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

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Edited by
J. Stewart Hollingsworth
Frederick A. Sundberg
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9218892 and EAR-9973180; they thank J. C. Kepper for suggesting that this section be included in their regional study of the “Lower-Middle” Cambrian boundary interval. They would also like to acknowledge the assistance of numerous undergraduate students who spent two weeks in late summer over several years working on numerous aspects of this study. All olenelloid collections made by L. and M. McCollum and F. A. S. were turned over to M. W. for study. Assistance during Webster’s fieldwork at the site was generously provided by E. Fowler in 2000 and by L. B. M. and C. Berg-Madsen in 2002. The authors would like to thank A. R. Palmer for his insights regarding past Cambrian investigations in this region. This manuscript benefitted from formal reviews by L. E. Babcock and R. R. Gaines.

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

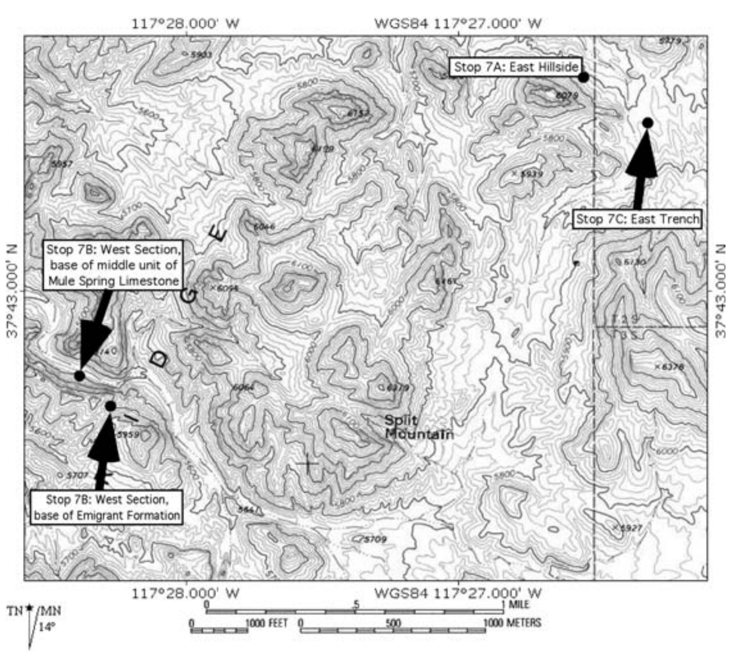

FIGURE *1*.—Map of the Split Mountain area, showing the location of the measured sections studied herein. Map created with TOPO! software (© National Geographic, 2002).

will also examine an outcrop of the overlying Emigrant Formation that contains the Dyeran-Delamaran boundary near its base and *Ehmaniella* Zone faunas (Topazan Stage) at the top. This paper describes the upper Dyeran litho- and biostratigraphy of the Split Mountain area; Delamaran strata are detailed in a companion paper (Sundberg et al., this volume, Stop 7C).

REGIONAL SETTING AND GENERAL STRATIGRAPHY

The Split Mountain area includes Lower Paleozoic exposures that range in age from the pre-trilobitic Cambrian (upper Deep Springs Formation) to the basal Ordovician (upper Emigrant Formation). The area is highly faulted, however, and a continuous section through this entire interval has not yet been pieced together. This paper focuses on just the upper Dyeran succession, comprising the uppermost Harkless Formation, Mule Spring Limestone, and lowermost Emigrant Formation, for which a complete composite section was constructed (Webster, this volume, Article 7, fig. 4.1). These formations were deposited on the outer shelf, close to the shelf edge and slope (Webster, this volume, Article 7, fig. 2). Similar outer shelf deposits outcrop elsewhere in Esmeralda County (Albers and Stewart, 1962; Stewart, 1970) and in the White-Inyo Mountains of Inyo County, California (Nelson, 1962, 1976; Nelson and Durham, 1966; Palmer, 1971).

The Harkless Formation (Nelson, 1962) is a thick succession of siltstone, sandstone/quartzite, and minor carbonates that is typically mildly tectonized and extensively faulted. The unit attains a total thickness of approximately 1,100 m in the Weepah Hills to the north (Stewart, 1970), but only the upper few tens of meters of the formation are exposed in the Split Mountain area studied herein. Body fossils are generally scarce in the Harkless Formation, although some intervals rich in trilobites and other shelly organisms are known (e.g., Nelson, 1963, 1976; Palmer, 1964; Nelson and Durham, 1966; Lipps and Sylvester, 1968; Stewart, 1970; Yochelson et al., 1970; Onken and Signor, 1988; Blaker et al., 1997; Hicks, 2006; personal observation).

The general scarcity of body fossils and the commonly fault-bounded nature of Harkless Formation outcrops have led to difficulty in precise correlation of the unit. The upper Harkless Formation is undoubtedly laterally equivalent to the Saline Valley Formation in the White-Inyo Mountains of California, and is widely held to be the lateral equivalent of the Zabriskie Quartzite in south-central Nevada (Nelson, 1962; Albers and Stewart, 1962; Stewart, 1970). However, Palmer (1964) reported *Bristolia* Harrington, 1956 from the upper part of the Saline Valley Formation, and *Bristolia* and *Arcuolenellus* Palmer and Repina, 1993 are documented herein from the uppermost Harkless Formation in the Split Mountain area. Elsewhere these genera occur in the Carrara and Pioche Formations, suggesting that at least the uppermost few tens of meters of the Harkless Formation post-date the Zabriskie Quartzite (Webster, this volume, Article 7, fig. 3).

