Sprain, C.J., Renne, P.R., Clemens, W.A., and Wilson, G.P., 2018, Calibration of chron C29r: New high-precision geochronologic and paleomagnetic constraints from the Hell Creek region, Montana: GSA Bulletin, https://doi.org/10.1130/B31890.1.

DATA REPOSITORY

Supplementary Table 1. Stratigraphic Sections

Table DR1. Summary of run-specific parameters

Table DR2. $^{40}Ar/^{39}Ar$ analytical data

SECTION DESCRIPTIONS

See Figure 7 and 8 for stratigraphic context and Supplementary Table 1.

McKeever Ranch

The McKeever Ranch locality (N47.59407º, W107.3267º; All latitude and longitude measurements are based on the WGS84 datum) is located roughly 44 km NW of the town of Jordan, MT. At this locality two lignites crop out. Both coals contain tephra deposits and detailed microstratigraphy for each coal is described in detail in Ickert et al. (2015). The lowermost coal (~35 cm thick) marks the base of the section and has been recognized as the IrZ coal, based on the identification of the Nirvana bentonite, using Pb-isotopes (per Ickert et al. 2015), that crops out 4 cm below the top of the coal. The Nirvana bentonite was collected for dating (MK13-3).

Roughly 14 m above the IrZ coal, a Y coal (~1 m thick) is identified. This coal contains seven tephra deposits. One tephra layer ~80 cm from the base of the coal was collected for chemical analysis (MK13-1). Pb-isotopic analysis of this tephra conducted by Ickert et al. (2015) reveals that it falls into the 'Unnamed assorted bentonites' category, and while it has similar compositions to Y coals from Lerbekmo, Hell Hollow, Jack's Channel, and Isaac Ranch, these tephras can't be correlated because some tephras in this category clearly represent different stratigraphic horizons. Roughly 1 km NW of the MK13-1 location, the Y coal is again recognized (this site is termed McKeever Ranch A). This coal is similarly ~1 m thick and contains at least six tephras. A tephra located 78 cm from the base of the coal (MK12-1) was collected for dating, reported in this study, and chemical analysis of it was conducted by Ickert et al. (2015). It similarly falls into the 'Unnamed assorted bentonites' category (Ickert et al., 2015).

Paleomagnetic sampling was conducted at both sites in the summer of 2013. Sampling at McKeever Ranch ranged stratigraphically from immediately above the IrZ coal, to 65 cm above the Y coal, with the lower three samples collected in siltstone or claystone, and the highest sample collected from a fine sandstone deposit that displayed fine cross-bedding. Below the Y coal, this section is dominated by siltstones and claystones, which are representative of a low-energy flood plain environment, ideal for paleomagnetic sampling. A channel deposit is identified at the top of our section and as such paleomagentic sampling was mostly limited to collection below this unit.

Paleomagnetic samples were also collected at our McKeever Ranch A site (N47.59773º, W107.3402º). Sampling at this locality was focused in an interval from Y coal down 5.5 m to the top of a large (~10 m thick) channel deposit. Two samples were collected, one right on top of the channel and one right below the Y coal. Both samples were collected in sandy siltstones. Again, this locality is dominated by floodplain deposits composed of siltstones and claystones. While the IrZ coal does appear to crop out at the base of this section, intervening rocks were not collected due to the large channel deposit that cuts through the top of the IrZ coal, and ends ~5.5 m below the Y coal.

Hell Hollow

Approximately 13 km SE of McKeever Ranch is the Hell Hollow locality (N47.53472º, W107.1687º). At this locality, four coals have been identified: the IrZ, HFZ, and two Y coals. All coals contain tephra deposits that are amenable to high-precision geochronology, and dates for tephras from the IrZ (HH12-1) and HFZ (HH12-2) are reported in Sprain et al. (2015). Tephra deposits from each coal were chemically analyzed using electron microprobe analysis and Pb-isotopic analysis in Ickert et al. (2015). Chemical analysis corroborates mapping done in this area by Archibald (1982), and confirms the identity of the IrZ coal (based on the identification of the Nirvana bentonite) and the HFZ and Y coals.

The two Y coals crop out 5 and 13 m (respectively), above the HFZ coal. The first Y coal (~20 cm thick) contains three tephras described in Ickert et al., (2015). The tephra 16 cm from the base of the coal (HH13-1) was collected for dating and results are reported in this study. Four tephra layers are identified within the second Y coal (1.5-m-thick), and are likewise described in Ickert et al. (2015). A tephra (HH13-2), 126 cm from the base of the coal, was collected for geochronology and is reported here.

Roughly 1.5 km SW from the HH13-2 collection site, is another outcrop of the second Y coal recognized by its distinctive thickness, elevation, and by the appearance of a similar distinctive capping unit, a tan/yellow sandstone, that similarly caps the HH13-2 coal. This site, named the Hell Hollow A locality, is along the side of the road and has limited stratigraphic range, encompassing around 2 m below and 4 m above the Y coal. The Y coal at this locality contains two tephras layers, and the first layer (80 cm from the coal base: HH13-3) was collected for dating. Both tephra samples from the second Y coal, HH13-2 and HH13-3, share similar distinctive Pb isotope compositions, further supporting their field-based correlation (Ickert et al., 2015). Microstratigraphy for the HH13-3 coal is described in Ickert et al. (2015).

Samples for paleomagnetic analysis were collected between the HFZ and second Y coal, to best locate the C29r/C29n reversal. Lithology at the collection site is dominated by thin layers of siltstone, claystone, and lignites, representative of low energy flood-plain deposition. Paleomagnetic samples were collected either from siltstone or claystone layers, with ~4 m resolution toward the base of the section and less than 1 m resolution near the reversal.

Paleomagnetic samples were also collected from the Hell Hollow A locality (N47.52228º, W107.1775º), focused around the Y coal to fill in gaps that were unavoidable due to plant cover at the Hell Hollow locality. Site lithologies agree with flood plain deposition.

Garbani Hill/Pearl Lake

The Garbani Hill locality (N47.5151º, W107.0683º) is located 8 km SE of Hell Hollow. Previous descriptions of this section describe two coals, a Y coal doublet and the X coal, outcropping at this locality (see Sprain et al. 2015 for details). However, upon closer inspection, three additional coals are exposed roughly 0.5, 2, and 6 m, below the Y coal doublet. While areas beneath the Y coal doublet are certainly influenced by slumping, we believe these coals are in place based on identification of distinctive tephras, and the fact that similar stratigraphy is found just north of Garbani Hill at the MacDonald locality.

