THE EVOLUTION OF OCCLUSAL ENAMEL COMPLEXITY IN MIDDLE MIOCENE TO RECENT EQUIDS (MAMMALIA: PERISSODACTYLA) OF NORTH AMERICA

by

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THESIS ABSTRACT

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Master of Science

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Title: The Evolution of Occlusal Enamel Complexity in Middle Miocene to Recent Equids (Mammalia: Perissodactyla) of North America

Four groups of equids, "Anchitheriinae," Merychippine-grade Equinae, Hipparionini, and Equini, coexisted in the middle Miocene, and only the Equini remains after 16 million years of evolution and extinction. Each group is distinct in its occlusal enamel pattern. These patterns have been compared qualitatively but rarely quantitatively. The processes controlling the evolution of these occlusal patterns have not been thoroughly investigated with respect to phylogeny, tooth position, and climate through geologic time. I investigated two methods of quantitative analysis, Occlusal Enamel Index for shape and fractal dimensionality for complexity. I used analyses of variance and an analysis of co-variance to test hypotheses of process. Results suggest that enamel shape was controlled by phylogeny, tooth position, and climate. The lower taxonomic levels are shown to have a strong effect on complexity, suggesting behavior is driving complexity rather than overarching phylogenetic constraint.

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CHAPTER I

INTRODUCTION

Horses have long been used as a primary example of evolution through adaptation to a changing environment (Osborn 1918, Simpson 1951, Franzen 2010). Horse adaptations to changing climates, specifically through dental evolution in response to an increasingly abrasive diet (grass phytoliths and grit from a drier environment), have been qualitatively analyzed, but rarely investigated quantitatively (Quinn 1955, MacFadden 1998, Famoso and Pagnac 2011, Famoso et al. *in revision*). Previous work on equid adaptation to an abrasive diet focused on changes in hypsodonty and enamel microstructure (Pfretzschner 1993, Strömberg 2006, Damuth and Janis 2011). Little work has been directed at the amount of occlusal (chewing surface) enamel and the complexity of its structure as adaptations to an abrasive diet (Rensberger et al. 1984, Famoso et al. *in revision*). An assessment of the evolution of enamel complexity in North American equids using Occlusal Enamel Index and Fractal Dimensionality has yet to be performed (Famoso et al. *in revision*). Evolution of horse teeth through an increase in hypsodonty (quantified by the ratio of mesostyle crown height and occlusal length [Forsten 1975, MacFadden 1984, 1988, Hulbert 1988a, b,] Unger 2010) has been documented in the Oligocene through Pleistocene fossil record, primarily for North America. Increased tooth height provides more resistive enamel over an animal's lifetime. These changes have been interpreted as an adaptation to feeding in open habitats as cooling and drying climates changed woodlands to grasslands, requiring horses to adapt to increased rates of tooth wear created by environmental grit and the phytoliths of grasses (Simpson 1951, Strömberg 2006, Damuth and Janis 2011). Pfretzschner (1993) investigated changes in equid enamel microstructure, concluding that adaptation to increased tooth wear was in place by the rise of "*Merychippus*" at about 19 Ma. The prisms and interprismatic matrix that make up enamel at the cellular level stiffen enamel and the arrangement of these prisms strengthens it with respect to mechanical stress patterns from grinding against opposing teeth and food (Pfretzschner 1993).

Evolutionary Context

Analyses of evolutionary adaptations must be investigated within the context of phylogeny (Felsenstein 1985). The current consensus on equid phylogeny includes three subfamilies, "Hyracotheriinae," "Anchitheriinae," and Equinae (MacFadden 1992, 1998, 2005) (Fig. 1). Within Equinae, there are two sub-clades, the tribes Hipparionini and Equini, and a basal grade mostly assigned to "*Merychippus*." This genus has long been considered a paraphyletic taxon, maintained through convenience to include all basal equines that do not possess apomorphies of either Equini or Hipparionini. Typical "*Merychippus*" have an upper dentition that maintains the plesiomorphic features of the basal "Anchitheriinae," a paraphyletic grade below Equinae (Fig. 2), but also share characters with derived Equinae (MacFadden and Hulbert 1988, Hulbert and MacFadden 1991, MacFadden 1998). Hipparionini and Equini have distinct tooth morphologies as well (Fig. 2). Members of the tribe Hipparionini are hypsodont, but relatively lower crowned and have more complicated enamel borders than their equin counterparts (Quinn 1955, MacFadden 1992, 1998). The two tribes of Miocene horses, Hipparionini and Equini, are diagnosed on the basis of differences of the structures formed by the folding of enamel on the occlusal surface of their teeth (Quinn 1955, MacFadden 1992, 1998, 2005, Famoso and Pagnac 2011,). The shape of the occlusal pattern was shown to be an important character in equin and hipparionin phylogeny (MacFadden 1994, 1998, Prado and Alberdi 1996). This leads me to question if complexity of occlusal enamel evolved differently because of phylogenetic constraint and/or climactic pressures between Equini and Hipparionini.

Because species are phylogenetically related to differing degrees, they cannot be considered as independent for statistical analysis (Felsenstein 1984). Felsenstein (1984) proposed using independent contrasts to compensate for the phylogenetic relationships. Ideally, a molecular tree-based method would be used for testing hypotheses of variations as a result of phylogeny, but current methods require known branch lengths and cannot yet be used with fossil-based morphological phylogenies (Stack et al. 2011, Cayuela et al. 2012). Nested variables in a multi-way analysis of variance (ANOVA) are an attempt at modeling phylogeny using the hierarchical taxonomic system as a proxy for phylogeney (Famoso et al. *in revision*). Using these nested variables in an ANOVA is not ideal for phylogeny, because it does not completely take the topology of a phylogenetic tree into account, but it is a coarse approximation.

