TRIASSIC-JURASSIC BOUNDARY ASSP AT FERGUSON HILL, MULLER CANYON (NEVADA, USA).

Jean Guex, Peter D. Ward, Annachiara Bartolini, David G. Taylor, Spencer G. Lucas, Lawrence H. Tanner and Christopher A. McRoberts

Introduction

The wide international scientific collaboration that, under the aegis of the Triassic/Jurassic Boundary Working Group of the International Subcommission on Jurassic Stratigraphy, has been seeking to define the base of the Jurassic system, ended up with a vote on the four following proposals for the primary marker event:

1) FO of the ammonite *Psiloceras planorbis*;
2) FO of the radiolarian *Canoptum merum*;
3) FO of the ammonite *Psiloceras spelae*;
4) A major delta^{13}C negative shift described as the "Initial Carbon Excursion".

The voting members of the Working Group selected proposal 3, which consists of the P. spelae group, known as the oldest representative of the ammonite genus Psiloceras, as primary marker of the base of the Jurassic. Consequently, the two localities containing that species became the candidates for the base Jurassic GSSP and ASSP. The voting members of the Working group selected Kuhjoch (Austria) as a GSSP and Ferguson Hill (Nevada, USA) as a ASSP with majorities of over 60 % each. Both selections were subsequently confirmed by the voting members of the Jurassic Subcomission with majorities of over 60 % .

The present report summarises the initial proposal by Lucas et al. published in 2007 (see references below) and refers to original field investigations by several different authors. It also eliminates discrepancies and minor imperfections that resulted from the multiple contributions by the many authors who dealt with the different facets of the initial proposals [see also Lucas et al. and McRoberts et al. in *International Subcommission on Jurassic Stratigraphy Newsletter* **34 (part 1);** these can be downloaded from the Jurassic Subcommission website at http://www.es.ucl.ac.uk/people/bown/ISJSwebsite.htm]

1. Location and access

1.1. Country: USA.
1.2. Name of site: Ferguson Hill, New York Canyon, Gabbs Valley Range, Nevada.
1.3. Coordinates: Latitude 38°29’11.7"N; Longitude 118°04’57.5”W.
1.4. General location map with access map to the Ferguson Hill section (Fig. 1).
1.5 Geological map in Ferguson and Muller (1949, plate 5): *US Geological Survey Professional Paper* **216**, ~1:20,000 scale (see Fig.7).
1.6 Photograph indicating the location of the section and of the boundary in the field (arrow indicates boundary) (Fig. 2).
1.7 Access: Less than 200 km from Reno, Nevada International Airport. Drive by car on paved highways to Luning; then an all weather (gravel) road for about 5 km to the east; then walk about 0.5 km. There are no access restrictions to the site; there may be some snow in winter, but generally accessible for 12 months of the year. A satellite view of Luning and the New York Canyon Area can be found on Google Earth.

2. Boundary Level

The boundary is placed at the lowest occurrence of *Psiloceras spelae* located 20 cm below bed N9 of the Muller Canyon Member, Gabbs Formation, Volcano Peak Group. The position of the proposed boundary level in the host formation/member is shown in Figs 2 and 3.

3. Ammonite biochronology

The ammonite biochronology, summarised in Fig. 3, and essentially that established by Jean Guex and Dave Taylor in several publications, is after the original Range Chart published in Guex et al. (2004), see references below, with the original bed numbers used in their collections and monographs.

Generally, ammonite assemblages from the Ferguson Hill section are diverse, abundant and well preserved. In the 14 m thick transitional interval across the boundary the diversity is low reflecting the end-Triassic crisis of ammonites. In this interval also the preservation is not optimal, the specimens being crushed and lacking suture lines.

Much of the upper part of the Mount Hyatt Member belongs to the *Choristoceras rhaeticum* zone, as that zonal species is present and co-occurs with *Arcestes nevadanus* Gabb and occasional *Placites*. The uppermost 5 metres of the Mount Hyatt Member and lowermost 1 metre of the Muller Canyon Member yield ammonites of the *Choristoceras crickmayi* zone (Fig. 2), including *C. shoshonensis*, *C. marshi*, *Arcestes nevadanus*, *Rhacophyllites* cf. *R. debilis* and *Placites*. These beds are followed by a stratigraphic interval about 7 metres thick that yielded crushed ammonites with involute internal whorls (i.e. similar to phylloceratids) and evolute adult coiling (typically a psiloceratid character). These undescribed forms do not have nodes on juvenile whorls and are interpreted as intermediate between phylloceratid and psiloceratids. They have not been found in Europe.

About 20 cm below bed N9 of the Muller Canyon Member is the LO of *Psiloceras tilmanni* accompanied by the LO of *P. spelae* selected for definition of the base of the Jurassic System, the Hettangian Stage and basal ammonite zone, the *P. spelae* horizon. These are the first psiloceratids, with nodes on the inner whorls. The upper beds of the Muller Canyon Member have yielded abundant tiny *Choristoceras* of the *minutum* group, co-occurring with *Psiloceras*, *Odoghertyceras* and *Neophyllites*. This is the *Choristoceras minutum* zone. The first abundant three-dimensional smooth *Psiloceras* of the *pacificum* group appear about one metre higher, now referred to the *P. pacificum* zone.