The Harkless Formation is conformably overlain by the Mule Spring Limestone (Nelson, 1962). The Mule Spring Limestone represents a predominantly shallow subtidal and intertidal (occasionally supratidal) carbonate bank environment developed on the distal shelf. It is often characterized as being oncolitic (Nelson, 1962; Albers and Stewart, 1962; Stewart, 1970), although a substantial part of the unit lacks oncoids and is dominated by a fenestral texture (see below; Webster, this volume, Article 7, fig. 4.1). The transition between the Harkless Formation and the Mule Spring Limestone is gradational and the contact must be somewhat arbitrarily defined. Stewart (1970, p. 62) placed the contact at "the change from greenish-gray siltstone (Harkless) to gray or brown limestone (Mule Spring) containing concretionary algal structures ("*Girvanella*") about 1/2—1 inch in diameter." However, thin, sandy, oncolitic limestones occur interbedded with the siltstones and fine sandstones of the uppermost Harkless Formation (see below). The base of the Mule Spring Limestone is here taken to be the base of the first major ledge-forming oncolitic limestone.

The author measured numerous sections through the Mule Spring Limestone in the Split Mountain area in 2005, and obtained a total thickness of approximately 224 m (Webster, this volume, Article 7, fig. 4.1). The Mule Spring Limestone therefore appears to be much thicker here than elsewhere in Esmeralda County; Albers and Stewart (1962) showed a thickness of approximately 120 m for the unit on a generalized stratigraphic section for Esmeralda County, and Stewart (1970) estimated a thickness of approximately 90 to 120 m in the Weepah Hills and of 120 to 150 m in most places in Esmeralda County. Nelson (1962) estimated a thickness of 305 m for the Mule Spring Limestone in its type area in the White-Inyo Mountains of California.

The internal stratigraphy and biostratigraphy of the Mule Spring Limestone has received little attention. Stewart (1970, p. 157) characterized the lower third of the Mule Spring Limestone as a brown-weathering and probably silty unit, the middle third as a very light gray weathering limestone with brown-weathering (silty?) beds, and the upper third as a medium gray-weathering limestone. He recognized that oncoids were present in the lower part of the Mule Spring Limestone and at scattered horizons elsewhere, and noted that at least one siltstone layer about 3 m thick occurs in the lower third of the unit. Stewart (1970, p. 64) listed genera now identified as *Bristolia*, *Peachella* Walcott, 1910, *Mesonacis* Walcott, 1885, and *Olenellus* Hall, 1862 from the Mule Spring Limestone, mostly from the lower silty part.

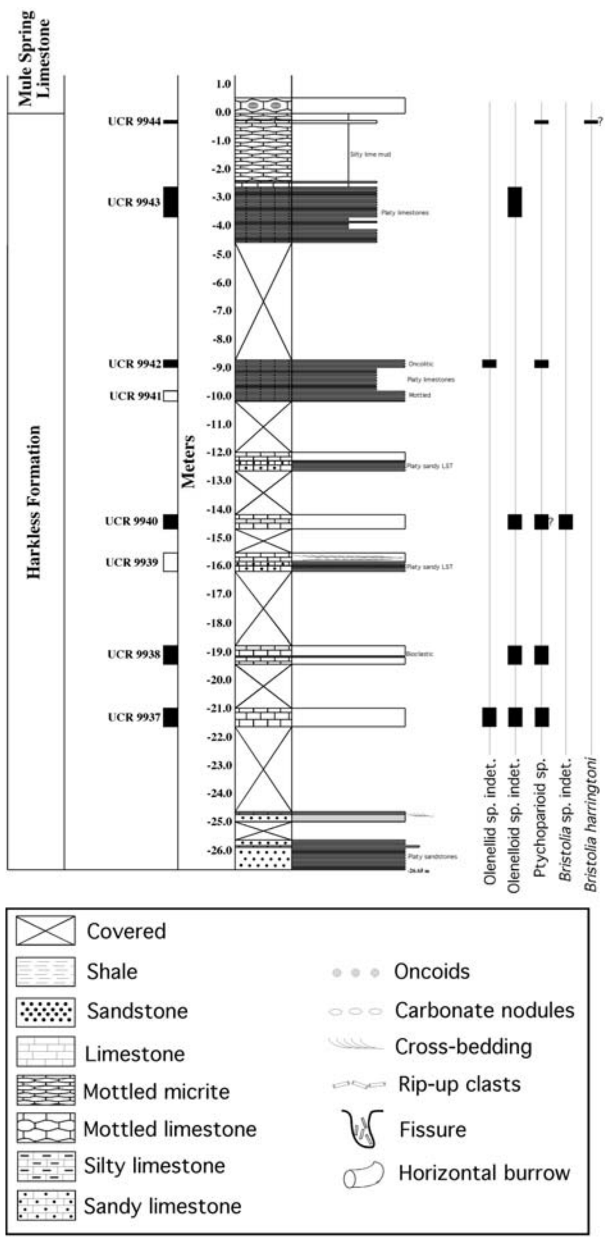

FIGURE *2*.—Biostratigraphic range chart for the uppermost Harkless Formation on the Split Mountain East hillside (Stop 7A). Meters measured from the base of the Mule Spring Limestone. Black bars to the left of the meter scale indicate provenance of stratigraphically constrained trilobite-bearing collections housed in the Geology Museum, University of California, Riverside (UCR); empty bars indicate intervals of failed searches for identifiable trilobites. A question mark next to a black bar indicates a tentative identification due to poor or incomplete preservation.