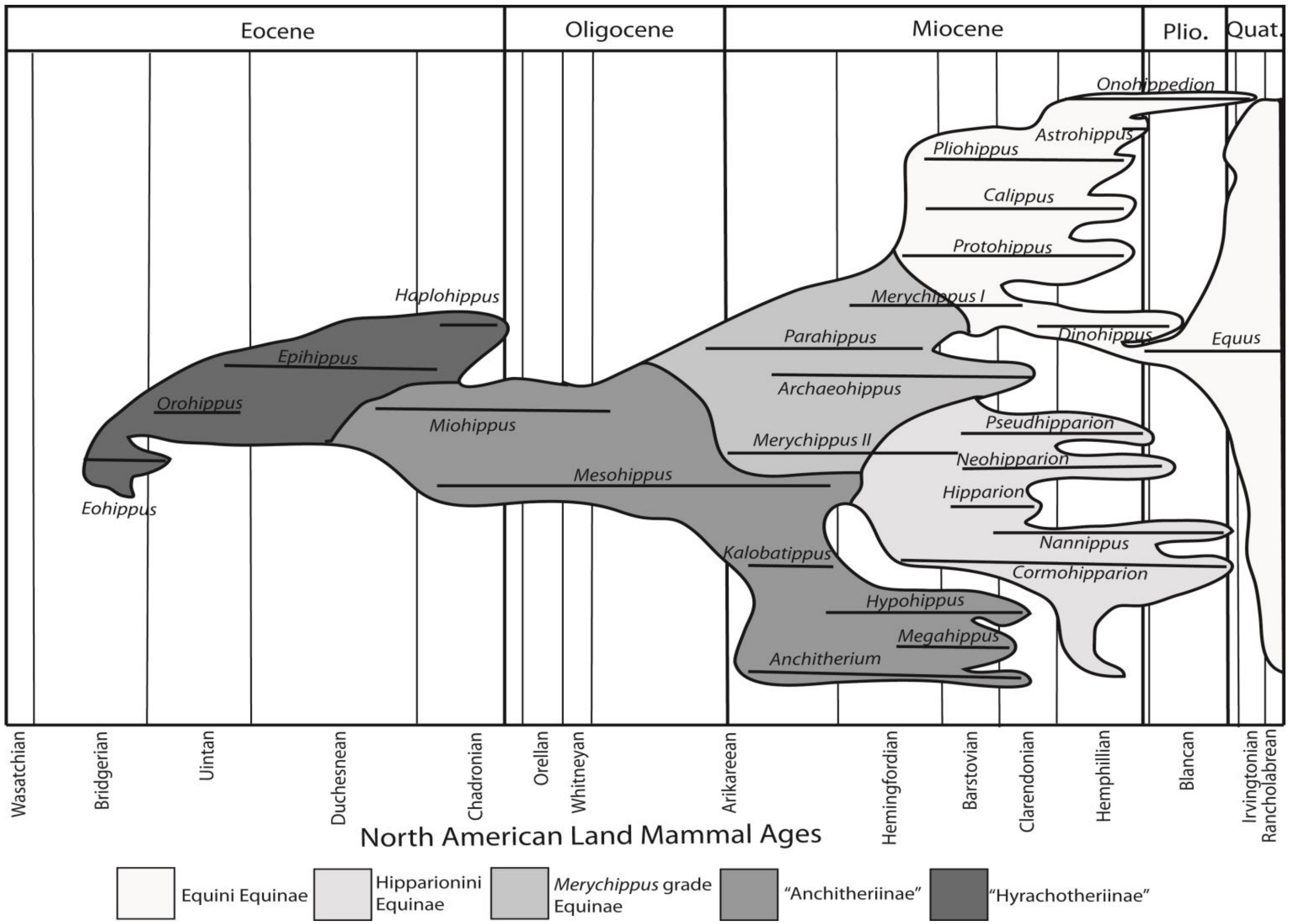

Figure 1: Phylogeny of Equidae used in this study, with North American Land Mammal Ages indicated on the right (after MacFadden 2005). This study begins with the Barstovian to capture the most advanced Equinae with derived enamel prismatic structure.

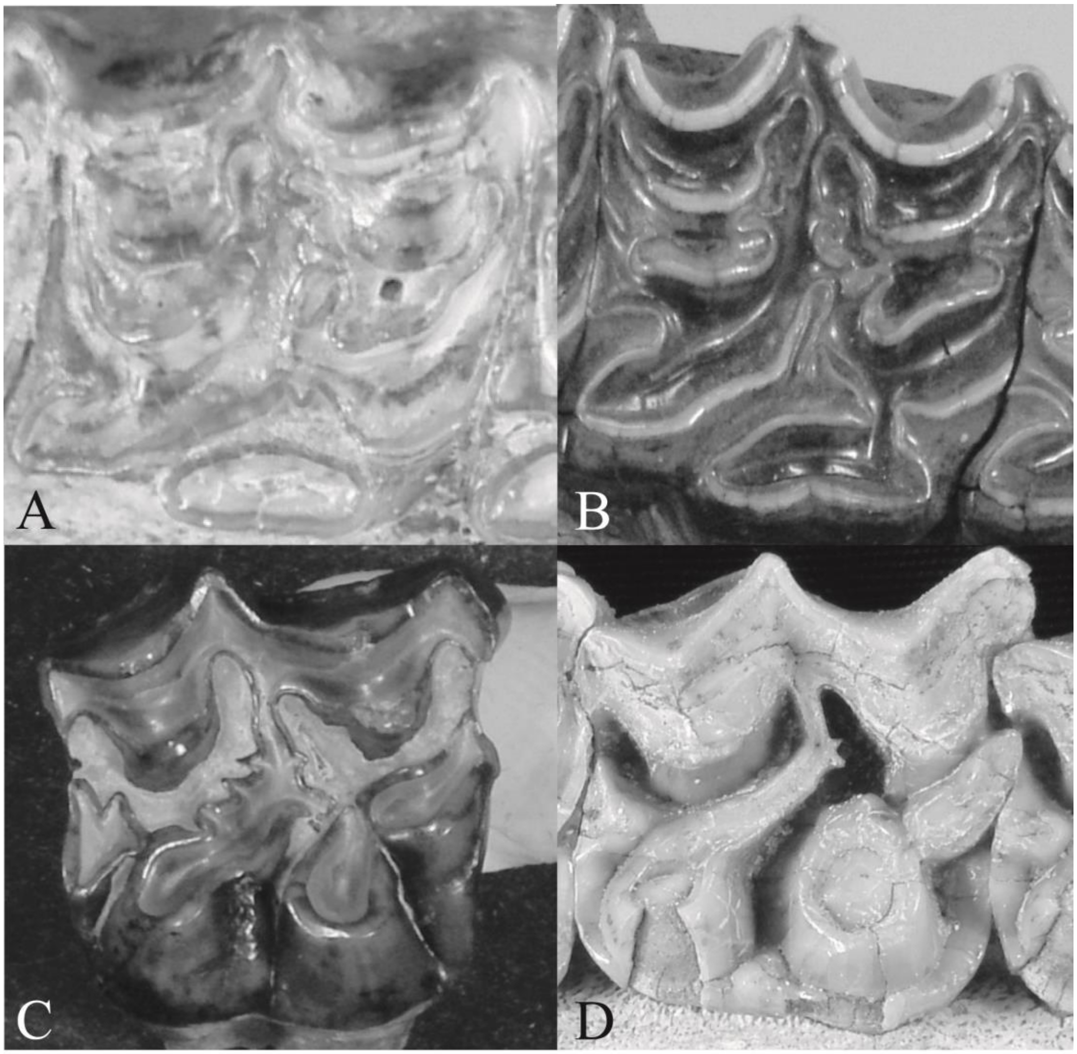

Figure 2: Representative teeth of each Tribal-level group in this study: (A) Hipparionini, (B) Equini, (C) "Merychippini," and (D) "Anchitheriniini." Each tribe has a distinct enamel pattern; starting with the "Anchitheriniini" in the lower right and going clockwise the patterns increase in complexity.

Measures of Complexity

Qualitative investigations have primarily been used to diagnose species and other higher taxonomic groups in horses; a majority of equid diagnoses are based on the differences in pattern of occlusal enamel (Quinn 1955, MacFadden 1994). Famoso et al. (*in revision*) introduced a numerical method to quantitatively measure and test the differences in enamel complexity in ungulates called Occlusal Enamel Index (OEI). A complicated enamel pattern should have longer occlusal enamel length thus producing more enamel per unit surface area on the occlusal plane. This metric is calculated by taking the length of enamel and dividing it by the square root of the true area for each tooth and produces a unit-less value. True area is the area actually contained within the curves of the teeth in occlusal view as opposed to the more traditional technique, which multiplies the measured length and width of the occlusal surface. True area is a proxy for body size, and OEI removes the effects of absolute scale on complexity. However, the effects of body size are not completely removed, as it does not adjust for size related differences in complexity, i. e. allomety (Famoso et al. *in revision*). Famoso et al. (in revision) also showed that phylogenetic relationships among ungulates play a role in the complexity of enamel. Another metric which has been applied to rodents is the enamel index (EI) or the total enamel band length (EL) per unit occlusal surface area (OSA) or $EI = \frac{EL}{OSA}$ (Becerra et al. 2012). OEI differs from EI in that the occlusal area is treated differently; OEI produces a unitless metric while EI does not.

Similar work on occlusal enamel complexity has been done within the Order Artiodactyla (Heywood 2010, Kaiser et al. 2010). Heywood (2010) analyzed molar occlusal surfaces and characterized them based on length, thickness, and shape of the enamel bands to discriminate diet in modern bovids. Heywood (2010) also noted that plant toughness is a primary driver of occlusal enamel form in bovids. Kaiser et al. (2010) investigated the arrangement of occlusal enamel bands in the molars of ruminants with respect to diet and phylogeny. Larger ruminants or those with higher grass content in their diet have a higher proportion of enamel ridges aligned at low angles to the direction of the chewing stroke (Kaiser et al. 2010).