The basal coal in this section, 6.13 m below the base of the Y doublet, is 1.46 m thick and three tephra layers are identified. The first layer is ~0.5-cm-thick, and is located 50 cm from the base of the coal. It is red in color (Munsell color 10 R 3/4), and not well consolidated, but appears to contain euhedral sanidine crystals. A second tephra is found 58 cm from the base of the coal. This layer varies from a few mm to 1 cm thick, it is pink/red in color (10 R 5/4), and also has apparent euhedral crystals. The third tephra (0.5–1 cm thick), is located 64 cm from the base, and is light pink in color (10 R 8/2). The next coal in stratigraphic sequence is located 3.85 m above the basal coal, and 1.98 m below the Y doublet. This coal is 30 cm thick and no tephra layers were identified. Approximately 0.55 cm below the Y doublet, the third coal (43 cm thick) in stratigraphic sequence is exposed. Three to four tephra layers were identified in this unit, starting at 30 cm from the base of the coal. Tephras are ~1 cm thick, pink in color (5 R 8/2), are exposed every 3–5 cm.

Using traditional nomenclature, these coals would be classified as variants of Z coals. However, we believe the basal coal in this section is the HFZ based on thickness, distinctive red tephras, and the fact that the HFZ was mapped at the same stratigraphic level to the North at the MacDonald locality and the Pearl Lake locality (LeCain et al., 2014). Therefore, the other two coals are best classified as part of the Y coal complex. LeCain et al. (2014) conducted a paleomagnetic study to the North of this area at Pearl Lake and identified the C29r/C29n reversal a few meters below what they call a Y coal stringer (a thin, <30 cm thick, coal bed). This study further attempts to correlate their findings at Pearl Lake to Garbani Hill, which contains important vertebrate fauna localities within the Garbani Quarry, by tying their Y coal stringer at Pearl Lake to the Y coal doublet at Garbani Hill. Paleomagnetic sampling was only conducted above the Y coal doublet at Garbani Hill, and all samples were of normal polarity, leading LeCain et al. (2014) to conclude the C29r/C29n reversal must likewise fall below the Y coal doublet. This conclusion is suspect in light of our new stratigraphy at Garbani Hill, as the Pearl Lake section reports the reversal to be below the first coal outcropping above the HFZ. This correlation is further suspect because the distinctive tephras in the Y coal doublet at Garbani Hill, identified and dated by Sprain et al. (2015), are not identified within the Y coal stringer at Pearl Lake.

To mediate this problem, paleomagnetic sampling was collected at Garbani Hill and Pearl Lake in this study. At Garbani Hill, sampling started 2.28 m below the Y coal doublet and continued to the base of the X coal. All samples were collected in siltstone to fine sandstone deposits, except two samples that were collected from the GC12-2 and GC12-3 tephras (described and dated in Sprain et al., 2015). Paleomagnetic sampling was conducted adjacent to the Garbani channel, however our site was specifically chosen so that the section was not affected by channel scouring and was dominated by flood plain deposition.

At Pearl Lake (N47.52343º, W107.0569º), paleomagnetic samples were collected starting 5.92 m above the HFZ coal and extended to 0.47 m above the Y coal stringer. All paleomagnetic samples were collected from siltstone deposits. Sampling was conducted along the same profile as in LeCain et al. (2014). The Y coal stringer at this locality is 22 cm thick and two thin (1–3 mm) light pink (5 R 8/2) tephra layers were identified ~7.5 cm and ~8.5 cm from the base of the coal. Both tephras pinch and swell and in some areas, pinch out completely. Both tephras have apparent euhedral feldspars. The first tephra was collected for $^{40}Ar/^{39}Ar$ analysis (PL14-1). Near the MacDonald locality, a tephra was also collected from the HFZ. The HFZ at this locality can be visually traced to the HFZ below our paleomagnetic section at Pearl Lake. The HFZ coal at the MacDonald locality is 1.2-m-thick and contains 4 tephra deposits. The first tephra is 37 cm from the top of the coal and is 4 mm thick. It is pink/brown (10 R 6/2) in color and has apparent feldspar crystals. The next tephra is 2 cm below the first layer, and is 2-mm-thick and pink-white (10 R 8/2) in color. The third tephra (MD15-1) appears 45 cm from the top of the coal and is 1–2 cm thick (10 R 8/2). This layer is red (10 R 3/4) in color and has euhedral feldspar crystals. We collected this tephra for geochronologic analysis. The highest tephra deposit is 86 cm from the top of the coal, is 1.5 cm thick, and is orange/brown (10 R4/6) in color.

Lerbekmo South (Hell Creek Marina Road)

Roughly 10 km E of Garbani Hill is our Lerbekmo South locality (N47.51602º, W106.9366º). This locality is roughly 1 km south, along County Road 543, from the Lerbekmo (Hell Creek Marina Road) locality, which contains one of the first recognized iridium anomalies, and is the location of the first radioisotopically dated bentonite layer (Folinsbee et al., 1963). The Lerbekmo locality has only one coal outcrop, and it is the Z coal. This Z coal is unique in that it is one of the few Z coals to contain both the Ir-anomaly, identified in an impact clay layer at the base of the coal, and the Lerbekmo and McGuire Creek bentonites (Ickert et al., 2015). These bentonites are characteristic of Z and MCZ coals that define the formational boundary in eastern Garfield County and McCone County, where the Ir-anomaly has yet to be identified.

One kilometer south at our Lerbekmo South locality, the section extends higher and the Z coal, identified by its thickness and unique bentonites, crops out at the base of a section with five additional coals above it. Of these five coals, which can best be described as a part of the Y coal complex, only one coal at the top of the section contains tephra deposits. The microstratigraphy of this coal is described in detail in Ickert et al. (2015). One tephra (HC13-1), located 20 cm from the base of the coal, was collected for dating (reported in this study) and chemical analysis (reported in Ickert et al., 2015). This tephra falls into the Unnamed assorted bentonites category, and therefore cannot be used to correlate this section to other parts of the region (Ickert et al., 2015).

Paleomagnetic sampling was conducted ranging from ~10 m above the Z coal to right above the uppermost Y coal. Samples were collected from siltstone or claystone deposits. While channel deposits can be seen around this locality, sampling was concentrated in a section that was not affected by channel deposition, and was dominated by lithologies representative of flood plain deposits.

Isaac Ranch

The Isaac Ranch locality (N47.66572º, W106.502º) is located roughly 37 km NE of Lerbekmo South. Three coals have been identified at this locality. The lowermost coal has been tentatively identified as the MCZ coal, based on the appearance of a thick bentonite layer similar to the Lerbekmo bentonite described in Ickert et al. (2015). The two upper coals, ~9 m and 11 m above the MCZ, are assigned to the Y coal suite. The first of these coals (~50 cm thick) contains two tephra layers, one of which (IS13-2, 40 cm from base of coal) underwent chemical analysis conducted in Ickert et al. (2015) and falls into the Unnamed assorted bentonite category. Detailed microstratigraphy for this coal can be found in Ickert et al. (2015).

Samples for paleomagnetic analysis were collected between the MCZ and first Y coal. All but one sample were collected from siltstone deposits, and the other sample was collected from a horizontally bedded fine sandstone. All lithologies within the sampling interval are associated with low energy deposition.