The author's studies in the Split Mountain area also suggest that the Mule Spring Limestone can be divided into three units (Webster, this volume, Article 7, fig. 4.1), although these do not coincide precisely with the divisions recognized by Stewart (1970). The lower unit recognized herein is just over 30 m thick, and consists of ledge- and cliff-forming outcrops of limestone, typically mottled through bioturbation. Oncolitic horizons are scattered throughout this unit, and at least one horizon contains rip-up clasts. The inferred depositional environment ranges from shallow subtidal to supratidal. The uppermost few meters form a prominent cliff that can be mapped throughout the Split Mountain area. Trilobite remains are abundant within the lower unit, but are too fragmentary to be identified. However, the occurrences of *Bristolia mohavensis* (Crickmay in Hazzard, 1933) in the uppermost Harkless Formation and of *Bristolia insolens* (Resser, 1928) in the middle unit of the Mule Spring Limestone (below) constrain the lower unit to lie within the *Bristolia mohavensis* Zone (Webster, this volume, Article 7).

The middle unit recognized herein is a largely recessive interval almost 24 m thick, comprising burrow-mottled micrite, burrow-mottled bioclastic limestones, and occasional oncolitic beds. A distinctive oolitic and peloidal bed occurs approximately 7 m above the base of the unit. The middle unit also contains numerous shale intervals, some at least two meters thick, although these are commonly covered by talus. The presence of fine-grained siliciclastics and the associated slowing or cessation of carbonate accumulation within the middle unit of the Mule Spring Limestone is inferred to result from relative sea-level rise. Abundant and well-preserved trilobite cephala typical of the *Bristolia insolens* Zone occur throughout the lower two-thirds of the middle unit. The *Bristolia insolens* Zone elsewhere in the southern Great Basin is interpreted as the interval of maximal flooding during a general deepening-to-shallowing sequence (Depositional Sequence I as defined by Webster, this volume, Article 7). However, the magnitude of deepening at Split Mountain was presumably relatively minor, because shallow-water oncolitic and oolitic beds occur between the shale packages. Olenelloids indicative of the *Peachella iddingsi* Zone have been found in float likely sourced from the upper part of this middle unit.

The upper unit recognized herein is a cliff-forming limestone almost 170 m thick. Much of the upper unit is oncolitic, although an interval of fenestral limestone that contains very few oncolitic horizons occurs approximately 76 m to 107 m from its base (Webster, this volume, Article 7, fig. 4.1). Several thin, intraformational conglomerates also occur near the base of the unit. This unit is interpreted as representing a return to shallow subtidal, intertidal, and supratidal facies (i.e., the highstand system tract of Depositional Sequence I and all of Depositional Sequence II; Webster, this volume, Article 7). Very few trilobites have been recovered from the upper unit. Incomplete cephala tentatively identified as *Bolbolenellus euryparia* (Palmer in Palmer and Halley, 1979), that defines the base of the *Bolbolenellus euryparia* Zone (Webster, this volume, Article 7), have been recovered from float sourced from the basal part of the upper unit (see below). Sundberg and McCollum (2003b) report trilobites from the upper meter of the Mule Spring Limestone (discussed below).

The Mule Spring Limestone is overlain by the highly condensed Emigrant Formation (Sundberg et al., this volume, Stop 7C). The sharp facies transition from the shallow-water Mule Spring Limestone to the pelagic and hemipelagic Emigrant Formation has been linked to sea-level rise (Ketner, 1998; Skovsted, 2006) and represents the sequence boundary at the base of Depositional Sequence III as defined by Webster (this volume, Article 7). Dyeran fossils indicative of the *Nephrolenellus multinodus* Zone have been found in a thin limestone 1.2 m above the base of the Emigrant Formation (see below; also Sundberg and McCollum 2003b).

STOP 7A: SPLIT MOUNTAIN EAST HILLSIDE

The first locality to be visited is a steep hill marked as "6079" on the topographic map, just over 2 km NNE of Split Mountain (Fig. 1). The less steep, lower part of the hillside exposes the uppermost Harkless Formation and the lower and middle units of the Mule Spring Limestone; the prominent cliffy summit of the hill consists of the basal part of the upper unit of the Mule Spring Limestone, which is not easily accessible here.

Shale and siltstone of the uppermost few tens of meters of the Harkless Formation are sporadically exposed in gullies on the lower part of the hillside, but numerous small-scale faults preclude