Previous work on occlusal enamel patterns in equids has been limited to the observation that patterns change through wear stages (Skinner and MacFadden 1977, MacFadden 1998). Famoso and Pagnac (2011) suggested that the differences in occlusal enamel patterns through wear correspond to evolutionary relationships in Hipparionini. To date, attempts at quantifying the patterns of evolutionary change in occlusal enamel complexity between and within these equid tribes have been limited by small sample sizes (Famoso and Pagnac 2011, Famoso et al. *in revision*). Famoso et al. (*in revision*) created OEI to allow direct comparison between organisms of varying body size. They showed that effects of body size were not completely removed from by OEI because of important allometric scaling of enamel length.

Fractal dimensionality (*D*) is a measure of complexity, comparing the way in which detail changes with scale (Mandelbrot 1983). Values of *D* range between 1.0 and 2.0 for a line crossing a defined area. A single point has a *D* of zero; a strait line a *D* of 1, while a line so convoluted that it appears to completely cover the surface has a *D* closer to 2 (Fig. 3). An object with a *D* of 3 is a solid volume. Fractal dimensionality has been used to assign a quantitative and comparable measure of complexity to objects (e.g. leaf venation, coast lines, etc.) that cannot be conventionally measured (Theiler 1990, Bruno et al. 2008). One efficient way of calculating *D* is the box counting method, which breaks down a convoluted linear pattern into a series of boxes with increasingly diminishing dimensions (Feder 1988, Bruno et al. 2008). The box counting method looks at the pattern within the different boxes to investigate how the detail changes. The method is based on the number of boxes of a specific size required to fill an entire area (Bruno et al. 2008). The smaller the size of the box, the more boxes are required to fill the area. The fractal dimension is calculated from the curviness of the line within each box. The curviness and the number of lines are used in tandem to calculate fractal dimensionality. The fractal dimension will assist in removing the effects of body size from studies of tooth complexity (Gilbert and Palmqvist 1995, Famoso et al. *in revision*).

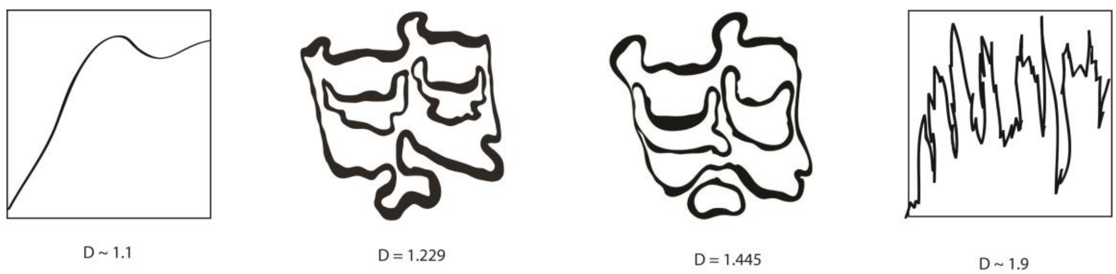

Figure 3: Examples of fractal dimensionality, increasing in complexity from left to right. The middle examples are traces of horse teeth (left: MVZ 154358, *Equus asinus*; right: AMNH F:AM 71891, *Cormohipparion quinni*). The examples at either end are generalized representations of a simple line and a convoluted line.

<u>Geography</u>

Physiographic regions in North America are associated with specific environments. For example in modern ecosystems, grasslands are characteristic of the Great Plains, pine dominated rainforests are typical of the Pacific Northwest, and boreal forests are representative of the Polar region (Molles 2008). Each region, then, has different ecosystems and thus likely different environmental pressures applied to populations allowing regional differences to serve as a proxy for paleoenvironmental differences. These regional paleoenvironmental pressures should manifest as differences in abrasiveness of diet. If the climatic differences were big enough in the climate factors that affect openness of habitat, then there would be changes in abrasiveness that would lead to changes in morphology in the dentition. Open habitats (e.g. grasslands) are relatively rich in abrasives in the form of grass phytoliths and grit from soils and windblown dust (Damuth and Janis 2011). Each region will change in climate through time and each time period will have different climates represented the regions. Evidence of a cooling and drying climate would be more noticeable in the regions far from the equator while the tropical regions (e.g. Gulf Coast and Central America) would see little change as those regions are more resistant to cooling. Nested variables, Region within NALMA, will also serve as a proxy for regional climatic variations through time.

Tooth Position

Beyond the pressures of the environment, tooth position is another aspect of enamel evolution that links back to phylogeny. It has been demonstrated that each tooth position develops differently and consequently has a distinct shape and enamel pattern (Famoso et al. *in revision*). The P2 and M3 are teeth that are easily identifiable in isolation. The P2 has a mesially pointed occlusal surface while the M3 is tapered distally (Fig. 4). The middle four teeth (P3-M2) are more difficult to identify as they have square occlusal surfaces. Premolars tend to be larger than molars within a single tooth-row (Fig. 4). A majority of identifiable fossil equid material tends to be isolated teeth, as teeth are composed of highly resistant materials (enamel, dentine, and cementum) in comparison to the surrounding cranial bone. In many cases, some taxa are only known from isolated teeth (MacFadden 1994, 1998). Because of their relative abundance in each tooth-row, a majority of isolated teeth tend to be the more difficult to distinguish P3 to M2 from the middle of the tooth row. Including isolated teeth would increase geographic and taxonomic diversity. Optimizing the sample size in my study design makes it important to identify whether tooth position has a significant effect on OEI for P3 - M3.

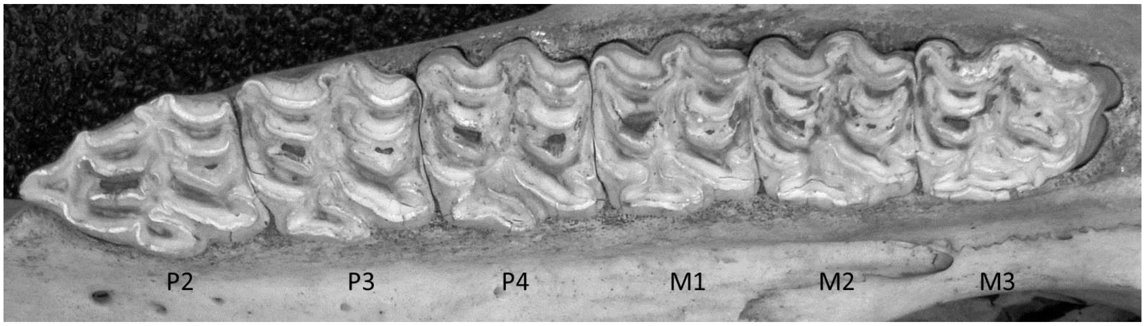

Figure 4: Tooth position of the left upper tooth-row of *Equus caballus* (UOMNCH B-8700). The second premolar and third molar have a very distinct occlusal shape compared to the four middle teeth.

<u>Questions</u>

Given current hypotheses of horse phylogeny and diversification in response to environmental changes and the extremely large available sample size (>2,581 known North American localities with fossil equids), I can use equid occlusal enamel band length and complexity of the occlusal surface to investigate the evolution of morphology in response to an increasingly abrasive diet. These observations lead to a series of questions: Do equids change their enamel complexity from the Miocene through the Recent? If so, is this change consistent with increasing adaptation to an abrasive diet? Is there a difference in enamel complexity between equid tribes, especially hipparionini and equine? If the evolution of enamel complexity is consistent with dietary adaptation, are there compromises between hypsodonty and enamel complexity? If so, do different tribes make different compromises?

Hypotheses

I hypothesize that an increase in the resistive cutting area for food processing, as expressed in occlusal enamel complexity, during mastication in equid teeth was in response to increased abrasion in their diet.

I will test this hypothesis by statistical analysis of enamel complexity derived from images of fossil horse teeth. If the statistical analysis shows a distinct pattern then equids responded to increased abrasion through an increase in occlusal enamel complexity, providing an increased resistive cutting area for food processing during mastication. If the statistical analysis shows a pattern indistinguishable from random, I will be unable to reject the null hypothesis of no unifying adaptive significance to changes in occlusal enamel complexity or that some other process that I have not tested is controlling occlusal enamel complexity.