4. Bivalves

Bivalves from the upper part of the Mount Hyatt Member and basal Muller Canyon Member are dominated by infaunal deposit feeders and characterized by an abundance (as much as 80% of the assemblage) of *Septocardia*, a Triassic indicator.

Most of the Muller Canyon Member above its base yields a bivalve assemblage with *Kalentera*, an inoceramid bivalve, undetermined non-siphonate infaunal forms, *Oxytoma inaequivalvis*, and *Agerchlamys boellingi* that has little in common with the *Septocardia* beds below. Thus, there is a substantial turnover in the bivalves in the

lower part of the Muller Canyon Member, just above the HO of conodonts and characteristic Late Triassic ammonites.

5. Microfossils

Conodonts from the upper part of the Mount Hyatt Member through the lower part of the Muller Canyon Member (up to bed 88 of Lucas et al. 2007) are the characteristic Rhaetian taxa *Misikella posthersteini* Kozur and Mostler and *Zieglericonus rhaeticus* Kozur and Mock. Sampling of higher beds in the Muller Canyon Member and the basal beds of the Sunrise Formation did not yield conodonts.

Identified radiolarians from the Ferguson Hill section are also from the upper Mount Hyatt Member through lower Muller Canyon Member. These include taxa indicative of the *Globolaxtorum tozeri* zone of latest Rhaetian age. Radiolarians are present stratigraphically higher in the Ferguson Hill section than the identified Rhaetian specimens, but have not been studied.

6. Carbon Isotope curves

Earlier controversy between Peter Ward and Jean Guex over carbon isotope curves was mainly due to bad luck on both sides: Guex's et al (2004) original curve had some internal noise due to the fact that some of our organic carbon values could have been locally altered. Ward's curve was based on samples collected more than 25 meters away that had a better diagenetic history, producing a less noisy curve. To make things more complicated, Ward's curve was projected onto the section sampled to integrate the paleontological information of his work, but the section is faulted in a tricky way because the fault can easily be missed. This led to discrepancies between the respective stratigraphic thicknesses of the two sequences of measurements. However, Ward was able to superpose correctly the major part of the two curves (see Ward et al 2007). After discussion of the two isotope sequences, Guex et al (2008) proposed a correlation that is now accepted by both of the first authors of the present report and is reproduced here in Fig. 4. From this we can see that the interpretation of Ward's less noisy curve is easier and we use Ward's curve here to suggest a correlation (indicated by X on Fig. 5) with the GSSP at Kuhjoch. Note that this correlation would place the minor C-isotope kick-back event slightly above the first appearance of *Psiloceras spelae* at Ferguson Hill but slightly below in Kuhjoch, perhaps suggesting a very slightly older age for the Ferguson Hill level within the same very short time-interval of an ammonite horizon.

7. Site conservation and protection

Access and conservation are guaranteed by the US Government. The Ferguson Hill section and surrounding lands are U. S. Government lands administered by the Bureau of Land Management (BLM), a branch of the Department of the Interior. At our request, the Bureau of Land Management has guaranteed “that BLM Nevada will maintain access to the section for qualified scientists and will conserve it for future use and study” (letter from R. Abbey to S.G. Lucas, 8 July 2004—see Fig. 6).

8. Arguments in favour of the Ferguson Hill (FH) as ASSP

1) The Ferguson Hill section has a very high ammonite biodiversity, highly complementary to that observed in the GSSP at Kuhjoch (Fig.3). At Ferguson Hill, 17 ammonite species and 11 genera, including phylloceratids, are present in the critical interval from the last Triassic ammonoids to the abundant smooth

Psiloceras (i.e. below the costate *Psiloceras* of the *polymorphum*, *costosum* and *naumanni* groups), enabling good correlation with the Pacific Realm. Ferguson Hill is also the type locality of *Psiloceras spelae*. It is important to note that the two experts on the ammonites, Jean Guex for Ferguson Hill and Axel von Hillebrandt for Kuhjoch, are agreed that, despite slight differences between the two populations, the key *Psiloceras spelae* (s.l.) can be correlated as being from the same short time-interval of an ammonite horizon.

2) The bivalve record around the Triassic/Jurassic boundary interval at Ferguson Hill is also complementary to that reported at Kuhjoch. It shows a major turnover with assemblages dominated by "Triassic" *Septocardia* replaced by more diverse assemblages including "typical Jurassic" genera *Nuculoma*, *Mesomiltha*, "*Chlamys*", *Agerchlamys*, *Gervilleia* and *Oxytoma* at Ferguson Hill and *Pseudolimea*, *Agerchlamys*, *Astarte*, *Cardinia* and *Modiolus* at Kuhjoch. This slightly earlier event provides a "proxy" for correlation of the ammonite-defined boundary.

3) Two independent studies of the carbon isotope stratigraphy of the Ferguson Hill section have been reconciled to provide a detailed stratigraphy with high correlation potential that complements that from Kuhjoch and other sections. This includes a slightly older major carbon-isotope excursion that has been widely recognised in different facies, again providing a "proxy" for correlation of the boundary.

4) Long term discussions between Jean Guex and Elizabeth S. Carter have convinced them that The Psiloceras spelae (ammonite) horizon at Ferguson Hill appears to correlate to near the base of the Canoptum merum (radiolarian) zone in the British Columbia sections at Kunga Island and Kennecott Point, opening further correlation with Circum-Pacific and Eastern Tethys sections.

