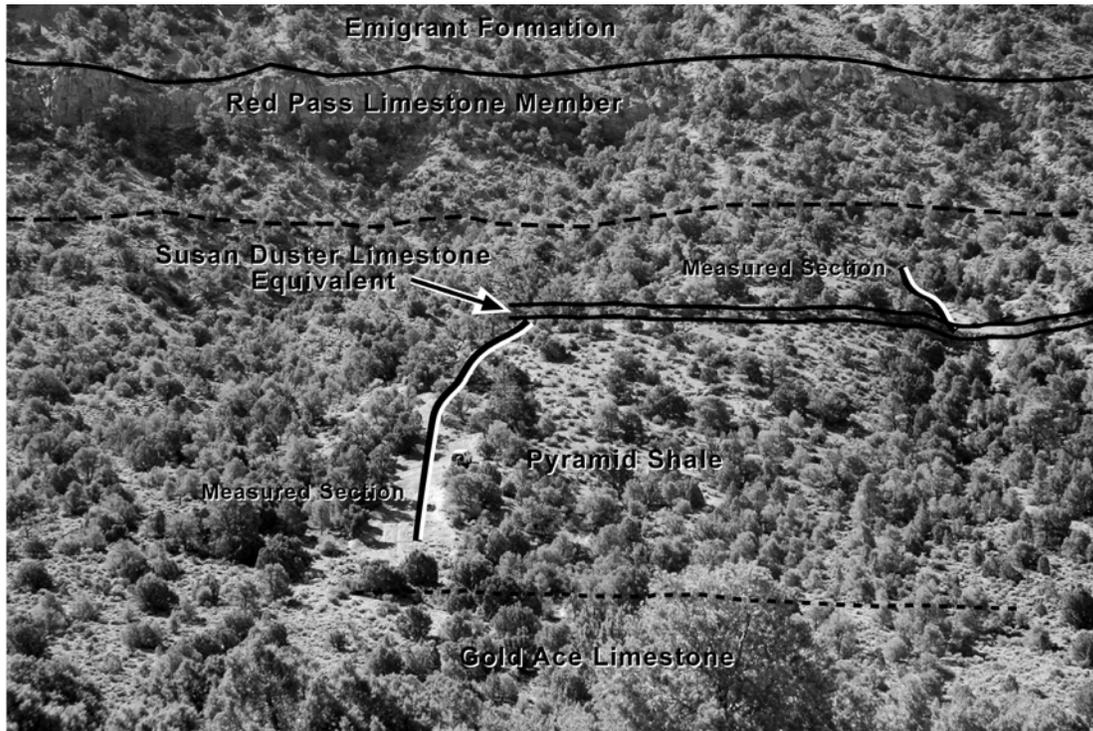


FIGURE 2.—Photograph of the hillside in the northern Groom Range, Lincoln County, Nevada, showing location of the measured section (Stop 6B). Several members of the Pioche Formation are exposed. The trenched interval cuts through the upper part of the Combined Metals Member and the overlying Comet Shale Member. Also shown is the Susan Duster Limestone Member and overlying Log Cabin Member.

In 1994 a trench was mechanically excavated through the Combined Metals Member of the northern Groom Range by the Bureau of Land Management (BLM), as part of an Eastern Washington University research project on the Lower-Middle Cambrian boundary interval conducted by L. B. McCollum and M. B. McCollum (Figs. 1, 2). Fossils collected from the resulting fresh exposure formed the basis of the Delamaran biostratigraphic and systematic work by Sundberg and McCollum (1997, 2002, 2003a). However, the Dyeran part of the trench has received little research attention beyond a preliminary biostratigraphic range chart depicted by Sundberg and McCollum (1997, fig. 4) and studies of the ontogeny of *Nephrolenellus multinodus* (Palmer in Palmer and Halley, 1979) based on exquisitely preserved silicified specimens recovered from the trench (Webster et al., 2001; Webster and Zelditch, 2005; Webster, 2007a). We conducted detailed studies and made collections of the upper Dyeran part of the trench in 1994, 2000, and 2002. Biostratigraphic charts for the upper Dyeran (Figs. 3, 4) are based entirely on the extensive collections made by Webster in 2002; full details of the section plus systematic descriptions of the Dyeran trilobites based on all available material will be published elsewhere.

DYERAN STAGE, NORTHERN GROOM RANGE SECTION

The general lithostratigraphic succession of the northern Groom Range is shown by Webster (Article 7, this volume, fig. 3). The trenched section that will be examined at Stop 6B exposes the clastic