Predictions

Occlusal enamel complexity will vary based on phylogenetic constraint and changes to regional ecosystems through time. The complexity of enamel on the occlusal surface of equid teeth should change through time, tracking changes in the abrasiveness in diet as climates changed through the Neogene. The complexity of enamel should also differ significantly between differing environments of North America if the environments are distinct in abrasiveness. Hipparionini and Equini will be structurally different from other Equinae or "Anchitheriinae."

If different lineages of horses find different compromises between hypsodonty and enamel evolution for their adaptation to tooth abrasion, then I would expect each tribe to have adapted differently from phylogenetic constraint. I expect Hipparionini to have the most complicated occlusal enamel followed by Equini and then the "*Merychippus*" grade horses and "Anchitheriinae" will have the lowest complexity. These predictions come from observations of tooth morphology and the relationship to diet (Heywood 2010, Kaiser et al. 2010, Famoso et al. *in revision*).

CHAPTER II

METHODS

The primary data of my analysis consists of scaled, oriented digital photographs of the occlusal surface of fossil and modern equid upper dentitions. Equid taxa from 16 Ma to recent ranging across North America were sampled. I measured a total of 800 teeth from a broad selection of Miocene through Recent equids (Appendix A). Photographs were taken with Kodak DC290, Fujifilm Finepix A345, Olympus Stylus Tough, and Canon Digital EOS Rebel SLR cameras. Samples were collected from the following museums: American Museum of Natural History, Smithsonian National Museum of Natural History, University of Nebraska State Museum, South Dakota School of Mines and Technology Museum of Geology, University of Washington Burke Museum of Natural History and Culture, John Day Fossil Beds National Monument, University of California Museums of Paleontology and Vertebrate Zoology, and the University of Oregon Museum of Natural and Cultural History. Some images from the University of California Museum of Paleontology were taken with permission from the online catalog. Care was taken to select individuals in medial stages of wear (no deciduous premolars and no teeth in extreme stages of wear). Skulls and complete to nearly complete tooth rows were preferred because I can be more confident in taxonomic identification. Isolated teeth were also photographed when more complete tooth-rows were not available from a geographic region or taxon. Geographic regions were sampled as evenly as possible, but this was constrained by the regional representation in museum collections (Fig. 5).

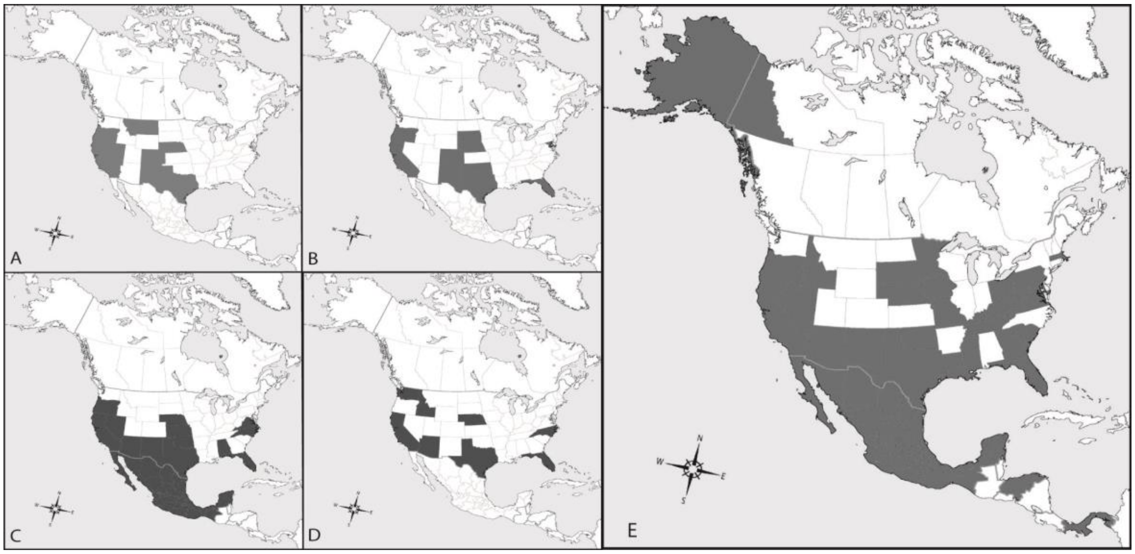

Figure 5: Geographic distribution of samples. Shaded regions represent a political area containing at least one sample for the (A) Barstovian, (B) Clarendonian, (C) Hemphillian, (D) Blancan, and (E) Irvingtonian and Rancholabrean North American Land Mammal Ages. Collecting and preservation biases result in some areas being more consistently sampled through geologic time than others.

Institutional Abbreviations

UNSM = University of Nebraska State Museum; **UOMNCH** = University of Oregon Museum of Natural and Cultural History; **UCMP** = University of California Museum of Paleontology; **MVZ** = University of California Museum of Vertebrate Zoology; **AMNH F:AM** = Frick Collection, American Museum of Natural History; **AMNH FM** = American Museum of Natural History; **UF** = University of Florida Museum of Natural History; **JODA** = John Day Fossil Beds National Monument; **CIT** = California Institute of Technology; **UWBM** = University of Washington Burke Museum of Natural History and Culture; **SDSM** = South Dakota School of Mines and Technology Museum of Geology; **USNM** = United States National Museum of Natural History.

Occlusal Enamel Index, OEI

The enamel length and true occusal surface area of each tooth were measured using the NIH image analysis program ImageJ. Site geology (formation and member), time period (epoch and North American Land Mammal Age [NALMA]), tooth position (if known), physiographic region, political region, and taxonomy (subfamily, tribe, genus, and species) were recorded for each specimen. Measurements and other data were stored in a Microsoft Excel 2010 spreadsheet. Occlusal Enamel Index (OEI) was calculated following Famoso et al. (*in revision*) by measuring occlusal enamel length (OEL) and true occlusal area (Fig. 6) where $OEI = OEL/\sqrt{True\ Area}$. Multi-way analysis of variance (ANOVA) and one-way ANOVAs were run on the data using JMP Pro 9 to determine whether the relationship between tooth size and enamel length fit predictions from my hypotheses. Raw data are presented in Appendix A.

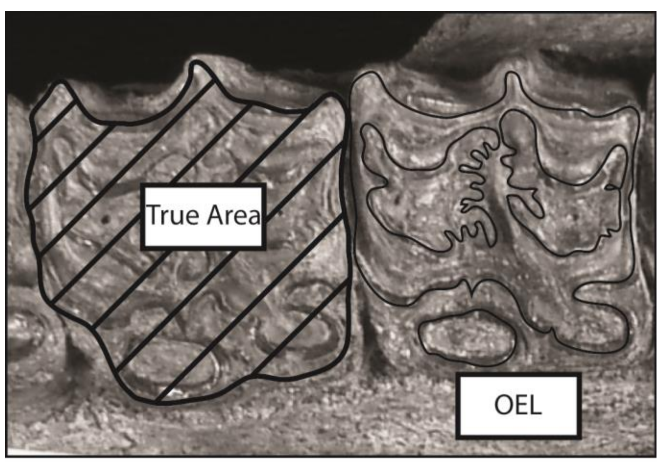

Figure 6: Examples of True Area and Occlusal Enamel Length (OEL) taken on digital images of UNSM 96997. Figure is based on methodology presented by Famoso et al. (*in revision*).

I used a Shapiro-Wilk W test (Shapiro and Wilk 1965) to test whether OEI values were normally distributed. If OEI is normally distributed then the data will not violate the assumptions of the ANOVA and a parametric test can be performed. When data from all tooth positions were pooled, they did not display a normal distribution. Upon further investigation, I determined that all but one position in the tooth row was normally distributed and excluded the non-normal tooth (M3) from further analysis.