Conclusion

The Ferguson Hill section is highly complementary to the selected GSSP Kuhjoch providing easy correlation with the British Columbia sections at Kunga Island and Kennecott Point, opening further correlation with Circum-Pacific and Eastern Tethys sections.

FIGURES

Fig 1: Geographic map showing the location of the Ferguson Hill section and relative to Volcano Peak and New York Canyon.

Fig.2: Photograph of the candidate ASSP at Ferguson Hill showing the bed numbers used in the range-chart of Fig 3 and the position of *P.spelae* (red horizontal arrow). The isotope curve is a smoothed version of the Guex et al 2004 curve.

Fig 3: Range chart showing the stratigraphical distributions of ammonites and bivalves as published by Guex et al (2004).

Fig. 4: Correlation between the Ward et al. (2007) and Guex et al. (2004) isotope curves (from Guex et al. 2008) .

Fig 5: Isotopic correlation between the potential GSSP and ASSP sections showing the relative position of *Psiloceras spelae* in the two sections: according to this interpretation *P.spelae* may to be slightly older in Nevada. Note that the scales are different in the two sections.

Fig. 6: Official letter from Robert Abbey, State Director, Nevada, of the Bureau of Land Management to Spencer Lucas concerning the conservation and protection of the ASSP at the Ferguson Hill section

Fig 7: Geological map of the New York Canyon area (Redrawn from Muller and Ferguson 1949).

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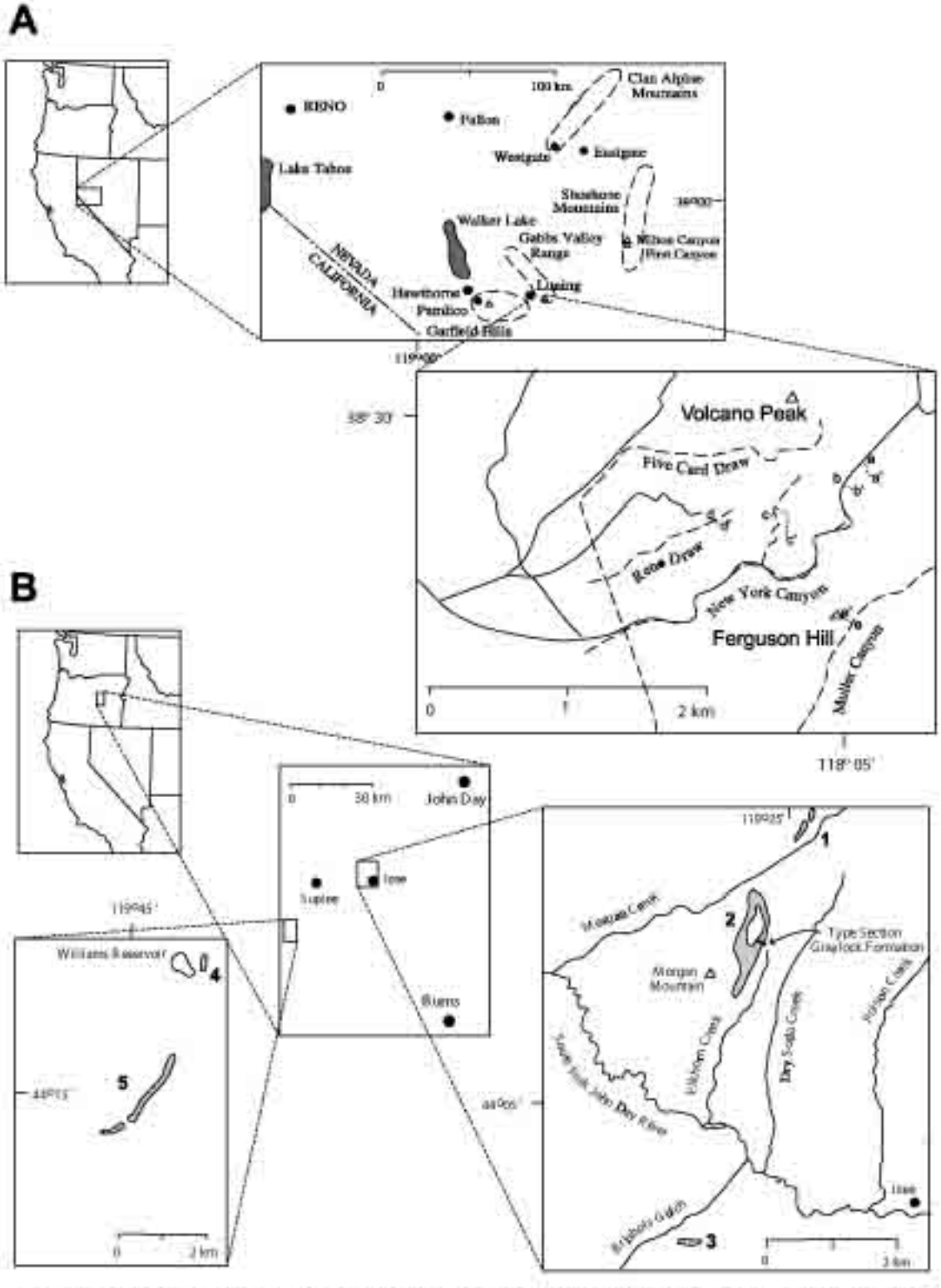
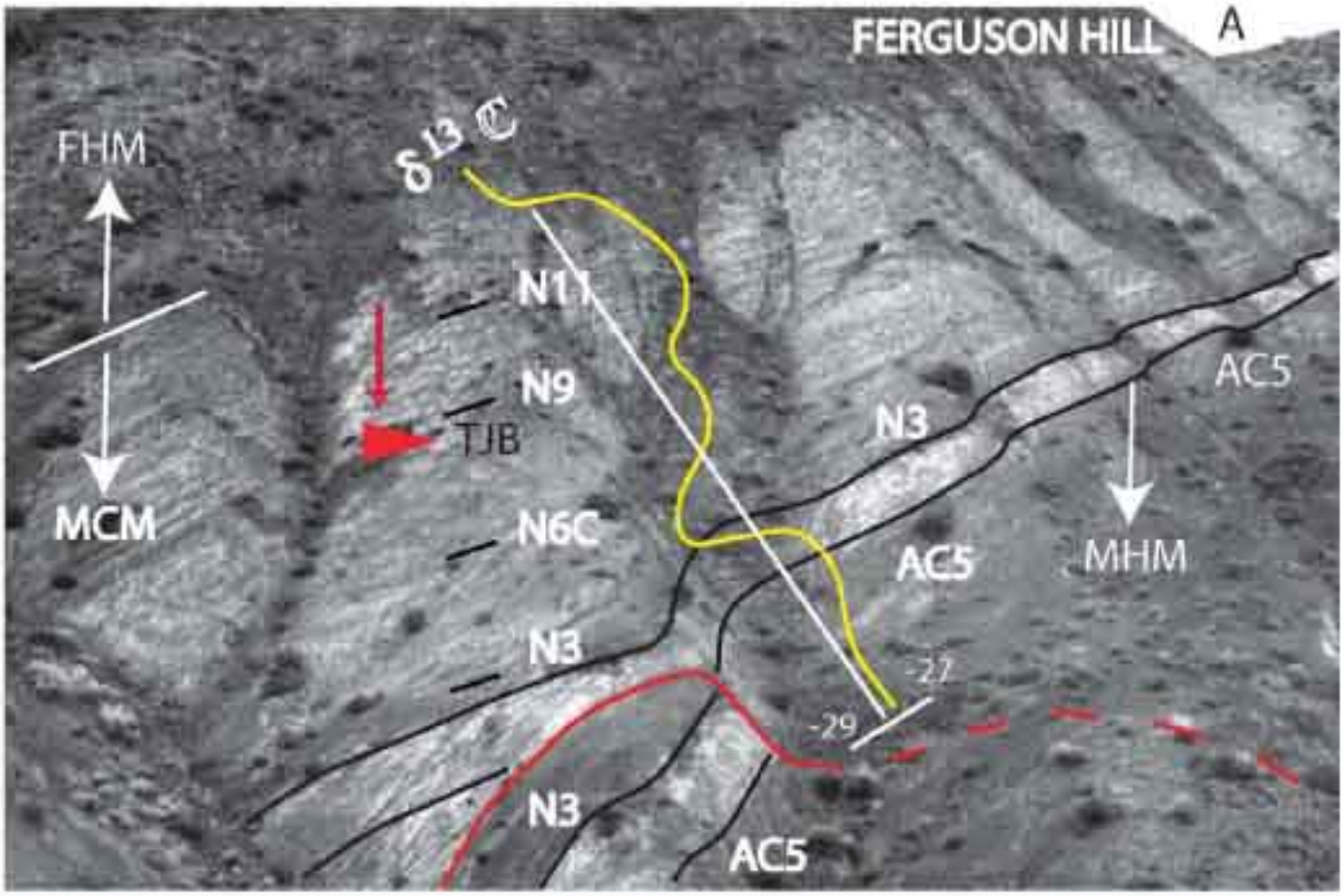