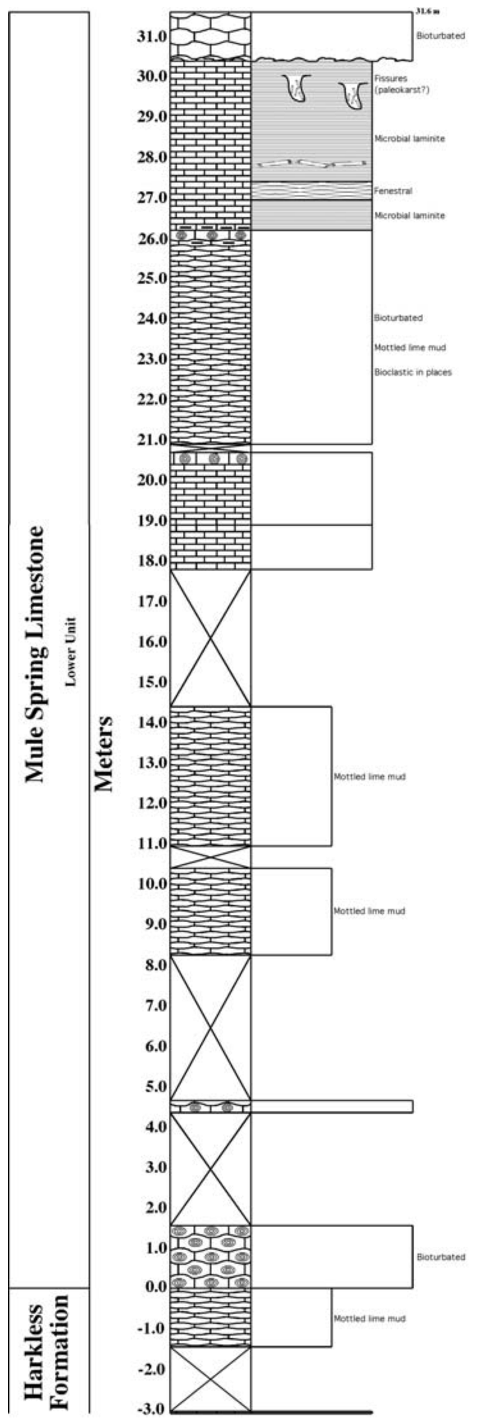

FIGURE 3.—Measured section through the lower unit of the Mule Spring Limestone on the Split Mountain East hillside (Stop 7A). Meters measured from the base of the Mule Spring Limestone. The exposure between 8.2 m and 14.5 m exhibits a locally anomalous dip and dip direction, and may represent a slump block of the overlying cliff-forming part of the uppermost lower unit. See Fig. 2 for explanation of symbols.

accurate stratigraphic placement of these isolated exposures. Nevertheless, a moderately diverse trilobite fauna has been recovered from this interval, including *Arcuolenellus* aff. *megafrontalis*, *Bristolia* *mohavensis*, *Olenellus clarki*? (Resser, 1928), *Olenellus* aff. *nevadensis*, *Mesonacis* aff. *cylindricus*, *Zacanthopsis* sp., *Bonnia* sp., and a ptychoparioid. This species list is a composite from all collections made in float and in situ, and it is unlikely that all species co-occurred stratigraphically. Based on this composite faunal list, it appears that the upper Harkless Formation here spans the *Arcuolenellus arcuatus* and *Bristolia mohavensis* Zones (Webster, this volume, Article 7).