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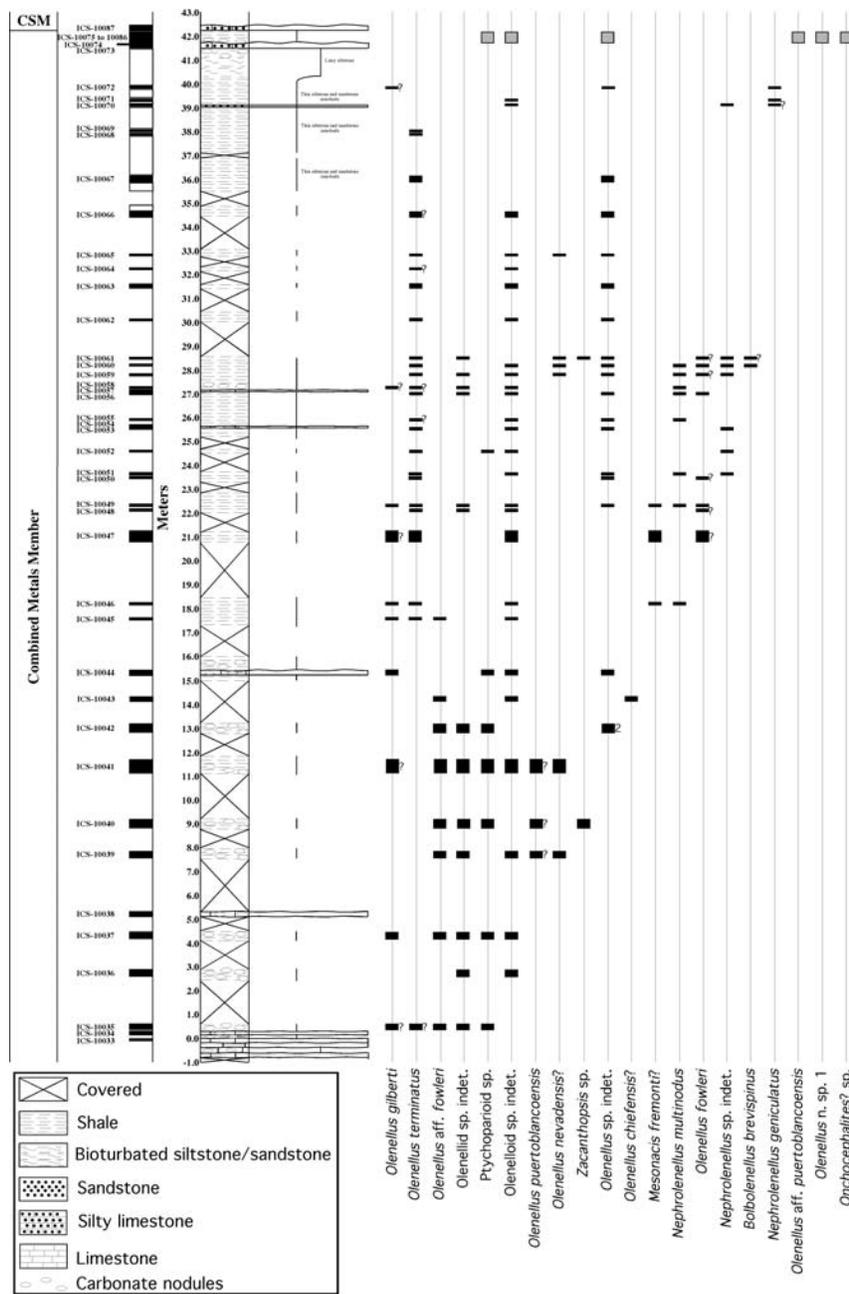


FIGURE 3.—Biostratigraphic range chart for the measured section through the upper part of the Combined Metals Member and basal-most part of the Comet Shale Member (Pieche Formation) at the northern Groom Range, Lincoln County, Nevada. Meters refer to distance above the top of the stratigraphically highest continuous limestone ledge of the Combined Metals Member. Black bars to the left of the meter scale indicate provenance of stratigraphically constrained trilobite-bearing collections housed in the Institute for Cambrian Studies, University of Chicago (ICS); empty bars to the left of the meter scale indicate intervals of failed searches for trilobites (although many of these collections contain brachiopods and trace fossils). Bars representing collections that show partial or entire stratigraphic overlap are shown offset and/or with different (arbitrary) width. Gray bars showing taxon occurrences indicate presence of the taxon in the uppermost part of the measured section, details of which are shown in Fig. 4. A question mark next to a black bar indicates a tentative identification due to poor or incomplete preservation; the number “2” next to an occurrence of *Olenellus* sp. indet. indicates that at least two unidentified species of *Olenellus* are represented in that collection. CSM, Comet Shale Member.

strata across the Dyeran-Delamaran stage boundary (upper Combined Metals Member and basal-most Comet Shale Member; Figs. 2, 3, 4). However, stratigraphically lower units can be observed adjacent to the trench. The Zabriskie Quartzite forms the western flank of the hill to the west of the trench, but the basal part of the Pioche Formation overlying it is not well exposed in the northern Groom Range; no trilobites have been recovered from either. *Peachella iddingsi* (Walcott, 1884) and *Bristolia anteros* Palmer in Palmer and Halley, 1979, indicative of the *Peachella iddingsi* Zone, have been recovered from limestone ledges on the east-facing dip slope of the hill to the west of the trench (Webster, unpublished data). This stratigraphic interval is herein assigned to the Delamar Member of the Pioche Formation, but is lithologically more similar to the Thimble Limestone Member of the Carrara Formation (see discussion above). Similar and presumably correlative carbonates interbedded within a yellow argillaceous shale from the southern Groom Range have yielded specimens now assigned to *Paranephrolenellus besti* Webster, 2007b, *Paranephrolenellus inflatus* Webster, 2007b, *Peachella iddingsi*, and *Bristolia anteros* (Walcott, 1886, 1890; see Palmer and Halley, 1979; Webster, 2007b, 2009a).