Thomas Ranch

Seven km roughly East of Isaac Ranch is the Thomas Ranch locality (N47.66675º, W106.4258º). Three coals crop out here and have been identified as the Null, MCZ, and Y coals. Detailed coal stratigraphy is reported in Ickert et al. (2015). The Null coal (~42 cm thick) was first noted at this locality by Lofgren (1995), and has since been corroborated by field analysis to other Null coal localities (i.e., Bug Creek) based on abundance of amber within the coal and identification of a distinctive fine-grain bentonite (1–2.5 cm thick, located ~35 cm from coal base) which has been collected at this locality (TR13-2) for dating (reported in this study) and chemical analysis (Ickert et al., 2015). Another tephra appears within the Null coal at Thomas Ranch that was collected for chemical analysis, but it is laterally discontinuous, similar to other Null coal outcrops. Due to an abundance of detrital grains within the Null coal tephra, chemical fingerprinting proved difficult and cannot be used to correlate the Null coal tephras.

Roughly 25 m above the Null coal, the MCZ is exposed. At this locality, the MCZ is 80–90 cm thick and contains at least three tephras. The lowest tephra layer (2–4 cm thick), ~16 cm from the top of the coal, was collected for geochronology (TR13-3) and chemical analysis. Pb-isotopic analysis of this tephra reveals that it falls into the McGuire Creek bentonite category, and thus the coal is confirmed to be the MCZ (Ickert et al., 2015). About 10.5 m above the MCZ another coal ~1.3 m thick crops out, and is nominally a Y coal. Three apparent tephra deposits are identified within the coal, and the lowermost tephra (20 cm from the base of the unit) was collected for dating (TR14-1).

Paleomagnetic sampling ranged from 4 m below the Null coal to 2.5 m below the Y coal. A channel sandstone cuts through the section ~8 m below the MCZ, and is ~5 m thick in our section. This unit was unavoidable due to its large lateral extent. The lithologies selected for paleomagnetic sampling were representative of low-energy deposition, including both fine-grained horizontally bedded sandstones, and siltstones.

Sandy Chicken

The Sandy Chicken locality (N47.62519º, W106.3527º) is located roughly 7 km SE of Thomas Ranch. Two coals are exposed in this section, nominally assigned to the Null and MCZ coals based initially upon stratigraphic position. The Null coal at this location is 27 cm thick and contains one tephra horizon (SC14-1) ~2 cm from the base of the coal. This layer is 2-cm-thick, pink in color (5 R 8/2), and is fine-grained. The coal here has notably less amber compared to other Null coal deposits. Roughly 27 m above the Null coal, the MCZ is identified. The MCZ is ~1.2 m thick, however contains three shale partings at 29, 46, and 78 cm from coal base and are roughly 8-, 13-, and 31- cm thick, respectively. A thick 8–10 cm bentonite occurs 3 cm from the base of this coal. This layer is brown-pink (10 R 4/2) in color, is waxy in appearance, and contains altered biotite and fine euhedral sanidine crystals, similar in character to the Lerbekmo bentonite described from other MCZ sections. No other tephra layers are apparent.

Paleomagnetic samples were collected from ~2.3 m below the Null coal, to 70 cm below the MCZ. All sampling sites were within low energy deposits, 6 collected from siltstone deposits and 1 collected from a fine-grained silty-sandstone. No channel deposits outcrop in the paleomagnetic section.

Bug Creek

Thirteen km NE of Sandy Chicken, in McCone County across the Big Dry arm of the Fort Peck Reservoir, is the Bug Creek locality (N47.68017º, W106.2138º). At this locality both the Null coal and the MCZ crop out, as originally mapped by Rigby and Rigby (1990) and are described in detail in Sprain et al. (2015) and Ickert et al. (2015), respectively. Both the MCZ and Null coal have been chemically analyzed (Ickert et al., 2015) and the tephra within the Null coal has been dated (BC1-PR/BC11–1; Sprain et al., 2015). Chemical analysis confirms identification of the MCZ.

Nowhere in the Bug Creek locality do the MCZ and Null coal crop out in a continuously exposed section. Previous magnetostratigraphy completed in the locality shows a section that ranges from the below the Null coal up through the MCZ. Based on our own field observations, this section was likely made by siting across large lateral distances, which becomes uncertain due to broad areas that are covered in vegetation. This type of correlation is unsuitable for a high-resolution geochronologic study, and therefore we collected paleomagnetic samples only from one hill, which ranges from 6.55 m below the Null coal, to 5.47 m above it. This section is composed solely of horizontally deposited flood plain sediments, and all samples were collected from siltstones.

Purgatory Hill

Five km NE of Bug Creek is our Purgatory Hill locality (N47.7033º, W106.1501º). At this locality, at least 5 coals are present. The lowermost coal is less than 1 m thick and contains no tephra deposits. However, if this coal is walked out to the north it thickens and tephras similar in appearance to the Lerbekmo and McGuire Creek bentonites appear, suggesting that this coal is the MCZ. The next four coals were designated by Rigby and Rigby (1990) to the Z, Y, and X coal groups (this designation is also used in Noorbergen et al., 2017). However, based on the similarity in stratigraphic position of these coals to what is found at our sites in Garfield County, specifically at Garbani Hill (where at least three coals are exposed between the mapped Y coal and the HFZ), we consider these coals to be contemporaneous with the Y suite and therefore assign them to such. The first of these is 1.75 m thick, and contains no tephras. Approximately 10 m above this coal another coal, ~75 cm thick, crops out. Within this layer both a shale parting and a tephra are identified. The shale parting is ~8 cm thick, and pink in color (5 R 8/2), and it is within the top 40 cm of the coal. Toward the base of the coal, at around 10 cm, the tephra layer is identified. It is pink/salmon (10 R 7/4) in color, and is up to 2 cm thick. This tephra (PH13-3) was collected for dating. A third coal is exposed roughly 8 m above. This coal is much thinner, only around 20-cm-thick, but within these 20 cm two tephras are exposed. Seven cm from the base of the coal a thin, < 0.5 cm tephra is found. It is pink in color (5 R 8/2) and contains visible euhedral crystals. Eleven cm above this layer, another tephra is identified. The tephra is peach in color (10 R 7/4), ~1.5 cm thick but pinches and swells laterally, and also contains visible euhedral crystals. This tephra (PH13-1) was collected for dating. Roughly 4 m above this section another thin coal crops out. It is only 15-cm-thick, but contains one tephra deposit. This tephra varies from 2 to 7 cm from the top of the coal. It is white-pink (10 R 8/2) in color, has apparent euhedral crystals, and is 1–3 mm thick. Occasionally, a second 1-mm-thick tephra is exposed below. This tephra (PH13-2) was collected for dating.