The ANOVA includes a wide array of statistical tests which are aimed at testing the equality of means (Zar 2010). One-way ANOVAs look at one numeric dependent variable and test the effects of only one independent factor. Multi-way ANOVAs have one dependent variable but test the effect of more than one independent factor. Nested (hierarchical) ANOVAs include levels of independent factors which occur in combination with levels of other independent factors. An analysis of co-variance (ANCOVA) is similar to an ANOVA but it also tests the covariance of two numeric categories in context with the independent factors. ANOVAs can only provide a test of all factors together, so a Tukey-Kramer test must be used to investigate how the data are breaking out into statistically different groupings (Zar 2010).

An analysis of tooth position was run on a subset of the data (n=528 teeth). This ANOVA was run to determine if there was a tooth position or group of tooth positions with indistinguishable OEI values, allowing me to limit the number of specimens to be measured for the subsequent analyses. The results of this analysis would provide a justification for the selection of a subset of teeth to consistently measure. I ran a multi-way ANOVA with OEI as the dependent variable and tribe, region, NALMA, and tooth position as the independent factors. Previous statistical analysis by Famoso et al. (*in* *revision*) has shown that tooth position is important for occlusal enamel complexity as represented by the OEI. It is clear that the P2 and M3 are distinct in their overall shape, and could be a source of variation that would cause significant differences among tooth positions for OEI. P2 and M3 were excluded as they have an overall different shape (Fig. 4) and are statistically different in OEI from the teeth from the middle of the tooth-row (Famoso et al. *in revision*). I additionally ran a one-way ANOVA with OEI as the dependent variable and tooth position excluding P2 and M3 as the independent factor. Tukey-Kramer tests (Kramer 1956) were also performed to investigate the origin of significance for independent factors. I also ran a one-way ANOVA with OEI as the dependent variable and tooth position excluding P2 and M3 for the subset of the data that only belonged to the genus *Equus*, the genus with the largest overall sample size. Using just one genus would eliminate any influence from higher level evolutionary relationships. I also ran a one-way ANOVA with OEI as the dependent variable and tooth position excluding P2 and M3 by tribe (just Equini, just Hipparionini, and just "Anchitheriinae") to test if variation in tooth position was consistent at this level of lineage. Tribal affiliations were used as a proxy for phylogenetic relationships, therefore all genera needed a tribal level affiliation to be included in the ANOVAs, but the basal members of the Equinae (members of the "*Merychippus*" grade) do not belong to the Hipparionini or Equini, so I applied the place-holder paraphyletic tribe "Merychippini". Similarly, for all members of the paraphyletic subfamily "Anchitheriinae", the place-holder name "Anchitheriini" was applied.

Running my analyses above the genus level limits the influence of lumping and splitting at the genus and species levels which arise from qualitative analysis of characters found in isolated elements. While working through museum collections, I found several manuscript names assigned to specimens. To keep those potentially valid species names from being labeled *nomen dubium*, I assigned the specimens to the most appropriate, currently-established genus name and left the species as indeterminate. Even for published species of equids, there are ongoing controversies about the validity of names. Major problem areas include genera and species split from the paraphyletic form genus "*Merychippus*" (Stirton 1940, MacDonald et al. 1992, Kelly 1995, MacFadden 1998, Pagnac 2006) as well as the number and identity of Plio-Pleistocene and recent *Equus* species (MacDonald et al. 1992, Azzaroli and Voorhies 1993, MacFadden 1998, Weinstock et al. 2005). There has been controversy as to the validity of the number of genera and species that belong to Hipparionini (Stirton 1940, Skinner and MacFadden 1977, MacFadden 1984, Whistler 1991, Kelly 1995, MacFadden 1998, Hulbert and Whitmore 2006). Leaving the analysis above the genus level removes any effect taxonomic uncertainty at the generic and specific levels.

Limiting the taxonomy to the Tribe and above also allows a more robust sample size. Equid genera are typically diagnosed through a combination of dental and cranial characters (Eisenmann 1988, MacFadden 1994, 1998, Woodburne 2007). Teeth are made of strong enamel which is resistant to external stresses, unlike most cranial bone, making teeth much more likely to be preserved in the fossil record in isolation than in toothrows in skulls. Most isolated dental specimens can only be identified to genus because of the lack of diagnostic features, so a genus or tribal cutoff for my analysis allows me to access the rich supply of isolated teeth.

Geographic regions serve as a proxy for environmental differences in this study. Region selection for this study was based on a combination of work done by Barnosky et al. (2005) and volumes edited by Janis et al. (1998) and Woodburne (2004). Consensus regions were selected for this study (Fig. 7).

It was necessary to combine several of the regions as well as NALMAs to have sufficient sample size for the analyses used here. These combinations are not ideal as they eliminate a portion of the regional and temporal resolution of this study. I combined six regions into three (Fig. 7). The Rocky Mountain region was merged with the Great Plains as most of the localities in Montana are actually from the plains region of the state. I united the East Coast and the Eastern US because of their proximity. Central America was merged with the Gulf Coast as most of the localities were near the coast of the Gulf of Mexico. For the NALMAs, I only united the Irvingtonian and Rancholabrean. They are both part of the Pleistocene and the Irvingtonian was not well sampled. I was also able to include specimens from the Pleistocene into the Irvingtonian and Rancholabrean bin where their NALMA was not known.

To accurately investigate OEI through hierarchical taxonomic relationships and changing regions through time, it was necessary to use nested terms in my analyses. Nesting tests hypotheses about differences among samples which are placed in hierarchical groups. Nested factors are usually random-effects factors, or a factor with multiple levels but only a random sample of levels is included in the analysis. When applied to an ANOVA, it is considered a modified one-way ANOVA (Zar 2010) where one variable is the random-effects factor and the other is considered a subsample. Including nested factors accounts for within-groups variability.