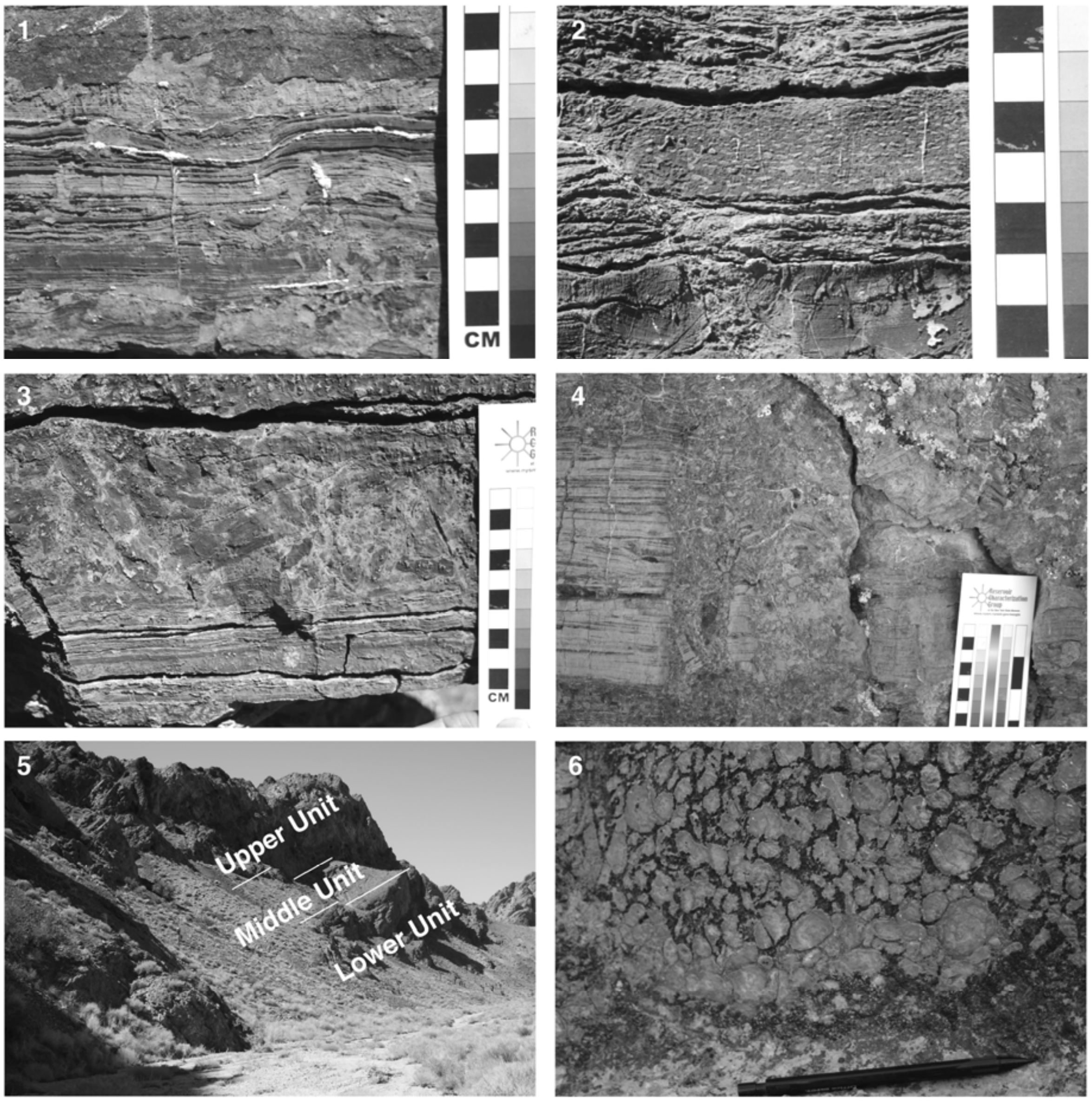

FIGURE *4*.—*1-4*, Sedimentary features in the lower unit of the Mule Spring Limestone on the Split Mountain East hillside (Stop 7A). *1*, Microbial laminite and microbial dolosiltites approximately 28.5 m above the base of the lower unit. *2*, Fenestral limestone just over 27 m above the base of the lower unit. *3*, Intraformational conglomerate with rip-up clasts just above the fenestral interval. *4*, Chaotically-filled fissure developed within the microbialite, approximately 29 m above the base of the lower unit. Scale bar in centimeters in all pictures. *5*, View of the lower part of the Split Mountain West section (Stop 7B), looking west. The boundaries between the lower, middle, and upper units of the Mule Spring Limestone are highlighted. *6*, Oncolitic limestone in the upper unit of the Mule Spring Limestone (pencil for scale) at the Split Mountain West section (Stop 7B).

Stratigraphic measurements become more reliable slightly higher up the hillside, where laterally traceable, ledgy outcrops become better exposed. The measured section presented herein (Fig. 2) spans the transition from the uppermost Harkless Formation to the basal Mule Spring Limestone. The lowest point in the measured section is a ledgy outcrop 1.07 m thick comprising a series of thin (1 to 2 cm thick), platy sandstones with a 4 cm thick, grainy limestone bed 0.1 m from the top; this is 26.65 m below the base of the Mule Spring Limestone as defined above. Several limey sandstones, sandy limestones, platy bioclastic limestones, and platy oncolitic limestones occur in this section of the uppermost Harkless Formation. Some of the beds contain cross-bedded laminae. This sequence is indicative of the transition from siliciclastic-dominated to shallow-water carbonate-dominated depositional regimes as the carbonate bank of the Mule Spring Limestone became locally established. Many of the limestones are richly bioclastic, but the entombed fossils are highly fragmented and can rarely be identified to species level. A limestone ledge 14.5 m below the base of the Mule Spring Limestone yields incomplete cephala of *Bristolia* that represent either *Bristolia mohavensis* or *Bristolia harringtoni* Lieberman, 1999. Specimens tentatively identified as *Bristolia harringtoni* have been recovered from a micaceous silty limestone and calcareous siltstones 0.35 m to 0.25 m below the base of the Mule Spring Limestone. This indicates that the highest Harkless Formation strata should be assigned to the *Bristolia mohavensis* Zone (Webster, this volume, Article 7).

The lower unit of the Mule Spring Limestone is 31.6 m thick on this hillside, and consists of ledge- and cliff-forming outcrops of limestone, typically mottled through bioturbation (Fig. 3). Oncolitic horizons are scattered throughout the unit. The uppermost few meters form a prominent cliff that can be mapped throughout the Split Mountain area. The upper part of the cliff is dominated by approximately 4 m of microbial laminite with local stromatolitic buildups. This microbialite interval weathers into distinctive gray bands alternating with orange-weathering microbial dolosiltites on a millimeter to centimeter scale (Fig. 4.1). The microbialite locally bears lenses of fenestral lime mud, especially in a narrow interval just over 27 m above the base of the Mule Spring Limestone (Figs. 3, 4.2). Individual fenestral lenses are from one to five centimeters thick, laterally pinching and swelling. Bands of fenestral texture grade laterally into non-fenestral laminite within single lenses. A 0.1 m thick conglomeritic bed occurs approximately 0.35 m above the fenestral interval (Fig. 4.3). The elongate, rip-up clasts are up to five centimeters long and chaotically oriented. At least two fissures are developed within the microbialite (Fig. 4.4). These fissures are approximately 0.1 m wide and 0.3 m deep, and are filled with locally-derived clasts in a chaotic arrangement. The fissures are interpreted as resulting from subaerial exposure of the microbialite in a supratidal environment (paleokarsts?). The infilled fissures were carpeted over when microbialite deposition subsequently resumed. The microbialite interval is truncated by a locally downcutting, irregular surface that is overlain by just over one meter of dark gray-weathering, burrow-mottled, non-laminated, limestone that caps the cliff.

The middle unit of the Mule Spring Limestone forms the recessive, mostly covered interval between the cliff described above and the massive cliff of the upper Mule Spring Limestone at the top of the hill. A measured section through most of the middle unit on this hillside (Fig. 5.1) is very similar to a measured section through the same unit taken at the better exposures at the Split Mountain West section (Fig. 5.2) and is described below. Incomplete cephala tentatively identified as *Bolbolenellus euryparia* have been recovered from float at the base of the upper unit of the Mule Spring Limestone on the Split Mountain East hillside.

STOP 7B: SPLIT MOUNTAIN WEST SECTION

If time permits, we will visit the spectacular canyon approximately 1.5 km west of Split Mountain (Fig. 1), where several sections were measured and described by the author. The sections described herein (Figs. 5.2, 6.2) were taken on the southwestern wall of the canyon that will come into view immediately after passing through the narrow canyon neck. This wall exposes a continuous section spanning the uppermost Harkless Formation, the entire Mule Spring Limestone, and most of the Emigrant Formation.

The lower part of this section duplicates the upper Dyeran strata that were described at the Split Mountain East hillside (Stop 7A, above) and is not discussed here.