Paleomagnetic sampling was conducted from ~3 m below the first Y coal to one meter below the top Y coal in our section. Large channel deposits were not identified in our section and paleomagnetic samples were collected from low energy deposits comprising siltstones and fine-grained horizontally laminated sandstones.

McGuire Creek (Lofgren)

Approximately 8.5 km south of Purgatory Hill is our McGuire Creek locality (also known as our Lofgren locality; N47.62985º, W106.1701º). At this locality three coals are identified: the MCZ, a Y coal, and an X coal per Rigby and Rigby (1990). Coal microstratigraphy is described in detail for the MCZ and X coal in Sprain et al. (2015), and for the Y coal in Ickert et al. (2015). Two tephras were dated from this locality in Sprain et al. (2015), one from the MCZ (LG11-1) and another from the X coal (MC11-3). The tephra dated in Sprain et al. (2015) from the MCZ coal, LG11-1, has been designated the type locality for the McGuire Creek bentonite characterized in Ickert et al. (2015). Due to the low precision of the MC11-3 date, and K/Ca ratios during step-heating analysis that are suggestive of plagioclase contamination, more tephra from the X coal was collected for dating. The second tephra layer in the X coal, ~90 cm from the base, was collected (LG13-1). This sample is pink (5 R 8/2), 0.5 cm–2 mm thick, and has apparent euhedral crystals.

Samples for paleomagnetic analysis were collected starting roughly 3.5 m above the MCZ and extending to 10 cm above the X coal. Sampled lithologies ranged from siltstone to fine-sandstone. All sandstone deposits in the section appear fine-grained, and horizontally laminated, with non-erosive features.

Jack's Channel

The Jack's Channel locality is 4 km SW of the McGuire Creek section. At this locality two coals, and one tephra bearing carbonaceous shale, are present. The coals at this locality have been informally named based on elevation (the 2380 and 2440 coals, respectively) and were mapped by D. Lofgren (personal commun.). Around twenty-five meters below the 2380 coal, the MCZ crops out and can be walked out laterally to our Z-line locality presented in Sprain et al. (2015). The tephra-bearing carbonaceous shale layer crops out in between the 2380 and 2440 coals. Each carbonaceous unit contains tephra deposits that have been chemically analyzed

(Ickert et al., 2015). Chemical analysis confirms that these coals fall into the Y/X suite (Ickert et al. 2015). $^{40}Ar/^{39}Ar$ ages for sanidine from tephras JC13-4 (2380), JC13-3 (carb shale), and JC13-2 (2440) are presented here.

Paleomagnetic sampling was conducted at Jack's Channel at three different locations. The first location is by the JC13-1 tephra, described in Ickert et al. (2015), and ranges from 2.65 m below the 2380 coal to 10 cm above it (N47.60567º, W106.2105º). The 2380 coal can be visually traced to our second sampling locality (N47.6047º, W106.2086º). This correlation is confirmed by Pb-isotopic analysis showing that Pb-isotopes from the JC13-1 tephra and JC13-4 tephra (collected from the same horizon within the 2380 coal at these two localities) are identical in composition. Sampling here starts 1 m above the 2380 and continues to 25 cm below the 2440. Another sampling locality was chosen in order to confirm previous magnetostratigraphic results (N47.60596º, W106.20665º). This site is roughly 0.5 km away and contains only the 2380 coal, identified by unique capping unit and thin tephra layer exposed near the top of the coal. Paleomagnetic sample collection was focused around the 2380 coal and extends 2 m above and 2 m below the coal. Sampled lithologies range from silty fine-grained sandstone to siltstone. No channel deposits are apparent in any of the sampling sections, however Jack's Channel, a 10-m thick channel deposit, crops out ~15 m below the 2380.

FOSSIL LOCALITIES

Puercan NALMA and base Puercan 1 interval zone

Following Lofgren et al. (2004) the bases of these biochronological units are defined by the First Appearance Datum (FAD) of the archaic ungulate *Protungulatum*. Initially the Bug Creek Anthills, Bug Creek West, and Harbicht Hill local faunas, which contain *Protungulatum,* were thought to be of Cretaceous age (Sloan and Van Valen, 1965). Subsequently it has been shown that these fossiliferous deposits contain time averaged assemblages of latest Cretaceous (Lancian NALMA) and Puercan fossils (Lofgren 1995). In Garfield and McCone counties occurrences of *Protungulatum* in Cretaceous strata have not been confirmed.

Published University of California Museum of Paleontology (UCMP) fossil localities: Garfield County: V72201, V72210-11, V73083, V73096, V74110-11, V74122-28, V75190-91, V75193-95, V77087, V77128-29, and V96268. McCone County: RV8137, V65122, V70199-205, V70209, V71203, V73100, V82008, V82013-14, V83052, V84151, V84154, V84190, V84193-4, V85064, V85085-86, V86031, V86093, V87028-31, V87033-38, V87040, V87050-52, V87066, V87070-74, V87077-78, V87082-84, V87086, V87088, V87091, V87094-95, V87098, V87101, V87114-15, V87114, V87117, V87119, V87123-24, V87151-53, V88036-38, V88042, V90086, V90088-90, V91016-18, V91024, and V91078

Puercan 2 Interval Zone

Following Lofgren et al. (2004) the base of this interval zone is defined by the FAD of the archaic ungulate *Ectoconus*. Local faunas attributable to this interval zone in Garfield and McCone counties have not yet been discovered and described. The unfossiliferous gap in Garfield County sections, which might include part of the Pu1 interval zone, appears to be on the order of 250 ka. This estimate is based on an interpolated age for the top of the channel that contains the McKeever 1 locality, which is the youngest bound for a Pu1 local fauna, 65.923 ±

0.021/0.038 Ma (calculated based on the age of the MK12-1 Y coal, which crops out 5.5 m above the channel, and the pooled age of the IrZ coal, which the channel just barely cuts into), and a tephra in the stratigraphically higher Y Coal (GC12-2; Sprain et al., 2015) cut by the Garbani Channel, 65.677 ± 0.041/0.059 Ma (Fig. 12). Other channels containing Pu1 local faunas in Garfield County have younger bounds that are only slightly older than the McKeever 1 locality, with ages of ~66.036 Ma (Hell Hollow Channel, cuts out the IrZ Coal with a channel capping 11.9 m below the HFZ) and ~66.010 (Carrie Padgett Channel, cuts out the IrZ Coal with a channel capping 7 m below the HFZ; Fig. 12).

Peppe et al. (2013) reported a preliminary radioisotopic age determination of an ash within in Nacimiento Formation in the San Juan Basin related to the Pu2 interval zone. When recalculated using the standards adopted here the age of this ash is 65.80 ± 0.01 Ma. They suggest the Pu2 interval zone was only ~150 ka long. Pu2 interval zone faunas in the San Juan Basin are found in strata deposited during C29n.