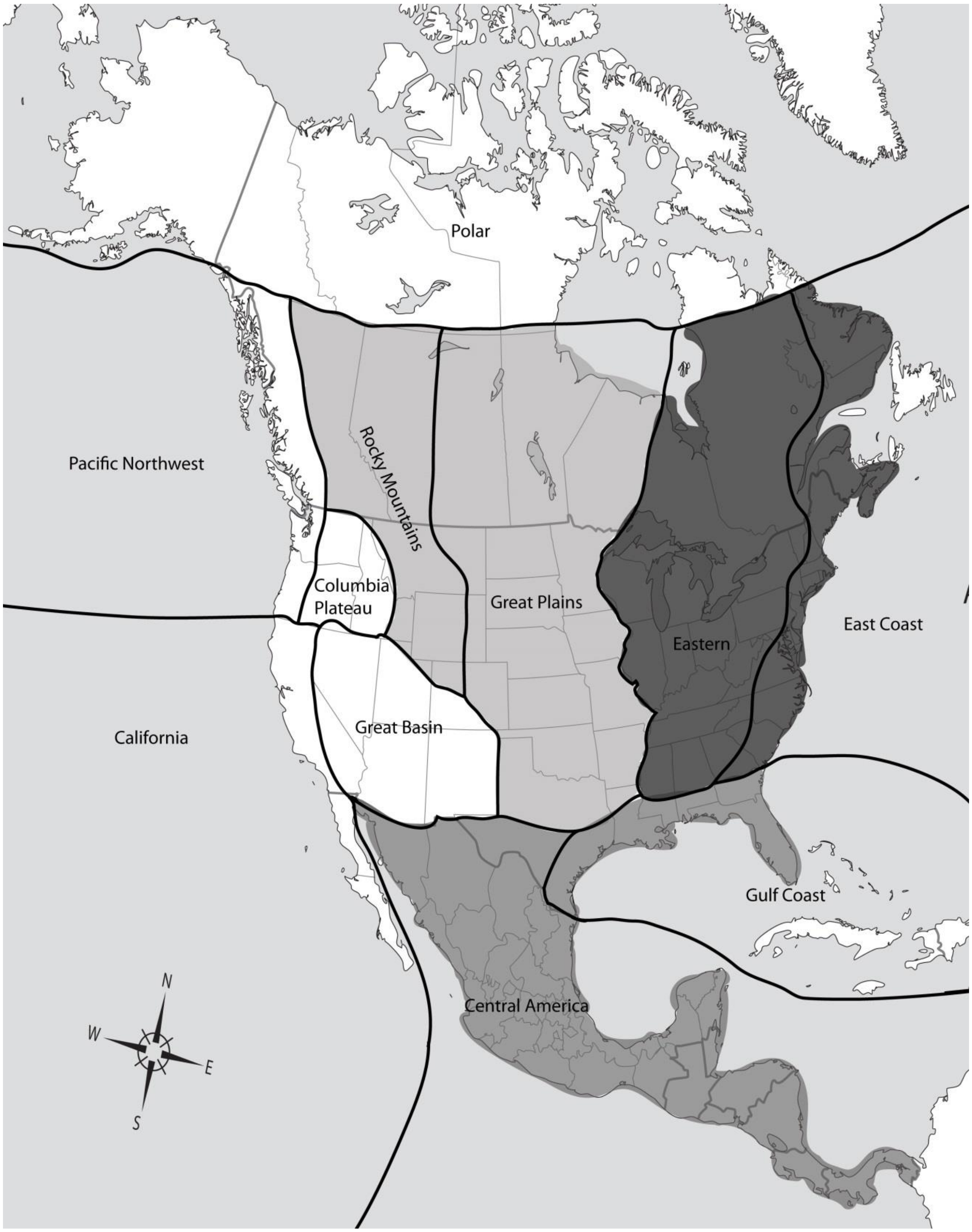

Figure 7: Consensus physiographic regions included in this study. Each region was chosen based on climate similarities and geographic barriers. Shading indicates regions which were combined into three larger region bins for the analysis in this study.

To make a single overall test of my hypothesis, I constructed a multi-way ANOVA with OEI as the dependent variable and tooth position, nested taxonomy (tribe within subfamily), and chronostratigraphy (geographic region nested within NALMA) as independent factors. In addition, I ran five groups of one-way ANOVAs with Tukey-Kramer tests to test my hypotheses of climate and phylogeny as drivers of OEI. My one-way ANOVAs use OEI as the dependent variable. My first group of one-way ANOVAs uses region as the independent variable to explore regional variations in climate within each NALMA. My next test uses tribe as the independent variable to investigate how OEI differs between lineages. I then used NALMA as the independent variable for each region to examine how OEI changes in the context of climate changes through time within each specific region. Next, I used tribe as the independent variable and separated by NALMA to investigate whether the different lineages are distinct in OEI at different periods of time. Finally, I used tribe as the independent variable separated by region to see whether the lineages differ between regional ecosystems.

Fractal Dimensionality, *D*

This is a pilot study for the method with a small sample size (n=20). I digitally traced twenty teeth using Adobe Illustrator for fractal analysis. The sample was split evenly between Hipparionini and Equini. This study was constrained to these two tribes to isolate effects from the larger phylogenetic signal. I restricted this analysis to the P3 to eliminate any effects from tooth position on the analysis. I then analyzed the traces using the fractal box method in ImageJ. Taxonomy (tribe, genus, and species), Fractal Dimension (*D*), and true occlusal area were used as variables this analysis. A Shapiro-Wilk W test of *D* revealed the data to be normally distributed. I then ran a nested two-way analysis of co-variance (ANCOVA) with phylogeny as a nested independent factor, true occlusal area as an independent factor, and *D* as the dependent factor in JMP Pro 9. ANCOVA is a combination of the ANOVA and a form of regression where a numeric dependent variable is tested by a numeric independent variable (Zar 2010). Raw data are presented in Appendix B.

CHAPTER III

RESULTS

Occlusal Enamel Index, OEI

Tooth Position

The one-way ANOVA with OEI as the dependent variable and tooth position (excluding P2 and M3) produced an F-test with *P*=0.0093. The Tukey-Kramer test indicates that P3, P4, and M2 are not significantly different from one another and P3, M1, and M2 are not significantly different from one another (Table 1). The P4 and M1 appear to be significantly different from each other. The one-way ANOVA with OEI as the dependent variable and tooth position (excluding P2 and M3) for *Equus* had the same overall result. The one-way ANOVAs with OEI (dependent variable) and tooth position (excluding P2 and M3) for each tribe resulted in tooth position not being significant.

Table 1: Results of Tooth Position ANOVA and Tukey-Kramer Test

Tooth Position	Group	Mean OEI
P4	A	17.67604
M2	AB	16.41501
P3	AB	16.35715
M1	B	15.75491

Nested Multi-way Analysis of Variance

All independent variables are significant for OEI at the α=0.05 level. Table 2 shows the *P* values for each variable.

Table 2: Results of the Nested Multi-way ANOVA

Dependent Variable	NALMA	Region [NALMA]	Tooth Position	Subfamily	Tribe [Subfamily]
OEI	*P* <0.0001	*P* = 0.0134	P<0.0001	P<0.0001	P<0.0001

ANOVA 1: OEI vs. Region within Each NALMA

These analyses are exploring regional variations in climate during specific time intervals. All NALMAs have significant ANOVAs at the α=0.05 level. See Table 3 for the results of the ANOVAs and Tukey-Kramer tests.

In the Barstovian (*P*=0.0138) there are two groups of regions. The Columbia Plateau is distinct from California. The Columbia Plateau has the higher OEI values. The Great Plains and the Great Basin are both overlapping with all other regional groups. California has the lowest OEI values. The Clarendonian (*P*=0.0009) has two groups as well. The Gulf Coast is a group. The Great Plains and California are the other group. The East Coast, Columbia Plateau, and Great Basin overlap and cannot be distinguished from either of the two groups. The Clarendonian has some regions with very low sample size: Eastern US, Columbia Plateau, Gulf Coast, and Great Basin all have a sample size under ten. There are two groupings in the Hemphillian (*P*=0.0016). The Eastern US, Columbia Plateau, and the Gulf Coast clump together. California is its own group. The Great Basin and Great Plains overlap both groups cannot be distinguished. The Blancan (*P*=0.0233) has many low sample size regions and none of the regions are significantly different from one another. In the Irvingtonian/Rancholabrean (*P*=0.0001) there are two groups. The Eastern US and the Gulf Coast form a group. The Great Plains and the Great Basin are a group. The Polar, Columbia Plateau, and California regions overlap the other groups and are indistinguishable.

There is some change in group membership through the Miocene NALMAs but California is consistently associated with group B and the Columbia Plateau is associated with group A. The Gulf Coast and Eastern US are consistently associated with group A from the Miocene through Pleistocene NALMAs.

Table 3: Results of ANOVAs and Tukey-Kramer Tests for OEI by Region for NALMA

NALMA	Region	n	Group
Barstovian	Columbia Plateau	57	A
Barstovian	Great Plains	68	AB
Barstovian	Great Basin	20	AB
Barstovian	California	15	B
Clarendonian	Eastern US	1	AB
Clarendonian	Columbia Plateau	1	AB
Clarendonian	Gulf Coast	5	A
Clarendonian	Great Basin	7	AB
Clarendonian	Great Plains	152	B
Clarendonian	California	10	B
Hemphillian	Eastern US	7	A
Hemphillian	Columbia Plateau	16	A
Hemphillian	Gulf Coast	24	A
Hemphillian	Great Basin	8	AB
Hemphillian	Great Plains	45	AB
Hemphillian	California	10	B
Blancan	California	6	A
Blancan	Columbia Plateau	25	A
Blancan	Eastern US	5	A
Blancan	Great Basin	4	A
Blancan	Great Plains	35	A
Blancan	Gulf Coast	1	A
Irvingtonian/ Rancholabrean	Eastern US	20	A
Irvingtonian/ Rancholabrean	Gulf Coast	24	A
Irvingtonian/Rancholabrean	Polar	20	AB
Irvingtonian/ Rancholabrean	Columbia Plateau	4	AB
Irvingtonian/ Rancholabrean	Great Plains	54	B
Irvingtonian/ Rancholabrean	Great Basin	11	B
Irvingtonian/ Rancholabrean	California	1	AB

ANOVA 2: OEI vs. Tribe

This analysis investigates how OEI differs between lineages. This ANOVA was significant ($P<0.0001$) (Table 4). Hipparionini and Equini are separate groups. “Merychippini” is between the two Hipparionini and Equini. The “Anchitheriini” is in its own distinct group.