Figure 1. Sketch maps showing fossil localities in Nevada (A) and Oregon (B). Nevada areas enclosed in dashed lines represent mountain ranges in which localities occur. Enlargement of Gabbs Valley Range portion known as New York Canyon area shows roads (solid lines), significant drainages (dashed lines), and stratigraphic sections (dotted lines) described in Figures 7, 9, and 10; primed letters for stratigraphic sections (labeled a through e) indicate top of section. Oregon localities are marked as shaded areas in enlarged maps and include those at (1) Camp Faraway, (2) Morgan Mountain, (3) Hole-in-the-Ground, (4) Williams Reservoir, and (5) exposures south of Williams Reservoir. Solid lines indicate streams.


FERGUSON HILL
A
FHM
δ13C
N11
N9
TJB
MCM
N6C
N3
AC5
MHM
N3
-27
-29
N3
AC5

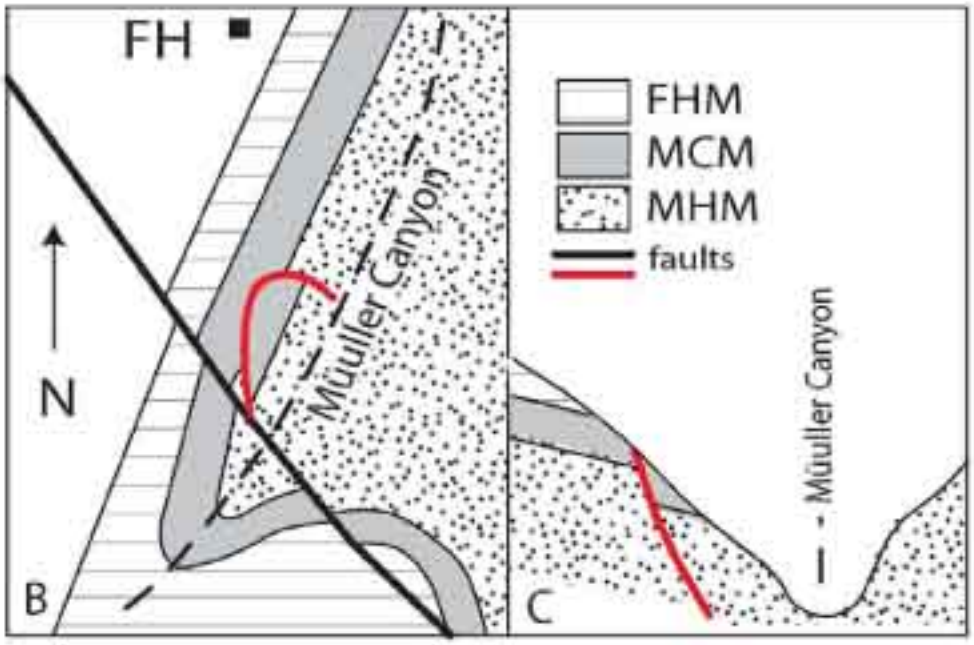

FH
FHM
MCM
MHM
faults
Müuller Canyon
N
B
C
Müuller Canyon

FIGURE 2

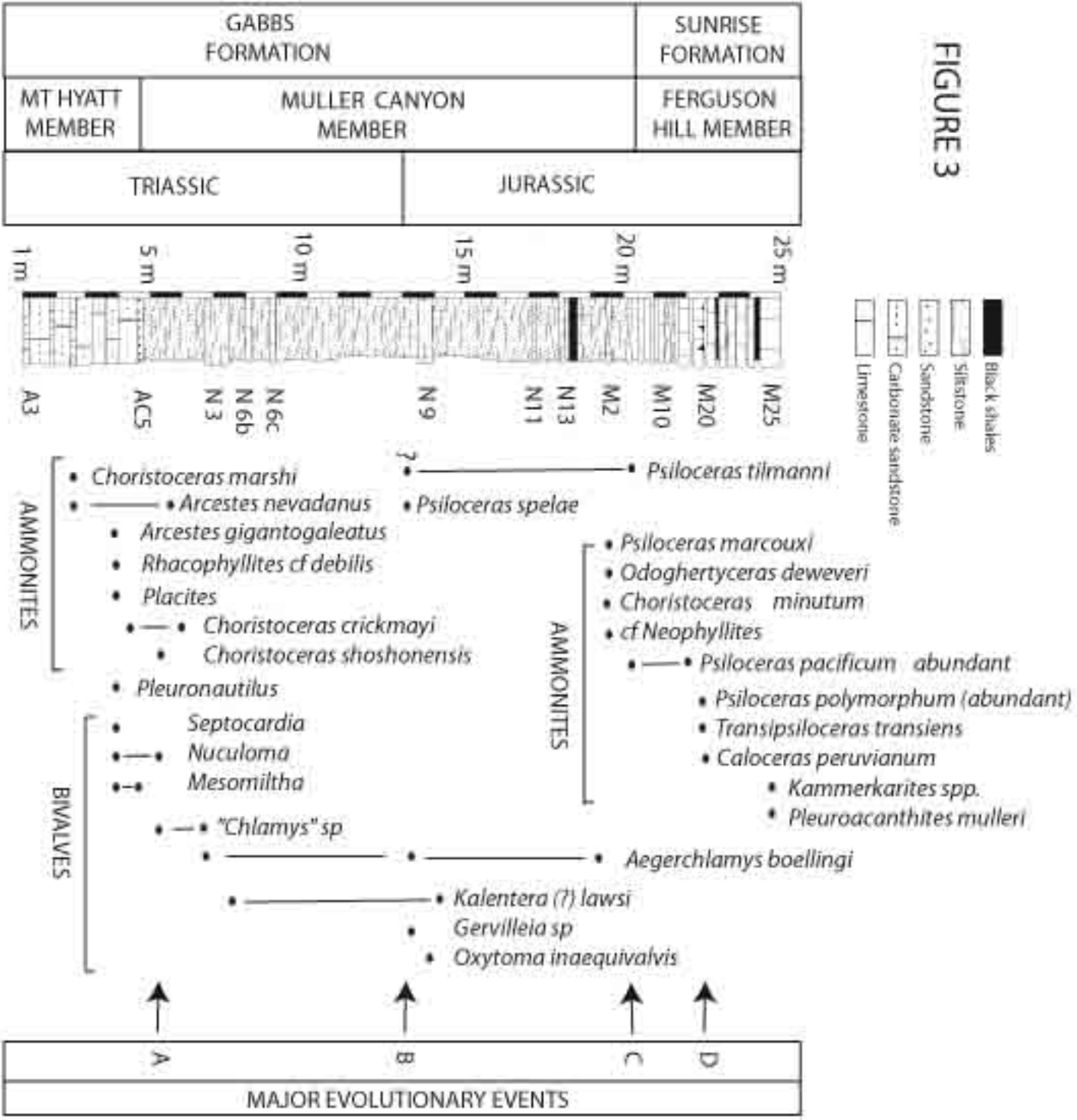

GABBS FORMATION
SUNRISE FORMATION
MT HYATT MEMBER
MULLER CANYON MEMBER
FERGUSON HILL MEMBER
TRIASSIC
JURASSIC
1 m
5 m
10 m
15 m
20 m
25 m
A3
AC5
N 3
N 6b
N 6c
N 9
N11
N13
M2
M10
M20
M25
Limestone
Carbonate sandstone
Sandstone
Siltstone
Black shales
AMMONITES
Choristoceras marshi
Arcestes nevadanus
Arcestes gigantogaleatus
Rhacophyllites cf debilis
Placites
Choristoceras crickmayi
Choristoceras shoshonensis
Pleuronautilus
?
Psiloceras tilmanni
Psiloceras spelae
AMMONITES
Psiloceras marcouxi
Odoghertyceras deweveri
Choristoceras minutum
cf Neophyllites
Psiloceras pacificum abundant
Psiloceras polymorphum (abundant)
Transipsiloceras transiens
Caloceras peruvianum
Kammerkarites spp.
Pleuroacanthites mulleri
BIVALVES
Septocardia
Nuculoma
Mesomiltha
"Chlamys" sp
Aegerchlamys boellingi
Kalentera (?) lawsi
Gervilleia sp
Oxytoma inaequivalvis
A
B
C
D
MAJOR EVOLUTIONARY EVENTS