Puercan 3 Interval Zone

Following Lofgren et al. (2004) the base of this interval zone is defined by the FAD of the multituberculate *Taeniolabis taoensis*. In Garfield County, Pu3 fossil localities occur in the Garbani Channel. *T. taoensis* has not been found at any of these localities. Simmons (1987) analyzed isolated teeth of *Taeniolabis* from Garbani Channel localities and identified them as *T. lamberti* and *T.* sp. Initially, local faunas found in the Garbani Channel were described as being of unresolved Pu2/Pu3 age (e.g., Clemens, 2002). Subsequently, the definition of the base of the Pu3 interval zone recognized in our study area has been relaxed to the FAD of any species of *Taeniolabis* (e.g., Clemens, 2013).

In Garfield County, in the area of the headwaters of Cottonwood Creek, a small tributary of Hell Creek, Archibald (1982) described two geological sections, S13 and S14. In section S13, 7 m of sedimentary rock separates the base of the W coal and the top of the Garbani Channel. In this section, the base of the Garbani Channel cuts a Y coal correlated with the Y coal at Garbani Hill, which includes a tephra with an age of 65.677 ± 0.041/0.059 Ma (GC12-2; Sprain et al., 2015). Using the average sedimentation rate of 8.3 ± 4.2 cm/ka (calculated between the W and V coals at Biscuit Butte) to estimate the duration of accumulation of sediments between the top of the Garbani Channel and the base of the W coal, the age of the top of the Garbani Channel is estimated to be 65.202 Ma (Fig. 12). Using these values, the interval of cutting and filling of the Garbani Channel in this area is estimated to have been 475 ka. The formation of the Garbani Channel occurred during chron C29n.

The only Pu3 local fauna discovered in McCone County so far is the Purgatory Hill local fauna (Van Valen and Sloan, 1965, Van Valen 1978). *Taeniolabis taoensis* has been reported as a member of this local fauna (Van Valen and Sloan, 1965). The age of the youngest tephra underlying the channel filling yielding this local fauna is 65.540 ± 0.041/0.059 Ma (PH13-2, this study). Both the sediments below the channel and a thin veneer of sediments capping it were deposited during chron C29n (Fig. 12).

Peppe et al. (2013) presented a preliminary radioisotopic age determination of a probable volcanic ash coincident with the first occurrence of Pu3 mammals in the San Juan Basin. When recalculated using the standards adopted here the age of this probable ash is 65.64 ± 0.04 Ma. Both the Pu3 local faunas of the San Juan Basin and northeastern Montana are found in strata deposited in C29n.

Published University of California Museum of Paleontology (UCMP) fossil localities: Garfield County: V72125-37, V72201, V73080, V73082, V73096, V74119-20, V74122-28, V75190-91, V75193-95, V75229-30, V80116-18, V81028-30, and V99438-39. McCone County: V71202.

Torrejonian NALMA and base Torrejonian 1 Interval Zone

Although not formally designated as type or reference sections, historically the concepts of the Puercan and Torrejonian NALMAs were developed on the basis of local faunas in the San Juan Basin, New Mexico. In this area, all Pu3 local faunas occur in strata deposited in magnetostratigraphic chron C29n. There and in the North Horn Formation, Utah, the oldest occurrences of early Torrejonian (To1) local faunas are in strata deposited in the latest part of chron C28n and the early part of C27r (Lofgren et al., 2004 and references cited).

Following Lofgren et al. (2004), the bases of the Torrejonian NALMA and Torrejonian 1 interval zone (To1) are defined on the FAD of the archaic ungulate *Periptychus carinidens.* Again, the index taxon for this NALMA and interval zone has not been found in northeastern Montana. In Garfield County the primitive primate *Paromomys* and other taxa making their earliest documented appearances in the Torrejonian elsewhere occur in the Farrand Channel and approximately contemporaneous Horsethief Canyon local faunas. Their presence was the basis for referring these local faunas to Torrejonian 1 (Clemens and Wilson, 2009).

The Farrand Channel as well as the chron C29n/C28r boundary are bracketed by the W and V coals (LeCain et al. 2014, Sprain et al. 2015). Tephras in the W and V coals have yielded radiometric ages of 65.118 ± 0.024/0.048 Ma (SS11-3; Sprain et al., 2015) and 65.041 ± 0.023/0.048 Ma (BB12-1; Sprain et al., 2015) respectively. Sprain et al. (2015) suggested the age of the chron C29n/C28 boundary is 65.075 ± 0.017/0.035 Ma (Fig. 12). High-resolution analysis of the relationship of the strata capping the Farrand Channel to the overlying V coal and the C29n/C28r boundary is a goal for future work.

Published University of California Museum of Paleontology (UCMP) fossil localities: Garfield County: V73094-5, V75192, and V76169-73.

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Supplementary Table 1. Stratigraphic Sections

McKeever Ranch Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
0.45	coal	clay rich, with layers of fissile shale	black	IrZ, MK13-3
0.75	siltstone		grey/brown	MK-1
0.1	shale	fissile	purple	
0.85	siltstone	ferricrete banding	grey/tan	
0.45	siltstone		grey/tan	
0.2	sandstone	thinly horizontally bedded	tan/yellow	
0.4	siltstone	rhythmic orange banding	tan	
0.9	siltstone		grey/brown	
0.75	shale	organic rich	grey/brown	
0.9	shale	organic rich	grey/brown	
0.3	carb shale		purple	
0.4	sandstone	sandstone lense	tan	
0.2	siltstone		tan	
0.25	sandstone		tan	
1.2	siltstone	rhythmic orange banding with sandstone lenses	taupe	
0.15	ferricrete	purple shale banding	purple	
0.5	siltstone	ferricrete banding	grey/tan	
0.8	siltstone	ferricrete blocks	grey/brown	
0.6	siltstone		dark brown	
0.35	carb shale	carbon-rich, fissile	purple	
0.05	coal	stringer	black	
0.6	siltstone		tan	
1.55	siltstone		grey/green	MK-2
0.2	carb shale	carbon-rich, fissile with some coal	purple	
1.95	siltstone	thin shale lenses, organic rich	grey/brown	MK-3 and MK-3.5
1	coal	~ 8 tephras	black	MK13-1
2	sandstone	some silty/ferric lenses, some cross-bedding, incision into bed below, coal stringer	tan/yellow	MK-4
0.3	sandstone	ferric sandstone blocks	orange/tan	
2.2	sandstone		tan/yellow	
0.25	carb shale	carbon-rich, fissile	purple	
0.2	coal	tephra, low grade	black	
0.1	carb shale	very fissile, C-rich	purple	

0.1	shale		orange	
2.2	sandstone	covered with vegetation	tan/yellow	
0.8	carb shale		dark brown	
1.4	sandstone	cross-bedded blocks	tan/yellow	