Table 4: Results of ANOVA and Tukey-Kramer Test for OEI by Tribe		
Tribe	n	Group
Hipparionini	208	A
"Merychippini"	48	AB
Equini	423	B
"Anchitheriini"	37	C

ANOVA 3: OEI vs. NALMA within Each Region

These analyses are aimed at investigating how OEI responds to climate changes through time in a specific region. Four ANOVAs in this group were significant (Table 5). The Columbia Plateau (*P*=0.1635) and Great Basin (*P*=0.0981) were not significant at the α=0.05 level. The Great Plains was the only of these ANOVAs with a large sample size for all NALMAs. There are two groups of NALMAs in California (*P*=0.0211). The Blancan and Barstovian form two groups. The Irvingtonian/Rancholabrean, Clarendonian, and Hemphillian are not significantly different and overlap the other two groups of NALMAs. None of the NALMAs were differentiated in the Eastern US (*P*=0.0386). There appear to be three groupings in the Great Plains (*P*<0.0001). The Irvingtonian/Rancholabrean and the Hemphillian form two groups. There is a third group which includes the Blancan, Clarendonian, and Barstovian but this group overlaps with the other two. The Blancan cannot be distinguished from the Irvingtonian/Rancholabrean, Clarendonian, or Barstovian. The Clarendonian and Barstovian are not significantly different from the Blancan or the Hemphillian. The Gulf Coast (*P*=0.0061) has three groups. The Irvingtonian/Rancholabrean stands alone. The Blancan and Clarendonian are not significantly different and are in the middle of the distribution of means. The Hemphillian is a distinct NALMA here.

The Miocene NALMAs tend to be associated with the lowest group (either B or C) in each region. The Blancan is usually in the middle group and the Irvingtonian/Rancholabrean is associated with the highest group (A). These tend to be true except for in the Eastern US where all NALMAs are in the same group.

Table 5: Significant results of ANOVAs and Tukey-Kramer Tests for OEI by NALMA for Region

Region	NALMA	n	Group
California	Irvingtonian/ Rancholabrean	1	AB
California	Blancan	6	A
California	Hemphillian	10	AB
California	Clarendonian	10	AB
California	Barstovian	15	B
Eastern US	Irvingtonian/ Rancholabrean	20	A
Eastern US	Blancan	5	A
Eastern US	Hemphillian	7	A
Eastern US	Clarendonian	1	A
Great Plains	Irvingtonian/ Rancholabrean	54	A
Great Plains	Blancan	35	AB
Great Plains	Hemphillian	45	C
Great Plains	Clarendonian	152	BC
Great Plains	Barstovian	68	BC
Gulf Coast	Irvingtonian/ Rancholabrean	24	A
Gulf Coast	Blancan	1	AB
Gulf Coast	Hemphillian	24	B
Gulf Coast	Clarendonian	5	AB

ANOVA 4: OEI vs. Tribe within Each NALMA

These analyses investigate at how the different lineages are distinct at different periods of time. All ANOVAs for NALMAs were significant. The results of the

ANOVAs are presented in Table 6. The Barstovian (*P*<0.0001) had two statistical groupings; one group is the "Merychippini" and Hipparionini, and the other is the Equini and "Anchitheriini." The Clarendonian (*P*<0.0001) had the same two groups. The Hemphillian (*P*<0.0001) and the Blancan (*P*=0.0013) both have two distinct groups, the Hipparionini and Equini. The groupings of tribes stay the same through time.

Table 6: Results of ANOVAs and Tukey-Kramer Tests for OEI by Tribe for NALMA

NALMA	Tribe	n	Group
Barstovian	Hipparionini	40	A
Barstovian	"Merychippini"	41	A
Barstovian	Equini	47	B
Barstovian	"Anchitheriini"	31	B
Clarendonian	"Merychippini"	5	A
Clarendonian	Hipparionini	107	A
Clarendonian	Equini	60	B
Clarendonian	"Anchitheriini"	4	B
Hemphillian	Hipparionini	48	A
Hemphillian	Equini	62	B
Blancan	Hipparionini	7	A
Blancan	Equini	69	B

ANOVA 5: OEI vs. Tribe within Each Region

The investigation in these ANOVAs is directed at how the lineages differ between regional ecosystems across time. The Eastern US was the only region which did not have a significant ANOVA with *P*=0.5223. This ANOVA had a small sample size (n=10 for Hipparionini and n=23 for Equini) (Table 7). In California (*P*=0.0220) there were two distinct groups, the Hipparionini and the Equini. The Columbia Plateau (*P*<0.0001) had three groups. The "Merychippini" and "Anchitheriini" are distinct while Hipparionini and

Equini cannot be distinguished from one another. Though the Great Basin had a significant ANOVA (P=0.0238), none of the tribes were distinguishable by the Tukey-Kramer test. The Great Plains (P<0.0001) has three groupings. Hipparionini is distinct, as are “Anchitheriini” and Equini. “Merychippini” is not distinguishable from Equini or “Anchitheriini.” The Gulf Coast (P=0.0050) has two distinct groups, Equini and Hipparionini.

Hipparionini and Equini tend to be in two separate groups in each region with Hipparionini in the group with higher OEI except in the Columbia Plateau and Great Basin. “Anchitheriini” is almost always in the lowest group except in the Great Basin.

Table 7: Results of ANOVAs and Tukey-Kramer for OEI by Tribe for Region

Region	Tribe	n	Group
California	Hipparionini	5	A
California	Equini	37	B
Columbia Plateau	"Merychippini"	18	A
Columbia Plateau	Hipparionini	30	B
Columbia Plateau	Equini	36	B
Columbia Plateau	"Anchitheriini"	18	C
Great Basin	Hipparionini	14	A
Great Basin	"Merychippini"	8	A
Great Basin	Equini	27	A
Great Basin	"Anchitheriini"	1	A
Great Plains	Hipparionini	117	A
Great Plains	Equini	204	B
Great Plains	"Merychippini"	21	BC
Great Plains	"Anchitheriini"	17	C
Gulf Coast	Equini	25	A
Gulf Coast	Hipparionini	29	B

Fractal Dimensionality, *D*

For this study α=0.05. The independent variables which have a signficant relationship on complexity are genus (P=0.0428) and species (P=0.0148). True area (P=0.4116) and tribe (P=0.0666) show no significant relationship.

CHAPTER IV

DISCUSSION

Occlusal Enamel Index, OEI

Tooth position does not significantly affect OEI for the middle four teeth (P3 – M2) of the upper tooth row. My investigation into tooth position indicates that I can include isolated molariform teeth in my study without taking tooth position into account if I exclude the P2 and M3. These two teeth have been shown to be different from the molariform teeth (Famoso et al. *in revision*). I also found that my data were normally distributed when the P2 and M3 were excluded. My ANOVA also showed that there was more variation in the M1 and P4 than in the M2 and P3. Because of this result I focused on measuring the M2 or P3 to add consistency to my data. My investigation into tooth position also explored if the variation in OEI for the various tooth positions were the same within lineages. Within each tribe tooth position is not significant for the four square middle teeth. Tooth position OEI varies significantly between tribes, suggesting that each lineage is adapting differently for each tooth.

The results of my nested multi-way ANOVA suggest that geographic regions, time, tooth position and nested taxonomy are all significant factors driving the length of enamel in horse teeth. Each of the subsequent one-way ANOVAs I ran were designed to tease apart the details of the multi-way ANOVA result.

OEI generally varies significantly for regions, but there is no consistent pattern to which areas differ through time. The small sample size of some of the region-time-bin combinations does not make me fully confident in the results. I did not perform

ANOVAs with only one bin (e.g. only one NALMA represented in Polar region). Small sample sizes do not take into account all of the possible variation in the actual population. Larger sample sizes have a statistical confidence on the actual mean of the population that is much lower than in small sample sizes.