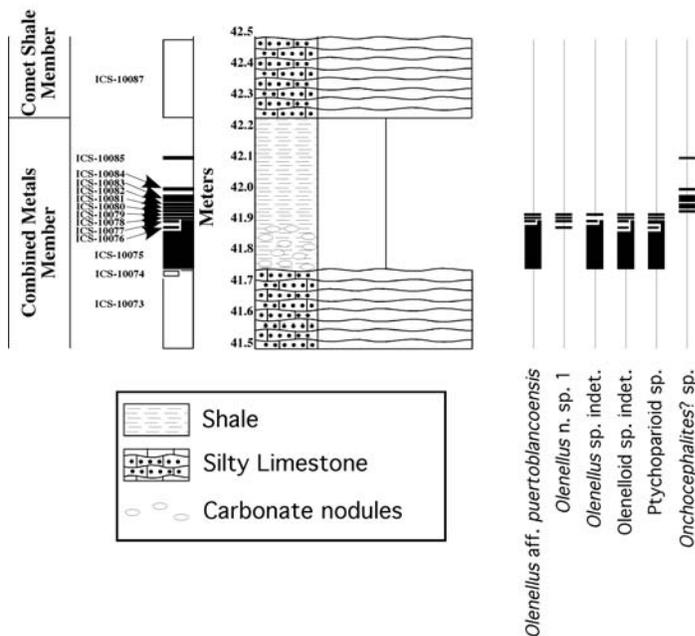


FIGURE 4.—Biostratigraphic range chart for the uppermost part of the measured section through the trenched interval of the upper part of the Combined Metals Member and basal-most part of the Comet Shale Member (Pioche Formation) at the northern Groom Range, Lincoln County, Nevada. Meters refer to distance above the top of the stratigraphically highest continuous limestone ledge of the Combined Metals Member. See Figure 3 for broader stratigraphic context and explanation of symbols.

Fragmentary cephalata tentatively identified as *Bolbolenellus euryparia* (Palmer in Palmer and Halley, 1979), diagnostic of the lower part of the *Bolbolenellus euryparia* Zone (Webster, Article 7, this volume), have been recovered from platy, silty carbonates at a section adjacent to the trench in the northern Groom Range (Webster, unpublished data). These strata are herein assigned to the uppermost Delamar Member of the Pioche Formation, although they share closer lithological similarity to strata within the Echo Shale Member of the Carrara Formation.

Rubbly-weathering limestones in the lower part of the overlying Combined Metals Member contain abundant, large, three-dimensional cephalata of *Olenellus puertoblancoensis* (Lochman in Cooper et al., 1952), *Olenellus* aff. *fowleri* (see appendix in Webster, Article 7, this volume), *Crassifimbria? metalaspis?* (Sundberg and McCollum, 2000) (a tentative identification), and *Zacanthopsis* sp., and are approximately correlative with the fossiliferous silicified beds of the Combined Metals Member in the Highland Range (Webster, this volume, Stops 5A, 5B, 6A; Palmer, 1957, 1958; Webster and Zelditch, 2011, in press; Webster, 2011).

The base of the measured section (the trenched interval) is the top of the stratigraphically highest continuous limestone ledge of the Combined Metals Member (Fig. 3). A limestone ledge 0.2 m above the base of the section attains a thickness of at least 0.13 m in places but grades laterally into shale and is

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therefore an unreliable marker bed. The upper Dyeran strata within the measured section comprise the upper part of the Combined Metals Member (Figs. 3, 4), and are much thicker than correlative strata in the Pioche-Caliente region (Webster, Article 7, this volume, fig. 6; Webster, this volume, Stops 5A, 5B, 6A) and in the Pyramid Shale Member of the Carrara Formation (Palmer and Halley, 1979; Fowler, 1999). Abundant trilobite remains have been recovered from the shale, providing the opportunity for detailed biostratigraphic sampling of large, morphologically mature trilobite specimens (Figs. 3, 4, 5). Silicified trilobites from correlative strata in the Pioche-Caliente region are of higher preservational quality and abundance, but their typically smaller size often hinders identification to the species level. The lower 28 m of the trenched shale part of the Combined Metals Member contains carbonate nodules dispersed throughout, but nodules occur much less commonly above 16 m. At least one horizon of carbonate nodules yields an exquisite silicified trilobite fauna (Webster et al., 2001; Webster and Zelditch, 2005; Webster, 2007a); nodules from other horizons are currently being processed by Webster.