McKeever Ranch A Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
1.25	siltstone		grey	MKA-1
0.1	coal	stringer	black	
0.8	siltstone		gray-green	
1.05	siltstone		grey	
0.6	coal	coal with carb shale interbeds	black	MKA-2
1.7	siltstone	interbedded sand and silt	tan	

Hell Hollow Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
0.1	coal		black	IrZ
1.85	siltstone		whitish	
0.1	carb shale		black	
0.68	siltstone		grey-reddish	
2	shale		light grey	
1.02	siltstone		grey	
0.1	carb shale		black	
6.35	siltstone		grey-brown	
0.1	carb shale		black	
0.78	siltstone		grey-brown	
1.94	shale		grey	
2.5	coal		black	HFZ
4	shale	ferricrete banding	grey-brown	HH-1
0.6	siltstone	popcorn texture	grey	HH-2
0.75	shale		grey	
0.5	coal	1 tephra	black/purple	HH13-1
4.35	siltstone	ferricrete banding	taupe	HH-3, 15HH1
0.35	shale	unconsolidated	light grey	HH-4, 15HH2
2.25	siltstone	some ferricrete banding	grey/taupe	HH-5, 15HH3
0.9	carb shale	fissile and foliated	purple	
0.75	coal	low grade, 2 tephras	black	HH13-2
2	sandstone		yellow/tan	

Garbani Hill Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
1.46	coal		black	HFZ
2.31	covered/siltstone			

1.54	siltstone	some Fe-banding	grey/tan	15GB-1A
0.3	coal	no tephra	black	Y coal
1	covered			tan/silty mudstone exposed in areas but mostly covered
0.43	coal	Tephra	black	Y coal
0.55	sandy siltstone		grey/tan	slightly covered
0.5	coal		black	GC12-3, lower Y doublet
0.25	carb shale			
0.86	coal		grey/tan	15GB-1, GC12-2, Upper Garbani Y coal
2.27	siltstone	not well consolidated	yellow	
0.95	siltstone	laminated near base	brown/grey	15GB-2
4.35	siltstone	partially covered	tan	15GB-3

Pearl Lake Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
1	coal		black	HFZ
6.25	siltstone	ferricrete layering and some Fe-banding	tan/grey	15PL-1A
0.04	ferricrete		purple	
2.16	siltstone	Fe-banding and one ferricrete layer	grey/taupe	15PL-1
0.63	carb shale	Starts as coal, grades to carb shale, then coal at top	black	
0.9	siltstone		grey	
0.35	shale	laminated, friable	grey	
0.32	coal		black	
1.32	covered	Some sandstone outcrops, some siltstone, but too covered to make units		
1.49	siltstone	Fe-banding	tan	15PL-2
0.4	coal		black	PL14-1
0.5	siltstone	ferricrete and Fe-banding	tan	

Lerbekmo South Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
1	coal	3 tephras, thick middle tephra	black	MCZ
4.75	siltstone	ferricrete banding	taupe	

0.3	coal	vitreous, no tephra	black	
0.55	siltstone	ferricrete banding-fissile	taupe	
0.2	carb shale		blackpurp	
1.2	siltstone	ferricrete banding-fissile	taupe	
1.5	siltstone		grey/brown	
0.25	coal	potential tephra	black	
1.4	siltstone	ferricrete banding	dark grey	
0.5	coal		black	
2.4	sandstone	ferricrete banding	tan	HC-1
1.65	siltstone	ranges from sandy silt to silt	grey/green	
0.9	siltstone		dark purple	
0.04	ferricrete		purple	
2.75	siltstone	alternating color bands	grey/brown	HC-2
0.16	coal	stringer, tephra	black	
0.08	siltstone	alternating color bands	grey/brown	HC-3
0.06	coal	stringer	black	
1	siltstone	alternating color bands	grey/brown	
0.35	siltstone	interbedded siltstone and claystone	brown	HC-4, 15HC1
0.4	coal	4 tephras	black	HC13-1
0.55	shale	fissile	red	14HC2
0.3	coal	coal stringer	black	
0.85	siltstone		tan	
0.45	shale		purple	

Isaac Ranch Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
1	coal		black	MCZ
0.35	mudstone		grey/green	
0.7	sandstone	massive bedding, one ferricrete band	beige	IS-1
0.5	siltstone		taupe	
0.5	sandstone		grey	
1.15	siltstone		grey/brown	IS-2
0.96	siltstone	ferricrete banding	taupe/grey	
1.78	siltstone	grey ferricrete bands	taupe	IS-3
0.08	mudstone		purple/black	
3	siltstone	ferricrete banding	taupe	IS-4

0.5	coal	tephra	black	Y coal
0.5	mudstone	fissile	tan/taupe	
0.22	coal	no tephra	black	Y coal
0.95	sandstone	unconsolidated	taupe	

Thomas Ranch Stratigraphic Section

Thickness	Lithology	Color	Features	Notes
0.83	sandstone	tan	Horizontal bands of Fe	TRA-1, 15TRA1
0.6	siltstone	grey	Fe-banding, popcorn weathering	
0.4	carb shale	grey-purple	laminated, popcorn weathering	
0.77	sandstone	tan/yellow		TRA-2
0.73	shale	grey/purple	Laminated	
0.43	sandstone	tan/yellow	Fe-staining	15TRA2
0.31	siltstone	grey	Some Fe-staining	TRA-3
0.44	coal	black		Null coal
0.3	siltstone	tan	popcorn weathering	
2.37	siltstone	tan	Fe-banding	TRA-4, 14TR-1
0.88	siltstone	grey/purple		
2.24	sandstone	tan		
2.4	sandstone	grey	Red ferricrete horizons	14TR-2, 14TR-3
2.35	siltstone	grey		
5.05	sandstone	grey	Red ferricrete horizons	
4.8	siltstone	grey/green		
1.58	siltstone	grey		14TR-4
2.06	siltstone	tan		14TR-5
0.57	coal	black		TR14-2,3 (MCZ)
3.72	sandstone	grey/tan		14TR-6
1.03	siltstone	dark grey		
2.47	sandstone	tan		
0.75	sandstone	light tan		14TR-7
2.5	siltstone	dark grey		
1.3	coal	coal		TR14-1

Sandy Chicken Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
1.16	sandstone	Fe-staining, some small nodules	tan	SC-1
1.1	siltstone	Waxy, not laminated	grey	SC-2
0.3	coal		black	Null coal
0.05	carb shale		pink	
1.4	siltstone		grey/taupe	SC-3, SC-4
0.65	covered		green	