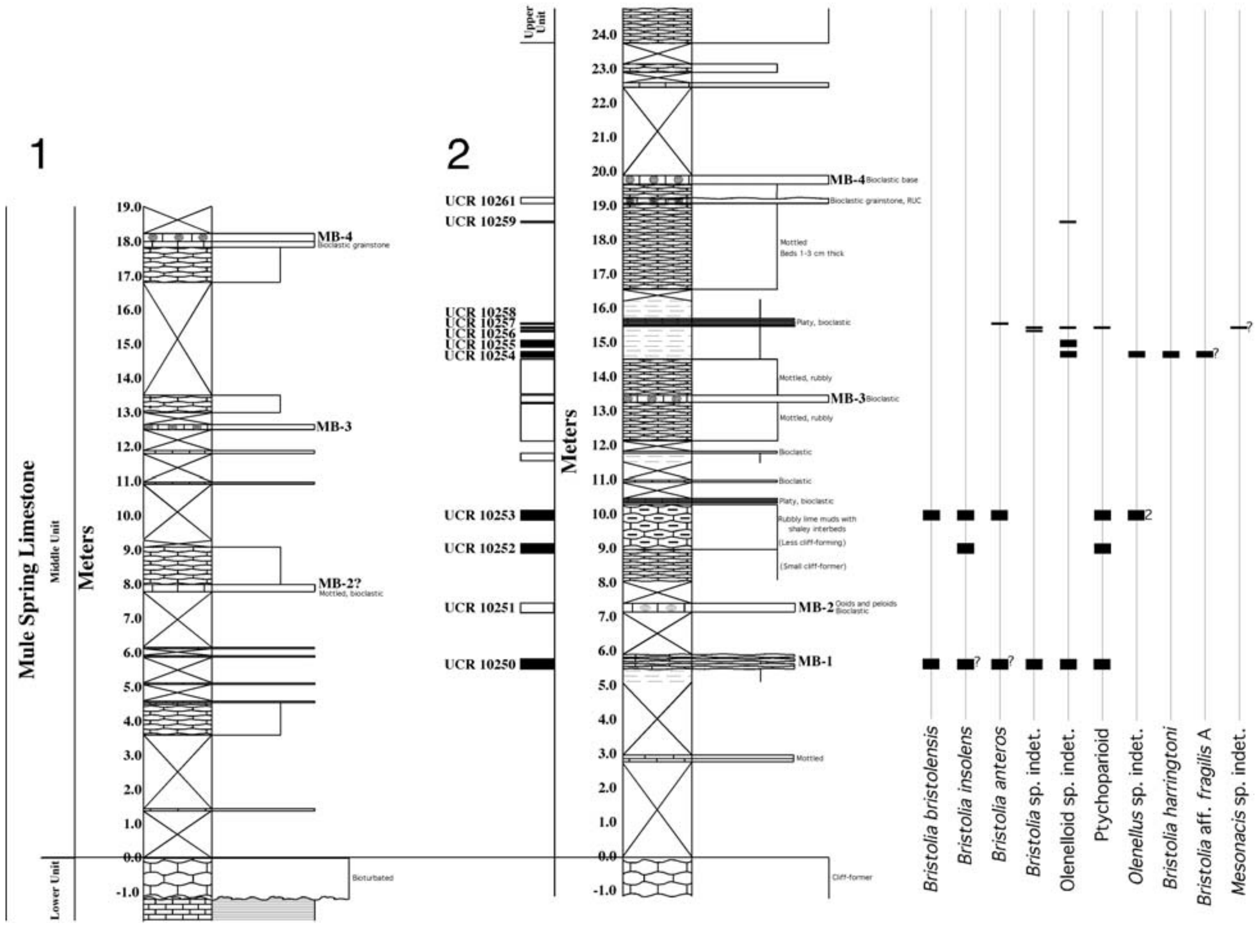

FIGURE *5*.—Measured sections and biostratigraphic range chart through the middle unit of the Mule Spring Limestone. *1*, Split Mountain East hillside (Stop 7A). *2*, Split Mountain West section (Stop 7B). Meters measured from the top of the lower unit of the Mule Spring Limestone (the surface 31.6 m above the base of the Mule Spring Limestone; Fig. 3). Marker beds used for correlation of these and other sections through this interval are labeled "MB". See Fig. 2 for explanation of symbols.

The middle unit of the Mule Spring Limestone is somewhat better exposed here than at Stop 7A, although several faults with meter-scale displacement can complicate lateral tracing of strata (Fig. 4.5). An apparently complete and unfaulted section through the middle unit was taken on the fourth ridge up the wall away from the canyon floor (Figs. 4.5, 5.2). The base of this measured section was the top of the cliff at the top of the lower unit of the Mule Spring Limestone, which forms a prominent scarp on the canyon wall (Fig. 4.5). The middle unit of the Mule Spring Limestone is almost 24 m thick here, comprised mostly of rubbly-weathering, burrow-mottled micrite interspersed with intervals of shale up to almost two meters thick. Several distinctive limestone beds serve as marker beds that can be identified in the middle unit of the Mule Spring Limestone at both the Split Mountain West and Split Mountain East areas; these are labeled "MB-1" to "MB-4" on the measured sections (Fig. 5.1, 5.2).