The trilobite fauna recovered from the basal 12 m of the measured section (Fig. 3) includes *Olenellus puertoblancoensis* s.s., *Olenellus gilberti* Meek in White, 1874 and specimens tentatively identified as *Olenellus nevadensis* (Walcott, 1910) and *Olenellus terminatus* Palmer, 1998a (rare). *Olenellus* aff. *fowleri* ranges up to almost 18 m above the base of the measured section. This latter horizon marks the lowest definitive occurrence of *Olenellus terminatus* (but see questionable lower occurrence, mentioned above), and this species is typically the most abundant taxon for almost 20 m up section. *Olenellus fowleri* Palmer, 1998a s.s. has been recovered between approximately 24 m and 29 m above the base of the measured section (Fig. 3). Specimens tentatively assigned to *Olenellus nevadensis* occur in the basal 12 m of the measured section and between 27 m and 33 m above the base of the measured section, but have not been recovered from the intervening strata. Morphometric analyses are currently under way to determine whether or not quantitative data support conspecificity of the stratigraphically low and high forms of this taxon, and of either form with “typical” *Olenellus nevadensis* (which elsewhere is restricted to the *Bristolia mohavensis* through *Peachella iddingsi* zones; Webster, Article 7, this volume). Similarly, morphometric analyses are required to determine whether subtle differences in length of the ocular lobe and in the size of the prelabellar field between “typical” *Mesonacis fremonti* (Walcott, 1910) and specimens recovered from the trench represent intraspecific variation or interspecific disparity. The specimens are tentatively identified as *Mesonacis fremonti* until such analyses are conducted (Fig. 3).

The lowest sampled occurrence of *Nephrolenellus multinodus*, which represents the local base of the *Nephrolenellus multinodus* Zone (Webster, Article 7, this volume), lies at 18.2 m above the base of the measured section. This species is then relatively abundant for 10 m up section. *Nephrolenellus geniculatus* Palmer, 1998a has been collected from sandier strata between 39.1 m and 39.85 m above the base of the measured section. Specimens exhibiting a morphology somewhat intermediate between these two species occur at 28.5 m above the base of the measured section, but no specimen of *Nephrolenellus* Palmer and Repina, 1993 has been recovered between 28.5 and 39.1 m (see Webster [2007a] for a discussion of similar morphologically and stratigraphically intermediate forms from other localities). Sundberg and McCollum (1997, fig. 4) show the range of *Nephrolenellus multinodus* extending to within approximately 7 m of the stratigraphically highest olenelloids, but this could not be confirmed by the collections made by Webster in 2002. The significance of the sandier lithology near the top of the measured section is discussed by Webster (Article 7, this volume) and McCollum et al. (Stops 5A-D, 6A, this volume).

Surprisingly, no sampled interval in the northern Groom Range bears the rich olenelloid fauna comprising co-occurring *Olenellus gilberti*, *Olenellus chiefensis* Palmer, 1998a, *Olenellus terminatus*, *Olenellus fowleri* s.s., *Bolbolenellus brevispinus* Palmer, 1998a, and *Nephrolenellus geniculatus* that characterizes uppermost Dyeran strata in the Combined Metal Member from the Pioche-Caliente region (e.g., Palmer, 1998a; Webster, 2007a, 2007b, 2009b; Webster et al., 2008; Webster, Article 7, this volume; Webster, Stops 5A, 5B, 6A, this volume). *Olenellus gilberti* and *Olenellus terminatus* are long-ranging species in the northern Groom Range. A general interval of overlap between these two species and both *Olenellus fowleri* s.s. and *Bolbolenellus brevispinus* occurs between approximately 28 m and 29

m above the base of the measured section. However, this overlap interval lies well below the lowest sampled occurrence of *Nephrolenellus geniculatus* and well above the single occurrence of *Olenellus chiefensis* (a tentative identification at approximately 14.2 m). Such differences may reflect an artifact of sampling or genuine spatio-temporal variation in species distributions.

The Dyeran-Delamaran stage boundary was not well constrained in the Carrara Formation by Palmer and Halley (1979). In the southern Groom Range, Palmer and Halley (1979, plate 17) reported *Nephrolenellus multinodus* from approximately 22 m above the base of the “Pyramid Shale Member”, consistent with the observed range of that species in the present study. Their next faunal collection was made almost 50 m above this horizon (Palmer and Halley, 1979, plate 17), and yielded Delamaran taxa now assigned to the *Poliella denticulata* Zone of McCollum and Sundberg (2007). A detailed sedimentological study (by McCollum) and high-resolution biostratigraphic collecting (by McCollum and by Webster) at the BLM excavation have refined the location of the Dyeran-Delamaran stage boundary in the northern Groom Range. The results of these studies are briefly summarized below.