6.66	siltstone	alternating bands of taupe and grey/green, varies between siltstone and claystone, some purple ferricrete, popcorn weathering	taupe/grey	SCA-1, SCA-2
1.48	sandstone		tan/taupe	
0.65	siltstone	popcorn weathering, ferricrete at base	grey-taupe	
0.57	siltstone	slight popcorn weathering	tan/taupe	
0.41	carb shale	siltstone interbeds	grey/purple	
0.6	siltstone		grey/green	
1.7	sandstone		tan/taupe	
0.23	ferricrete		red/purple	
4.87	sandstone	some ferricrete horizons, covered at top	tan/taupe	
1.43	siltstone		grey/green	
2.7	sandstone		tan/taupe	
0.42	coal	no tephras	black	
2.77	sandstone	doesn't appear laminated, some parallel lamination	tan	
0.7	siltstone	popcorn weathering	tan/pink	SCA-3
1.21	coal	3 shale partings, bentonite 3 cm from base	black	MCZ

Bug Creek Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
0.55	siltstone	staining	tan	15BC1
0.25	mudstone		dark brown/purple	
0.7	siltstone		tan	BC-1
1	mudstone	popcorn weathering	tan/grey	
0.2	carb shale		purple	
1	siltstone	popcorn weathering	grey/purple	
0.1	carb shale		light pink	
1.4	siltstone	slight popcorn weathering	grey/taupe	BC-2
0.3	carb shale		Purple	
1.05	siltstone	popcorn weathering	grey/taupe	14BC-2A

0.33	coal		black	Null Coal, BC11-1/BC-1PR
1.35	siltstone	Fe-concretions	tan/grey	14BC-2B
0.05	filler			
0.77	siltstone	pink carb shale at base and at top	dark purple-grey	
0.05	filler			
0.7	siltstone	Fe-staining in fractures	tan/taupe	BC-3
0.05	filler			
1.32	siltstone	Fe-staining in fractures	grey/taupe	
0.3	sandstone		grey	
0.23	siltstone	Fe-staining in fractures	taupe	BC-4
0.8	siltstone	dark red Fe-concretions	tan	

Purgatory Hill Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
0.25	mudstone		brown-red	
0.35	siltstone		taupe	
0.3	mudstone		grey/black	
2.25	siltstone	rhythmic ferricrete banding and grey banding	taupe	
0.6	sandstone	no banding	beige	15PH-1
2.45	siltstone		taupe	
1.75	coal		black	
3.35	siltstone		taupe	
2.5	sandstone	Some Fe-banding, large indurated blocks	taupe	
2	sandstone	horizontally bedded, Fe-lamination	grey/taupe	15PH-2
0.47	mudstone		pink	
1.35	siltstone	Fe-banding	taupe	
0.75	coal		black	PH13-3
4.45	siltstone	rhythmic ferricrete banding, 6 cm thick carb shale 1.5 m from top	tan	
0.65	siltstone		grey	15PH3
2.93	siltstone		grey	15PH4
0.2	coal		black	PH13-1
4.32	siltstone	ferrricrete bands	light tan	15PH-5, 16PH-2
0.2	coal		black	PH13-2
5	siltstone		tan/light grey	

Lofgren Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
0.6	coal		black	MCZ, MC11-3
3.42	siltstone	ferricrete banding	tan	
1.73	sandstone		grey/tan	LG-1 at base, medium grained
1.55	siltstone	Fe-stained with few ferricrete horizons	tan	LG-2 near top
0.75	siltstone	weathers grey	pink/tan	
0.85	coal		black	LG14-2
1.45	siltstone		tan	
1	carb shale		pink/purple	locally grades to coal
1.75	siltstone	ferricrete banding	tan	coarse grained
6.1	sandstone	orange and purple ferricrete banding	grey	LG-3 at base, LG-4 in middle, LG-5 at top,med/fine grained, 15LG-1 above LG-5
0.35	coal	thin tephra	black	
0.63	carb shale	white-light purple silt base, dark purple shale top	purple	
1.66	siltstone	Fe-banding	tan/yellow	LG-6 at base
1.05	sandstone		grey	LG-7 at base, 15LG-2 between LG-7 and LG-8
0.52	siltstone		grey/pink	LG-8 at base,
1.97	coal	2 tephras, carb shale in middle	black	X coal, LG13-1, LG11-1
0.5	sandstone		yellow	15LG-3

Jack's Channel Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
1	coal		black	
2.74	siltstone	orange concretion bands, purple ferricrete at top, variegated	grey-taupe	
8.54	sandstone	fluting common, large indurated blocks, x-bedded		
2.23	siltstone	indurated blocks at top, horizontal bedding	grey/green	
3.3	siltstone	x-bedding at base, variegated, Fe-staining, popcorn weathering	grey/green	

1.14	carb shale	laminated, ferricrete at top	dark purple/pink	
1.62	siltstone	layers of Fe-rich concretions (orange)	black	
1.6	siltstone	yellow tan at base, grey at top, no popcorn weathering	grey/tan/yellow	
0.85	sandstone	dark purple, white staining on top	grey	
0.47	carb shale	top 5 cm grade into coal	purple	
1.53	siltstone	ferricrete banding, not laminated, grades into shale	tan	14JC-1, 14JC-2
0.23	shale		grey-taupe	
0.42	shale		grey	
0.55	coal	tephra	black	2380 coal, JC13-4
2	sandstone	occacional ferricrete banding, horizontally bedded	taupe	JC-1
0.5	siltstone	clay-rich	grey	JC-2
0.2	carb shale	organic rich, contains tephra	purple	JC13-3
0.85	sandstone	horizontally bedded, few Fe-rich sections	tan-red	
0.1	coal	stringer	black	
2.05	siltstone	Fe-rich patches and nodules	grey-taupe	JC-3
1.05	coal	3 tephras	black	2440 coal, JC13-1

Jack's Channel Stratigraphic Section

Thickness	Lithology	Features	Color	Notes
0.7	sandstone	ferricrete, horizontal bedding	tan	
0.97	sandstone	some Fe-banding	grey/tan	15JC-1
0.55	mudstone		grey	15JC-2
0.4	coal		black	2380 coal
1.28	sandstone	Fe-banding	tan/grey	15JC-3
0.11	carb shale	No tephras	purple	
0.74	siltstone	Some ferricrete and Fe-banding	tan/grey	15JC-4 measured at top