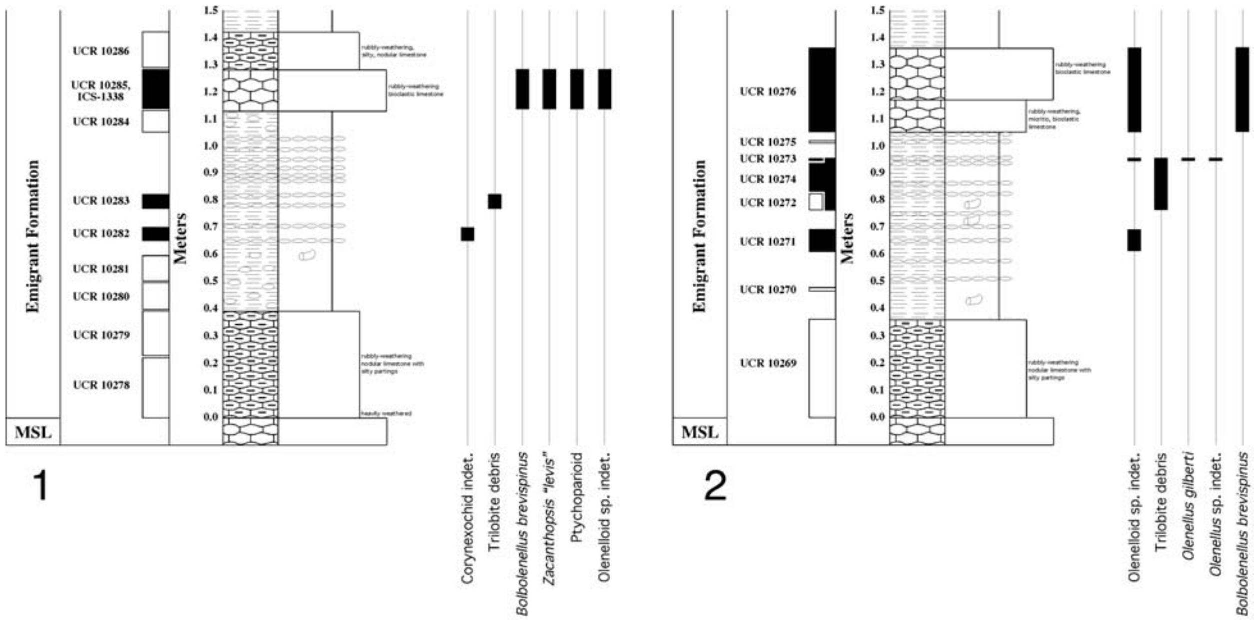

FIGURE *6*.—Biostratigraphic range charts for the basal Emigrant Formation. *1*, Split Mountain East trench section (Stop 7C). *2*, Split Mountain West section (Stop 7B). Meters measured from the top of the Mule Spring Limestone. The range charts shown here are based only on specimens collected by the author and held at UCR. Sundberg and McCollum (2003b) also reported *Olenellus* sp., *Bolbolenellus brevispinus*, *Crassifimbra walcotti*, a kochaspid? species and a second ptychopariid species from the thin limestone 1.2 m above base of the Emigrant Formation at the eastern trench (collections USNM 41938 and USNM 41939; equivalent to UCR 10285 and ICS-1338 [which is held at the Institute for Cambrian Studies, University of Chicago]). See Fig. 2 for explanation of symbols.

Fossil collections demonstrate that the local base of the *Bristolia insolens* Zone is no higher than 5.5 m above the base of the middle unit of the Mule Spring Limestone. At this horizon and one approximately 4.5 m higher, the zone fossil co-occurs with *Bristolia anteros* Palmer in Palmer and Halley, 1979 and *Bristolia bristolensis* (Resser, 1928). These three species also co-occur in a narrow stratigraphic interval within the upper third of the Latham Shale in southeastern California (Webster et al., 2003). *Bristolia harringtoni* re-occurs almost 15 m above the base of the middle unit of the Mule Spring Limestone, stratigraphically above the last occurrence of *Bristolia bristolensis*, but has not been found in fossil collections in the 45 m between its lower occurrence in the uppermost Harkless Formation (see above) and this occurrence. This Lazarus taxon pattern of occurrence is typical of *Bristolia harringtoni* in all southern Great Basin sections studied to date (e.g., Webster et al., 2003; Webster, 2007b; discussed by Webster, this volume, Article 7). As is also typical regionally, the stratigraphically high specimens of *Bristolia harringtoni* co-occur and/or show range overlap with *Bristolia* aff. *fragilis* A and *Bristolia anteros* (Webster, this volume, Article 7; Webster et al., 2003; Webster, 2007b). Specimens tentatively identified as *Bristolia fragilis* Palmer in Palmer and Halley, 1979 have been recovered from float from above the fourth marker bed in a measured section adjacent to the one described here, suggesting that the uppermost part of the middle unit ranges into or perhaps even through the *Peachella iddingsi* Zone (Webster, this volume, Article 7).

The entire upper unit of the Mule Spring Limestone can be examined in the Split Mountain West section (the composite section is shown in Webster, this volume, Article 7, fig. 4.1). The basal part of the upper unit can be easily examined in exposures that extend to the canyon floor. Examination of the rest of the upper unit, including the 31 m-thick interval of fenestral limestone, involves scrambling up the steep, boulder-strewn hillside that banks up against the sheer Mule Spring Limestone cliff. The uppermost 45 m of the Mule Spring Limestone can only be accessed through a precarious climb up a rock face. The carbonates of the upper unit include fine examples of oncolitic (Fig. 4.6) and fenestral limestones, but are essentially devoid of identifiable trilobites. The contact with the overlying Emigrant Formation is exposed at the top of the Mule Spring Limestone cliff. This contact and the fauna of the basal Emigrant Formation are discussed at Stop 7C.