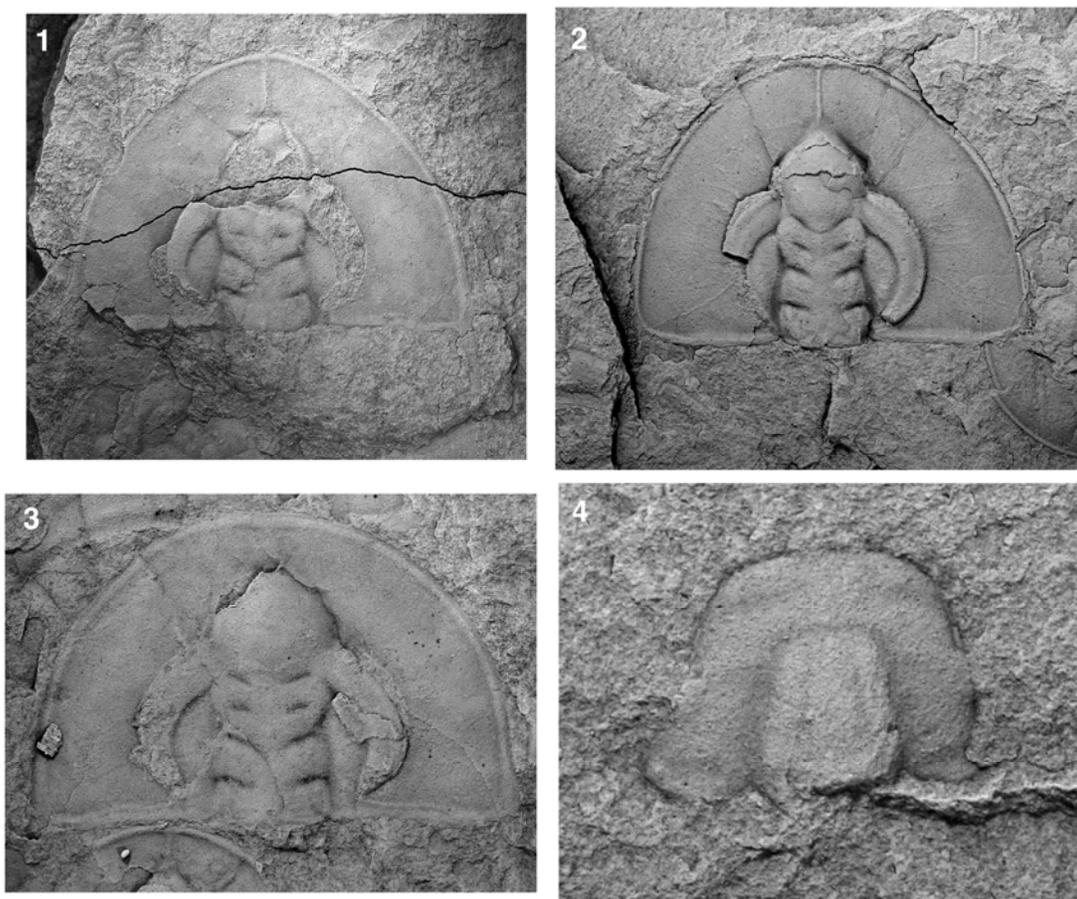


FIGURE 5.—Representative upper Dyeran trilobites from the northern Groom Range and Hidden Valley localities. 1, Cephalon of *Olenellus* n. sp. 1, internal mold, ICS-10078, x2. 2, Cephalon of *Olenellus* n. sp. 1, internal mold, ICS-1186, x4. 3, Cephalon of *Olenellus* aff. *puertoblancoensis*, latex cast of external mold, ICS-10079, x4. 4, Cephalon of *Onchocephalites?* sp., internal mold, ICS-10080, x10. 1, 3, and 4 from northern Groom Range; 2 from Hidden Valley, Burnt Springs Range, Nevada. All specimens held at the Institute for Cambrian Studies, University of Chicago (ICS).

Strata 41.48 m to 42.22 m above the base of the measured section of the upper Combined Metals Member represents a depositional sequence within which the stratigraphically highest olenelloid trilobites have been recovered (Fig. 4; i.e., upper Dyeran Depositional Sequence IV as defined by Webster, Article 7, this volume). The sequence begins with an unfossiliferous, 0.25-m-thick, massive, ledgy, silty

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limestone to ferric dolostone. This unit is overlain by 0.14 m of sandy, bioturbated shale containing dispersed carbonate nodules; ripples in the upper surface of this unit are filled with dark green glauconite-coated grains. This surface is in turn overlain by 0.15 m of fissile shale and 0.20 m of thinly interbedded, sandy, hackly mudstone and sandstone containing *Planolites* traces. Olenelloid trilobites have been collected by the authors up to 41.91 m above the base of the measured section (Fig. 4); they occur throughout the sandy, bioturbated shale unit and in the basal four centimeters of the fissile shale, in association with a ptychoparioid (currently under study) and abundant inarticulate brachiopods and hyolithids (Fig. 4). A different, rather effaced ptychoparioid, tentatively identified as a species of *Onchocephalites* Rasetti, 1957 (Fig. 5.4), makes its first appearance within the fissile shale unit at 41.92 m above the base of the measured section, and occurs in moderate abundance to at least 42.09 m (within the hackly mudstone and sandstone unit); no other trilobite has been recovered from this interval (Fig. 4). Dense aggregations of hyolithids (sometimes showing current alignment) and inarticulate brachiopods occur on surfaces throughout the observed range of *Onchocephalites?* sp.