Table DR1. Summary of run-specific parameters

			Mass Discrimination		Background values									
Run	Lab	MS	D	±D	^{40}Ar	±σ	^{39}Ar	±σ	^{38}Ar	±σ	^{37}Ar	±σ	^{36}Ar	±σ
1a	BGC	1	1.0127	0.0011	0.010537	0.000830	0.000287	0.000110	0.000021	0.000014	0.000039	0.000008	0.000046	0.000009
1b	BGC	1	1.0127	0.0011	0.012404	0.000900	0.000232	0.000110	0.000022	0.000016	0.000040	0.000008	0.000053	0.000011
2	BGC	1	1.0128	0.0013	0.008490	0.001800	0.000135	0.000081	0.000017	0.000011	0.000035	0.000008	0.000036	0.000013
3a	BGC	1	1.0130	0.0009	0.005970	0.002800	0.000096	0.000092	0.000023	0.000013	0.000037	0.000009	0.000033	0.000014
3b	BGC	1	1.0130	0.0009	0.009670	0.001700	0.000432	0.000150	0.000020	0.000013	0.000037	0.000010	0.000045	0.000011
3c	BGC	1	1.0130	0.0009	0.007890	0.001200	0.000163	0.000096	0.000019	0.000010	0.000035	0.000009	0.000041	0.000010
4a	BGC	1	1.0123	0.0008	0.010710	0.002100	0.000532	0.000270	0.000029	0.000010	0.000037	0.000008	0.000052	0.000013
4b	BGC	1	1.0123	0.0008	0.006574	0.000730	0.000098	0.000075	0.000014	0.000009	0.000039	0.000008	0.000034	0.000008
5a	BGC	1	1.0125	0.0012	0.004286	0.000420	0.000082	0.000056	0.000015	0.000010	0.000038	0.000006	0.000027	0.000009
5b	BGC	1	1.0125	0.0012	0.005160	0.001200	0.000080	0.000047	0.000014	0.000010	0.000037	0.000007	0.000030	0.000010
5c	BGC	1	1.0125	0.0012	0.004260	0.000890	0.000137	0.000200	0.000016	0.000012	0.000036	0.000009	0.000027	0.000009
5d	BGC	1	1.0125	0.0012	0.004921	0.000240	0.000078	0.000054	0.000016	0.000009	0.000038	0.000007	0.000026	0.000008
6a	BGC	1	1.0124	0.0012	0.005786	0.000680	-0.000170	0.000130	0.000015	0.000010	0.000038	0.000008	0.000034	0.000010
6b	BGC	1	1.0124	0.0012	0.004464	0.000540	-0.000279	0.000150	0.000020	0.000021	0.000032	0.000007	0.000023	0.000012
7a	BGC	1	1.0143	0.0013	0.007100	0.002100	0.000097	0.000058	0.000016	0.000013	0.000044	0.000009	0.000040	0.000013
7b	BGC	1	1.0143	0.0013	0.006063	0.000760	0.000103	0.000065	0.000022	0.000012	0.000043	0.000011	0.000039	0.000012
8a	BGC	1	1.0144	0.0014	0.006660	0.000970	0.000105	0.000049	0.000031	0.000012	0.000047	0.000013	0.000041	0.000015
8b	BGC	1	1.0144	0.0014	0.009870	0.002100	0.000499	0.000310	0.000030	0.000019	0.000046	0.000014	0.000048	0.000017
9a	BGC	1	1.0103	0.0013	0.023193	0.000740	0.000425	0.000140	0.000028	0.000019	0.000029	0.000009	0.000090	0.000011
9b	BGC	1	1.0103	0.0013	0.025440	0.001800	0.000393	0.000150	0.000037	0.000023	0.000032	0.000017	0.000105	0.000018
10a	BGC	1	1.0117	0.0008	0.015340	0.001700	0.000811	0.000290	0.000027	0.000016	0.000024	0.000008	0.000053	0.000008
10b	BGC	1	1.0117	0.0008	0.013393	0.000590	0.000417	0.000160	0.000022	0.000014	0.000022	0.000006	0.000048	0.000012
11a	BGC	1	1.0120	0.0007	0.008465	0.000660	0.000089	0.000064	0.000019	0.000014	0.000035	0.000017	0.000031	0.000015
11b	BGC	1	1.0120	0.0007	0.008794	0.000420	0.000082	0.000052	0.000023	0.000016	0.000036	0.000015	0.000034	0.000010
11c	BGC	1	1.0120	0.0007	0.007774	0.000540	0.000081	0.000059	0.000021	0.000012	0.000024	0.000012	0.000028	0.000014
12a	BGC	1	1.0119	0.0011	0.008411	0.000370	0.000135	0.000085	0.000012	0.000010	0.000027	0.000012	0.000030	0.000014
12b	BGC	1	1.0119	0.0011	0.007667	0.000470	0.000096	0.000065	0.000018	0.000013	0.000028	0.000011	0.000029	0.000010
13	BGC	1	1.0113	0.0010	0.008167	0.000730	0.000098	0.000066	0.000018	0.000012	0.000026	0.000010	0.000027	0.000010
14a	BGC	1	1.0121	0.0006	0.007943	0.000770	0.000112	0.000071	0.000016	0.000009	0.000024	0.000006	0.000026	0.000014
14b	BGC	1	1.0121	0.0006	0.008861	0.000950	0.000095	0.000051	0.000016	0.000010	0.000026	0.000011	0.000035	0.000011
14c	BGC	1	1.0121	0.0006	0.008794	0.000420	0.000082	0.000052	0.000023	0.000016	0.000036	0.000015	0.000034	0.000010
15a	BGC	1	1.0122	0.0010	0.006150	0.001100	0.000102	0.000096	0.000015	0.000013	0.000023	0.000012	0.000022	0.000008
15b	BGC	1	1.0122	0.0010	0.006067	0.000330	0.000112	0.000064	0.000018	0.000014	0.000021	0.000008	0.000023	0.000010
16a	BGC	1	1.0107	0.0011	0.009980	0.001100	0.000411	0.000230	0.000020	0.000013	0.000026	0.000008	0.000036	0.000010
16b	BGC	1	1.0107	0.0011	0.008341	0.000970	0.000192	0.000091	0.000021	0.000012	0.000021	0.000008	0.000030	0.000010
17	BGC	1	1.0113	0.0014	0.007530	0.001300	0.000226	0.000160	0.000017	0.000012	0.000023	0.000007	0.000026	0.000010
18a	BGC	1	1.0113	0.0008	0.005092	0.000520	0.000048	0.000029	0.000013	0.000007	0.000020	0.000008	0.000019	0.000009
18b	BGC	1	1.0113	0.0008	0.009020	0.001900	0.000172	0.000130	0.000018	0.000013	0.000022	0.000008	0.000029	0.000013
18c	BGC	1	1.0113	0.0008	0.007500	0.000960	0.000119	0.000066	0.000015	0.000012	0.000020	0.000006	0.000025	0.000007
19a	BGC	1	1.0110	0.0008	0.011540	0.001200	0.000739	0.000240	0.000020	0.000014	0.000028	0.000007	0.000042	0.000011
19b	BGC	1	1.0110	0.0008	0.007795	0.000900	0.000186	0.000087	0.000018	0.000010	0.000021	0.000007	0.000026	0.000011
20	BGC	1	1.0108	0.0014	0.007806	0.000720	0.000212	0.000087	0.000018	0.000011	0.000021	0.000008	0.000026	0.000011

Notes: Run refers to time periods over which noted parameters apply; MS refers to mass spectrometer (1= MAP 215C, 2= MAP 215-50); D refers to mass discrimination per dalton (based on a power law) derived from air pipettes normalized to the data of Lee et al. (2006); Background values are given in the same units i.e., nA and reflect the arithmetic mean and standard deviation.