FIGURE 3

FIGURE 4

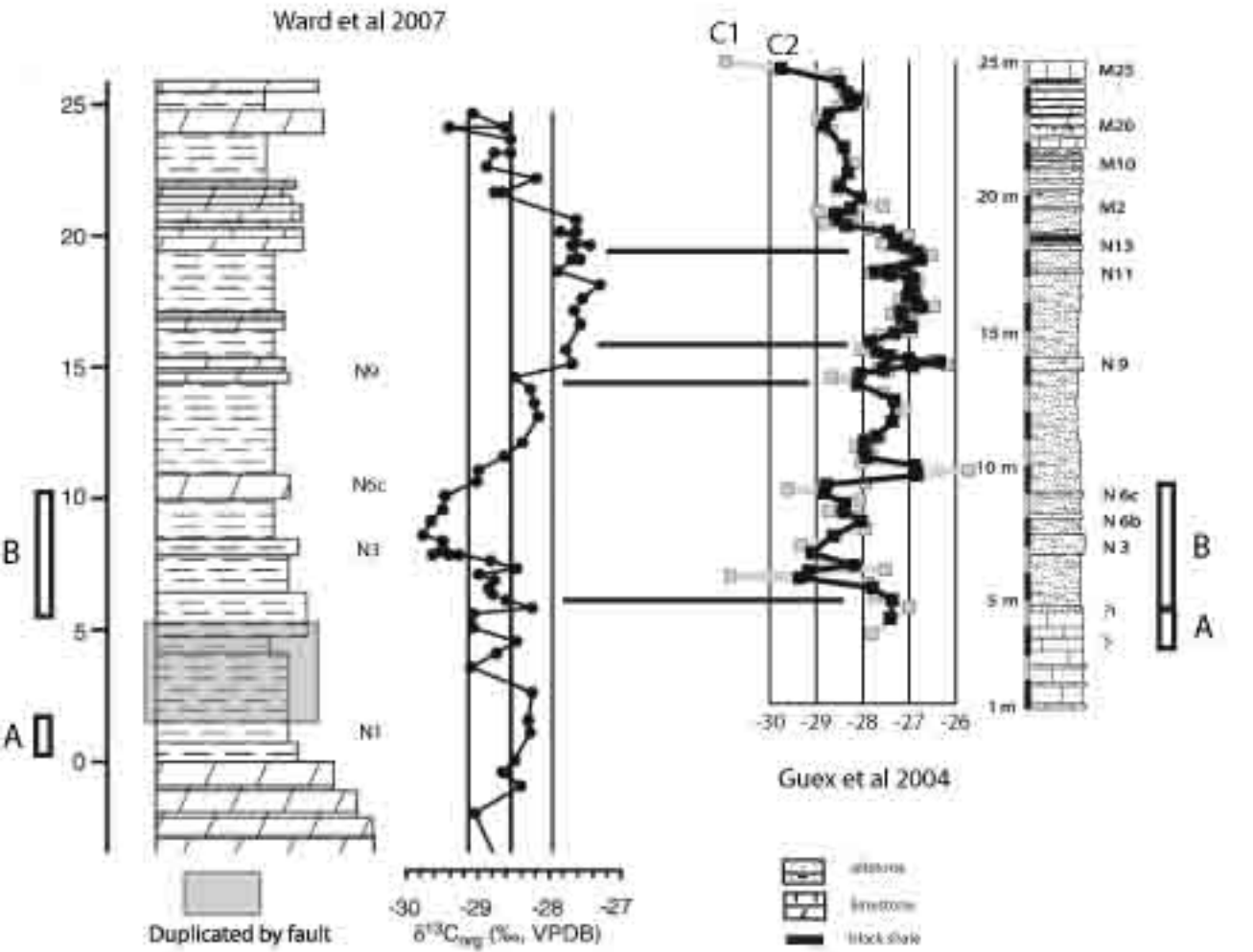
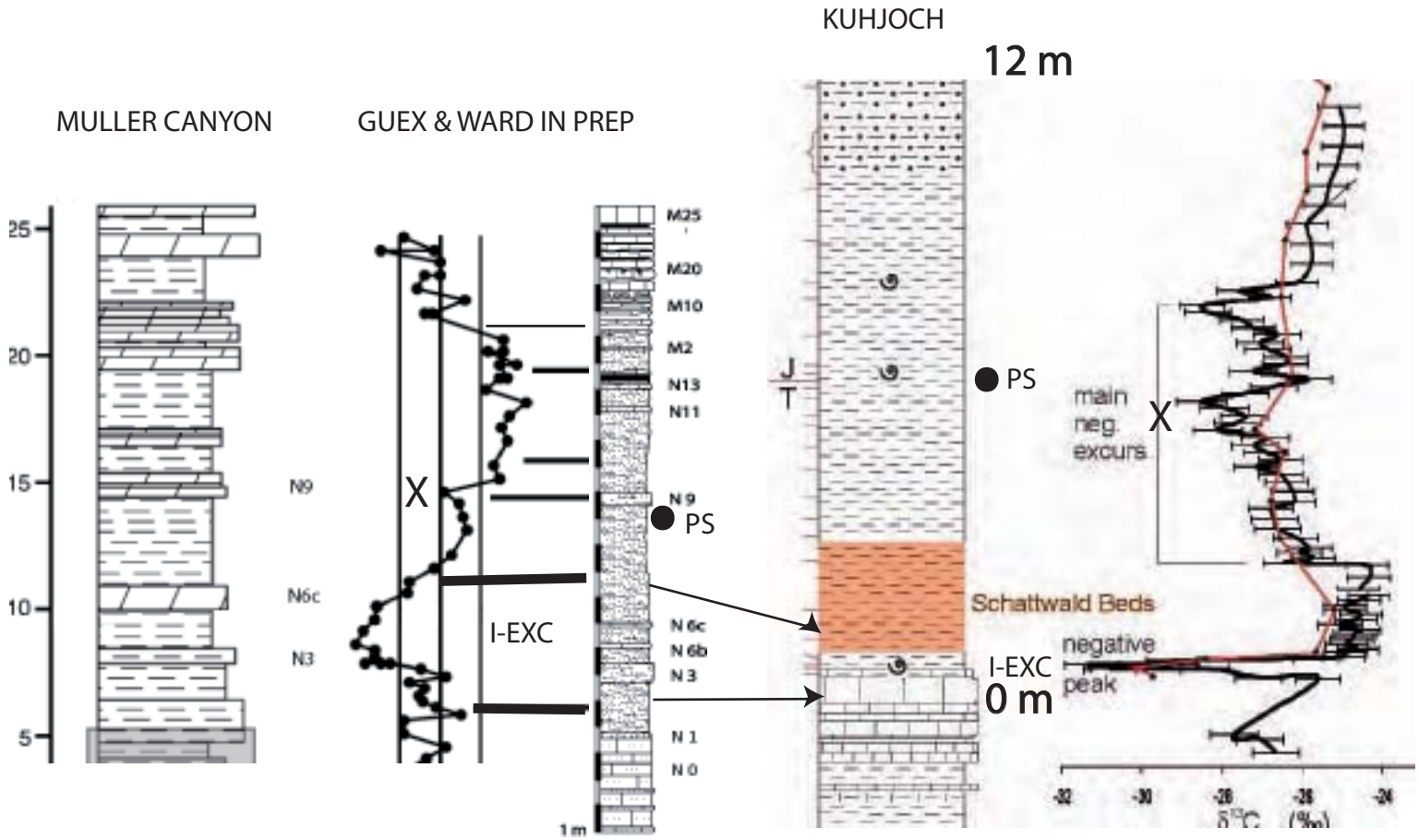

Ward et al 2007
C1
C2
25
20
15
10
5
0
B
A
N9
N5c
N3
N1
Duplicated by fault
-30
-29
-28
-27
δ13Corg (‰, VPDB)
-30
-29
-28
-27
-26
Guex et al 2004
25 m
20 m
15 m
10 m
5 m
1 m
M25
M20
M10
M2
N13
N11
N 9
N 6c
N 6b
N 3
B
A
limestone
black shale

FIGURE 5



● PS PSILOCERAS SPELAE

→ CORRELATION OF THE NEGATIVE EXCURSION

I-EXC INITIAL EXCURSION

APPENDIX 1. BLM LETTER

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Nevada State Office
P.O. Box 12000 (1340 Financial Blvd)
Reno, Nevada 89520-0006
http://www.nv.blm.gov

TAKE PRIDE IN AMERICA

In Reply Refer To:
8100 (NV-930)

JUL 0 8 2004

Spencer G. Lucas, Ph.D.
Curator of Paleontology and Geology
New Mexico Museum of Natural History
1801 Mountain Road, N.W.
Albuquerque, NM 87104

Dear Dr. Lucas:

I am writing in response to your letter dated April 20, 2004, concerning designating the global stratotype section and point (GSSP) for the Triassic-Jurassic boundary. I am pleased that you are nominating a location on Bureau of Land Management (BLM) managed land in Nevada to be a global standard by which all geologists define the Triassic-Jurassic boundary.