The next sequence, beginning at 42.22 m above the base of the measured section, represents the lowest depositional sequence of the Delamaran Stage (DMS 1, as defined by McCollum and McCollum, Article 8, this volume) and the base of the Comet Shale Member (Figs. 4, 6). The base of this sequence is represented by another massive, ledgy, silty limestone to ferric dolostone; this bed is 0.22 to 0.30 m thick and, like the analogous bed of the preceding sequence, it is devoid of fossils (Fig. 4). Above this is 7 m of fissile shale from within which sparse hyolithids have been recovered (Fig. 6). This is overlain by a ledgy, calcareous sandstone, 0.7 m thick, that contains the characteristic Delamaran trilobite *Eokochaspis piochensis* (Palmer in Palmer and Halley, 1979). Unfortunately *Eokochaspis nodosa* Sundberg and McCollum, 2000, the zone fossil defining the base of the Delamaran, has not been recovered from the northern Groom Range. The base of the Delamaran is therefore now biostratigraphically constrained to lie between 41.91 m and ~50 m above the base of the measured section.

The two stratigraphically highest olenelloid species recovered from the northern Groom Range are identified as *Olenellus* n. sp. 1 and *Olenellus* aff. *puertoblancoensis* (Figs. 3, 4, 5.1, 5.3; “*Olenellus* (*Paedeumias*) n. sp.” of Sundberg and McCollum, 1997, fig. 4). In the northern Groom Range, the first occurrence of both species is stratigraphically above the highest known occurrence of olenelloids that elsewhere typify the uppermost Dyeran olenelloid assemblage (e.g., *Nephrolenellus geniculatus*, *Olenellus terminatus*, *Bolbolenellus brevispinus*; Fig. 3). However, specimens apparently representing *Olenellus* n. sp. 1 co-occur with *Nephrolenellus geniculatus* at the Hidden Valley locality in the Burnt Springs Range in the Pioche-Caliente region (Fig. 5.2; Webster, 2009b). The high stratigraphic first appearance of this species in the northern Groom Range therefore likely represents either a local sampling failure or a case of spatio-temporal variation in species distribution.

The stratigraphically lowest occurrence of *Olenellus* aff. *puertoblancoensis* (Fig. 5.3) within the southern Great Basin is equivocal, for two reasons. First, *Olenellus* aff. *puertoblancoensis* appears to differ from the stratigraphically lower *Olenellus puertoblancoensis* s.s. only in terms of possessing a subtly narrower (tr.) cephalon relative to cephalic length but, given the variation in this feature resulting from both biologic (including ontogenetic) and taphonomic factors, quantitative morphometric analysis is necessary to determine whether the supposed difference is sufficiently robust to warrant species-level distinction. Second, even if *Olenellus* aff. *puertoblancoensis* is found to be a distinct species, similar and potentially conspecific morphologically immature specimens are known from a horizon just below an occurrence of *Bolbolenellus brevispinus* in the uppermost Mule Spring Limestone at Split Mountain (figured as “*Olenellus* (*Paedeumias*) *puertoblancoensis?*” by Sundberg and McCollum, 2003b; see Webster, Stops 7A-7C, this volume). Confident species-level identification of the Split Mountain material will require collection of morphologically mature specimens.

The stratigraphically highest sampled occurrences of various olenelloid species in the northern Groom Range warrant some discussion because these bear on discussions surrounding the tempo and mode of the olenelloid extinction (McCollum, 1994; McCollum and McCollum, 1994; Palmer, 1998a; Montañez et al., 2002; McCollum et al., this volume, Stops 5A-D, 6A; Webster, Article 7, this volume). The “terminal Dyeran” olenelloid fauna described by Palmer (1998a) from the Pioche-Caliente region

comprised common *Nephrolenellus geniculatus*, *Olenellus gilberti*, *Olenellus terminatus*, *Olenellus fowleri*, *Olenellus chiefensis*, and *Bolbolenellus brevispinus*, plus two rare species of *Olenellus* Hall, 1862. The coincident nature of the last occurrences of all these species immediately beneath the basal Delamaran ribbon limestone in the Pioche-Caliente region was interpreted as evidence for an abrupt extinction event affecting a diverse uppermost Dyeran olenelloid assemblage (Palmer, 1998a). However, in the northern Groom Range, the last occurrences of these species are not coincident. The stratigraphically highest occurrences of *Olenellus gilberti*, *Olenellus terminatus*, and *Nephrolenellus geniculatus* are approximately 10 m higher than those of *Olenellus fowleri* and *Bolbolenellus brevispinus*, and approximately 25 m above the sole (and questionable) occurrence of *Olenellus chiefensis* (Fig. 3). Furthermore, *Olenellus* n. sp. 1 and *Olenellus* aff. *puertoblancoensis* occur approximately 2 m higher than the stratigraphically highest occurrences of *Olenellus gilberti*, *Olenellus terminatus*, and *Nephrolenellus geniculatus* at this locality (Fig. 3).