STOP 7C: SPLIT MOUNTAIN EAST TRENCH

At this stop we will examine the Dyeran-Delamaran boundary, which lies approximately 1.5 m above the base of the Emigrant Formation. The boundary is well exposed and easily accessible in a trenched section located approximately 400 m southeast of the hillside exposures examined at Stop 7A (Fig. 1). The trench was excavated and collected by Linda and Mike McCollum and students of Eastern Washington University during 1998, 1999, and 2000, with the purpose of conducting a high-resolution biostratigraphic study of the lower part of the Emigrant Formation (see Sundberg and McCollum [2003b] for a historical account). The resulting data have given this site international importance with respect to intercontinental correlation around the provisional Stage 4-5 boundary of the developing global Cambrian chronostratigraphic nomenclature (McCollum and Sundberg, 1999, 2007; Sundberg and McCollum, 2003b). The present paper focuses on the litho- and biostratigraphy of just the Dyeran part of the Emigrant Formation; the Delamaran part, including the interval relevant to the provisional Cambrian Stage 4-5 boundary, is discussed by Sundberg et al. (this volume, Stop 7C).

Detailed measured sections through the basal Emigrant Formation, including the contact with the underlying Mule Spring Limestone, were taken by the author at both the Split Mountain East trenched section (Stop 7C; Fig. 6.1) and the Split Mountain West section (Stop 7B; Fig. 6.2). The sections are very similar, and are therefore discussed together.

The topmost Mule Spring Limestone forms a prominent surface at both localities, and is used as the zero datum in both measured sections. Regionally, identifiable trilobite remains are scarce in the upper unit of the Mule Spring Limestone. This results in some ambiguity as to the age of the contact with the overlying Emigrant Formation in terms of the upper Dyeran trilobite zones defined by Webster (this volume, Article 7). An indeterminate ptychoparioid was recovered from the uppermost meter of the Mule Spring Limestone by the author at the western section. Sundberg and McCollum (2003b) reported *Olenellus puertoblancoensis*? (Lochman in Cooper et al., 1952) and a ptychoparioid from the uppermost meter of the Mule Spring Limestone at the eastern section. The specimens of *O. puertoblancoensis*? figured by Sundberg and McCollum (2003b, pl. 3, figs. 2, 6) are morphologically immature. It cannot be determined whether they represent *O. puertoblancoensis* s.s. (that elsewhere occurs in the *Bolbolenellus euryparia* Zone; Webster, this volume, Article 7) or *O*. aff. *puertoblancoensis* (known from the uppermost part of the *Nephrolenellus multinodus* Zone at the northern Groom Range; Webster et al., this volume, Stop 6B). Nevertheless, almost 170 m of carbonates accumulated between the base of the *Bolbolenellus euryparia* Zone and this horizon. Conservatively, this is probably at least twice as thick as correlative strata in the northern Groom Range, and on the order of four times the thickness of correlative strata in the Pioche-Caliente region. Such dramatic offshore thickening is testament to the generation of greater accommodation space on the distal shelf and to the ability of carbonate accumulation to keep pace with this relative subsidence. The rapid accumulation rate of the upper Mule Spring Limestone also stands in stark contrast to the highly condensed nature of the overlying Emigrant Formation (Sundberg et al., this volume, Stop 7C).

The base of the Emigrant Formation is represented by less than 0.4 m of silty, nodular limestone with silty partings, resting with apparent conformity on the topmost bed of the Mule Spring Limestone (Fig. 6.1, 6.2). This is overlain by bioturbated shale containing carbonate nodules. Such nodular horizons suggest that this interval is relatively condensed, because sediment starvation or winnowing encourages growth of such diagenetic nodules below a static sediment surface (Brett et al., 2006; Peters, 2007; Webster et al., 2008). At the eastern section, the nodules occur in ten distinct horizons and as isolated nodules scattered within the shale below the first horizon and above the tenth horizon (Fig. 6.1). At the western section, carbonate nodules form eleven distinct horizons within the shale; the highest being in very close proximity to the base of the overlying rubbly-weathering, vuggy, tan-colored, micritic, bioclastic limestone (Fig. 6.2). This limestone is 25 to 29 cm thick, and contains a moderately diverse assemblage of brachiopods, small shelly fossils, and trilobites. The trilobite fauna of this limestone and the underlying nodular shale includes *Crassifimbra walcotti* (Resser, 1937), *Zacanthopsis* "*levis*" (Walcott, 1886) (see the appendix in Webster, this volume, Article 7 for a discussion of this taxon), *Bolbolenellus brevispinus* Palmer, 1998a, *Olenellus gilberti* Meek in White, 1874, and several indeterminate ptychoparioids and olenellids (Fig. 6.1, 6.2; also Sundberg and McCollum, 2003b). These species are indicative of the uppermost *Bolbolenellus euryparia* Zone and the *Nephrolenellus multinodus* Zone (Webster, this volume, Article 7). A small shelly fauna from the basal nodular limestone and the uppermost Dyeran limestone bed was described by Skovsted (2006). Unfortunately, the limited study of small shelly faunas from upper Dyeran (and equivalent) strata elsewhere limits the biostratigraphic utility of this assemblage (Skovsted, 2006). *Eokochaspis nodosa* Sundberg and McCollum, 2000, that defines the base of the Delamaran, has been recovered from shale 0.25 m above this limestone (Sundberg and McCollum, 2003b; Sundberg et al., this volume, Stop 7C). The basal ≈ 1.6 m of the Emigrant Formation in the Split Mountain area therefore contains the sequence boundaries at the base of upper Dyeran Depositional Sequence IV (as defined by Webster, this volume, Article 7) and at the base of Delamaran sequence DMS 1 (as defined by McCollum and McCollum, this volume, Article 8), but the precise position of these boundaries within this interval has not yet been determined.

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