The location you identified in the Gabbs Valley Range near Luning in the NW¼, of the NE¼, Section 9, T7N, R35E of Mineral County is managed by our Carson City Field Office. I have been in contact with the staff there and they fully support the nomination. It is an honor to have BLM managed lands in Nevada designated in this way and there is no conflict with the designation and the BLM's multiple use mandate.

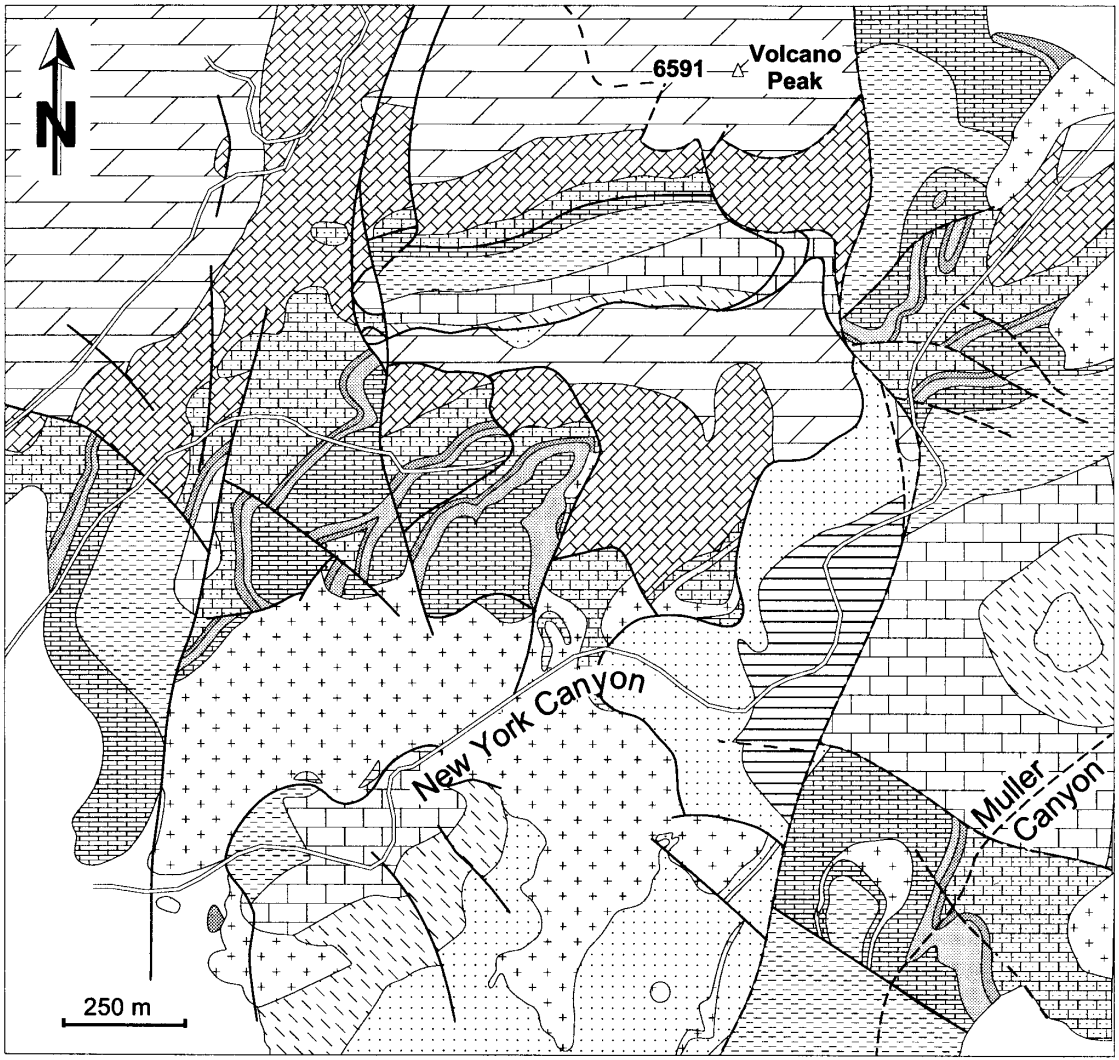
To the extent allowed by the law, I can assure you that BLM Nevada will maintain access to the GSSP for qualified scientists and will conserve it for future use and study.

Thank you for your interest in geological resources on BLM managed land in Nevada. I hope you are successful in having the International Union of Geological Sciences recognize Nevada as the best place for the Triassic-Jurassic boundary GSSP.

If you need any further assistance please contact Pat Barker at (775) 861-6482.

Sincerely,

Robert V. Abbey
State Director, Nevada



ap
Aplite

Toarcian
- Jd2 — Tuffaceous sandstone
- Jd1 — Conglomerate and fanconglomerate

Pliensbachian
- Js5 — Shale and limestone

Sinemurian
- Js4 — Calcareous sandstone and shale
- Js3 — Shale

Hettangian
- Js2 — Shale and limestone
- Js1 — Limestone and shale

Rhaetian
- Trg3 — Limestone and shale

Norian
- Trg2 — Argillaceous and sand limestone and shale
- Trg1 — Shale and limestone

Carnian
- TrL — Dolomite some limestone