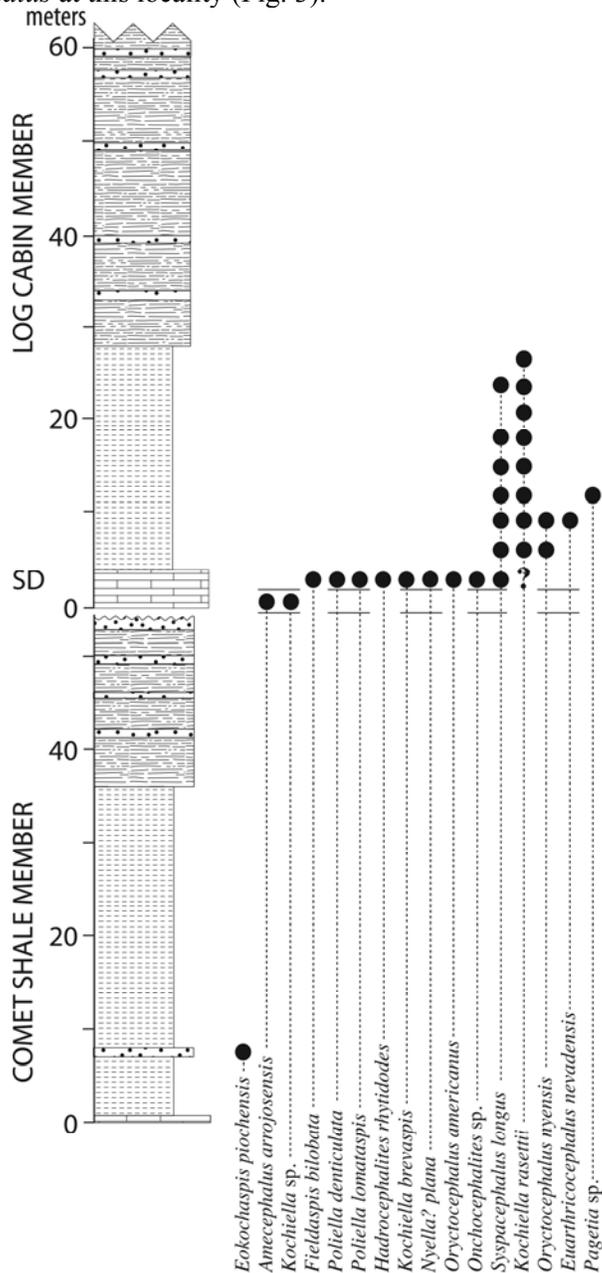


FIGURE 6.—Biostratigraphic range chart for the Delamaran strata of the Pioche Formation, overlying the trenched interval in the northern Groom Range, Lincoln County, Nevada. The carbonate at 0 m is the sandy carbonate at the top of the measured section shown in Figs. 3 and 4. Modified from Sundberg and McCollum (2003a). SD, Susan Duster Limestone Member.

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The stratigraphically dispersed nature of these last occurrences in the northern Groom Range can be interpreted in two ways: (1) the olenelloid extinction was abrupt, and the staggered disappearances of species in the northern Groom Range results from local sampling failure (the Signor-Lipps effect [Signor and Lipps, 1982]) and/or spatio-temporal variation in species distribution; or (2) the olenelloid extinction was protracted over a relatively longer duration, and the coincident disappearance of all taxa in the Pioche-Caliente region results from non-deposition and/or minor erosion of uppermost Dyeran strata (as argued by McCollum, 1994; McCollum and McCollum, 1994; McCollum et al., Stops 5A-D, 6A, this volume). The inconsistent order of stratigraphic first appearances of many olenelloid species among localities in the southern Great Basin certainly demonstrates that incomplete sampling and/or spatio-temporal variation in species distribution are widespread in the upper Dyeran (see above for an example). However, multiple excursions apparent in the carbon isotope record across the Dyeran-Delamaran stage boundary interval in the southern Great Basin may reflect stratigraphic hiatuses of sub-biostratigraphic resolution (Montañez et al., 2002). Webster (Article 7, this volume) presents a new interpretation of the nature of environmental and biological events around the Dyeran-Delamaran boundary interval, based on newly developed sequence stratigraphic and biostratigraphic frameworks for the upper Dyeran.

DELAMARAN STAGE, NORTHERN GROOM RANGE SECTION

McCollum and McCollum (Article 8, this volume) recognize five depositional sequences within the Delamaran Stage. Two of the lower three sequences occur within the lower 150 m of the strata assigned to the Delamaran Stage in the northern Groom Range, and will be seen at this stop (Fig. 6). The first sequence defined by McCollum and McCollum (Article 8, this volume; DMS 1) is a relatively barren siliciclastic interval; the second sequence (DMS 2) is not present at this section, probably due to erosion; and the third sequence (DMS 3) is of particular importance because it has a very fossiliferous interval of the *Syspacephalus longus* assemblage of Sundberg and McCollum (2003a), which has some species in common with the outer shelf *Oryctocephalus indicus* Zone fauna.

The basal Delamaran sequence (DMS 1) begins at a silty limestone to ferric dolostone marking the base of a 43-m-thick, upward coarsening facies of interbedded shale, siltstone, and sandstone containing *Eokochaspis piochensis* (Fig. 6). This sequence contains a moderately diverse ichnofauna and a few specimens of *Eokochaspis piochensis* in the lower half, and wrinkle marks in the upper half. The uppermost 3 m is a greenish gray, thin bedded to laminated, fine-grained sandstone containing fecal pellets and occasional *Planolites montanus* traces.

The next preserved depositional sequence (DMS 3) begins with a 4-m-thick, ledge-forming limestone that is in sharp contact with sandstone of the underlying sequence. This bioclastic carbonate, with oolitic and oncolitic layers, represents the Susan Duster Limestone Member of the Pioche Formation (Fig. 6). The basal half-meter contains an *Amecephalus arjosensis* Zone fauna, and it is overlain by a *Poliella denticulata* Zone fauna (Fig. 6; Sundberg and McCollum, 2003a).

The Susan Duster Limestone Member strata are overlain by 25 m of dark, laminated shale. Trilobites of the *Syspacephalus longus* assemblage commonly display an orange color, presumably derived from the weathering of pyrite, and represent the age equivalent of the *Oryctocephalus indicus* Zone (McCollum and McCollum, this volume, Article 8). Common trilobites present are *Syspacephalus longus* Palmer in Palmer and Halley, 1979 and *Kochiella rasettii* Sundberg and McCollum, 2002. Rare species include *Oryctocephalus nyensis* Palmer in Palmer and Halley, 1979 and *Euarthrocephalus nevadensis* (Sundberg and McCollum, 1997), both of which are found with *Oryctocephalus indicus* (Reed, 1910) in the Emigrant Formation at localities to the west (Sundberg and McCollum, 2003b). The overlying 50 m of siltstones and sandy siltstones are generally bioturbated, but no trilobites have been found in this interval. This 75 m interval is assigned to the Log Cabin Member of the Pioche Formation (Fig. 6).

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STOPS 7A, 7B, AND 7C
UPPER DYERAN LITHO- AND BIOSTRATIGRAPHY OF THE SPLIT MOUNTAIN AREA,
NEVADA

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INTRODUCTION

SPLIT MOUNTAIN is located within the hills of Clayton Ridge in Esmeralda County, Nevada (Fig. 1). The hillsides around Split Mountain offer excellent exposures of Dyeran and Delamaran strata deposited on the outer shelf. In contrast to the siliciclastic-dominated cratonic settings (Stops 3, 4A, 4B), upper Dyeran strata of the outer shelf are carbonate-dominated. Much of the upper Dyeran Mule Spring Limestone accumulated in shallow subtidal to intertidal facies on a carbonate bank. Periodic shoreward expansion of this carbonate bank resulted in the correlative mixed carbonate-siliciclastic deposits of the Carrara and Pioche Formations on the middle and inner shelf (Stops 5A-D, 6A, 6B; Webster, this volume, Article 7, fig. 3).

We will examine upper Dyeran strata in the Split Mountain area that record the history of the carbonate bank in this region, from its initial establishment during the *Bristolia mohavensis* Zone (Webster, this volume, Article 7) to its ultimate demise just prior to the Dyeran-Delamaran boundary. We

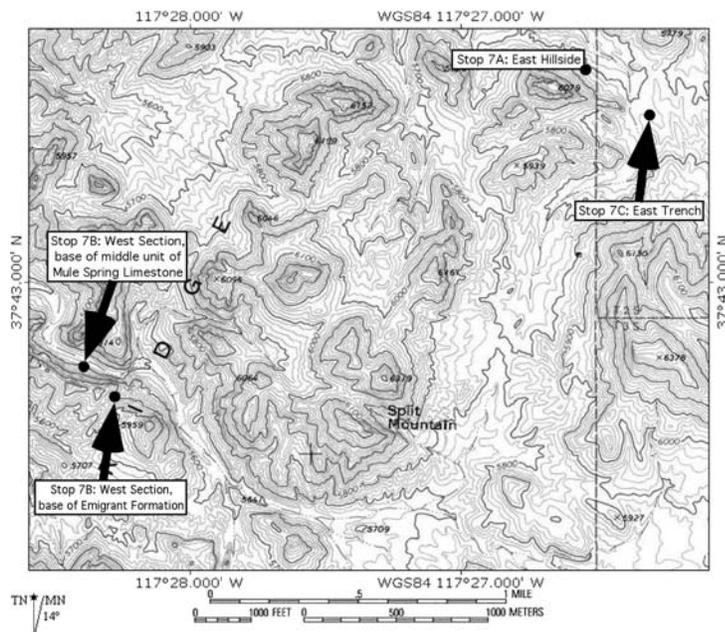


FIGURE 1.—Map of the Split Mountain area, showing the location of the measured sections studied herein. Map created with TOPO! software (© National Geographic, 2002).