Some regions in an ANOVA, such as Great Plains in the Clarendonian, have a comparatively large sample (n=152) while others much smaller (ranging from 1 to 10). The Barstovian is more evenly sampled across regions, so that I have more confidence in the results for the Barstovian ANOVA and Tukey-Kramer test. To make the group of ANOVAs which test for climatic influence on OEI more powerful in future analysis, it will be necessary to increase the sample from regions in each NALMA with a low sample size. In the Barstovian I would like to collect more specimens from California, Great Basin, Gulf Coat, and Eastern US. More samples from the Clarendonian of Columbia Plateau and Eastern US (n=1 for both regions), as well as Gulf Coast, Great Basin, and California (n<12 for these regions) would be useful. I would also like to collect more samples in the Hemphillian from all regions except the Great Plains. There is one Blancan locality with horse material from Alaska, the Cape Deceit Fauna (Guthrie and Matthews 1971), which I would like to sample. Additionally I would like to sample more from California, Eastern US, Great Basin, and Gulf Coast. Regions needing a more robust sample in the Irvingtonain/Rancholabrean are Great Basin, Columbia Plateau, and California. Generally the Great Plains is very well sampled in this database because a majority of the collecting done by the museums I visited was done in the Great Plains. Adding these data would help in achieving more statistical confidence in these regions so I can better understand regional variations in climate during each time period and response to climate changes through time in a specific region. Removing regions with very low sample size or combining those regions with other regions would strengthen the analysis but would remove some of the resolution.

In the Barstovian, equids from higher latitudes appear to have longer enamel than those from the southern latitudes. Longer enamel would suggest that there are more abrasive food stuffs in the northern latitudes than in the southern latitudes. The analysis on the Hemphillian suggests that that the longer enamel lengths are in the east and the lower lengths are in the west. This suggests that horses are feeding in environments with more abrasive ingesta in the eastern portion of the continent than in the western portions at this time period. The Pleistocene has higher enamel lengths in the Eastern US and the Gulf Coast. The lowest lengths are in the Great Plains and the Great Basin. The trend of lower lengths seems to match the Barstovian where there appears to be a latitudinal rather than a longitudinal relationship, a product of habitat and climate differences. The complex enamel in the Eastern US and Gulf Coast fit with qualitative observations; however I expected the Polar region to have the lowest enamel lengths, not the Great Plains and Great Basin.

When I investigated the NALMAs by region I see a slight pattern emerge. Generally the Irvingtonian/Rancholabrean has higher enamel lengths. It is important to note here that the Irvingtonian/Rancholabrean bin includes several periods of glacial and interglacial cycling. Glacial ice sheets moved across the landscape moving habitats north and south, expanding or compressing the ranges. What I am sampling is the combination of these range shifts. There is an increase in OEI from the Miocene NALMAs to the Pleistocene in most regions. As with the above group of ANOVAs there were some

NALMAs that were better sampled in each region than others. The enamel band changes may also be an effect of preferentially changing climates. Each region may have been affected differently by the overall cooling climate from the Mid Miocene Climactic Optimum (16 Ma) to recent (Zachos et al. 2008). OEI generally increases through the overall cooling from the Miocene to the Recent which suggests that as climate became cooler and dryer, and the abrasiveness of the equid diet increased, increased OEI provided a selective advantage. More variability in recent climates may explain the difficulty in distinguishing regions in the Pleistocene.

The overall analysis of OEI by tribes revealed a distinct pattern supporting the hypothesis that the tribes had distinct evolutionary responses in occlusal enamel evolution. The results of the Tukey-Kramer test very closely reflect the evolutionary relationships of the family. Hipparionini and Equini are sister taxa, and both are in distinct groups. “Merychippini” includes the common ancestor between these two within the subfamily and is grouped with both the Hipparionini and Equini as is expected in light of the phylogeny. “Anchitheriini” is from a different paraphyletic group that is the ancestor to “Merychippini.” The “Anchitheriini” is in its own group statistically and has the lowest OEI. Members of “Anchitheriini” are either browsers or intermediate feeders with a low percentage of abrasive material in their diet. Browse comprises a larger portion of the diet for “Anchitheriini” than any of the other tribes, and should have lower OEI because of the lower percentage of ingested abrasive material.

ANOVAs for tribes by NALMAs indicate some consistent patterns. The relative enamel lengths do not become more distinct over time. Phylogeny seems to be a major driving factor for enamel length. When the four tribes are present, Hipparionini and

“Merychippini” are grouped together. Equini and “Anchitheriini” are also grouped. This pattern is only seen in the Barstovian and Clarendonian. Groupings may represent tribes which were competing within the groups. Hipparionini and “Merychippini” may have been competing for the same resources. Both tribes would have been utilizing the same adaptation and would appear similar in morphology. The sample for “Merychippini” may be dominated by ancestral forms of Hipparionini which would also yield this signal because more of the equin “*Merychippus*” have been split out into their own genera. It is possible that Equini could be an intermediate feeder and only partially competing with browsing “Anchitheriini” for resources. It is interesting to note that in the Great Plains Equini and “Anchitheriini” compose a small percentage of the relative abundance of horses in the Clarendonian (Famoso and Pagnac 2011). The similarity in OEI and relative abundance between these two groups suggests that these tribes were competing for resources and eventually Equini became more successful. Hipparionini were the most relatively successful tribe during the Clarendonian in the Great Plains, but were eventually outcompeted by the end of the Blancan. “Anchitheriini” and “Merychippini” go extinct by the Hemphillian leaving Equini and Hipparionini. The two tribes are statistically different in the Hemphillian and Blancan. Hipparionini are constrained to the southern latitudes during the Blancan and are extinct by the end of the Blancan. Hipparionini remain in regions closer to the equator where the effects of climate change are not as noticeable. In those regions they continue to have higher OEI than their equin counterparts. Hipparionini food source may have been restricted to warmer climates thus restricting the range of the tribe. The warmer regions may have served as refugia for North American hipparionin horses.

Within regions, “Anchiitheriini” consistently has the lowest OEI when present. The Great Plains and the Columbia Plateau have different tribes with the highest OEI, Hipparionini in the Great Plains and “Merychippini” in the Columbia Plateau. These differences suggest a difference in niche partitioning through food source, climate, and/or behavior. Niche partitioning may exist and be manifested in OEI where several species of horses from the same tribe co-occur in the same locality (e.g. Ashfall Fossil Beds). MacFadden et al. (1999) suggested that six sympatric species of contemporaneous hypsodont fossil horses of Florida were partitioning into browsers, intermediate feeders, and grazers based on isotope and microwear data. As ungulates with different feeding strategies have smaller OEI if they are browsers and larger if they are grazers (Famoso et al. *in revision*), it is possible that different tribes of horses were specializing in different feeding strategies. Furthermore, Maguire and Stigall (2008) suggest that Miocene climate change influenced the radiation of horses. Climate change has an impact on the location of food sources (grass vs. browse) giving a specific region a suite of vegetation which the local populations of horses feed upon.

Because regions serve as a proxy for environmental differences I can interoperate the results of this group of ANOVAs as the influence of climate on OEI. Each regional climate is behaving differently through time and the horses are adapting to the specific environment around them. The Great Plains had the only regional ANOVA at all similar to the overall tribe analysis. The Great Plains region may be dominating the signal in the overall analysis because of the larger sample of specimens from the region included in this study (n=359 for Great Plains out of a total n=661). Collecting a random subsample of the Great Plains from this data set that is equal in size to the other regions would prevent its ecological signal from dominating in the overall analysis.

Climate and phylogenetic lineages seem to be major drivers of OEI. The general OEI trend is an increase from the Miocene through Pleistocene. In every interval in this analysis, each lineage has a distinct OEI, suggesting that any phylogenetic constraint controlling OIE evolved early in the history of the lineages.

Fractal Dimensionality, *D*

The results of my nested two-way ANOVA indicate that complexity is not significantly different between hipparionines and equines. However, I found a significant difference amongst each of the lower taxonomic levels. I only used taxa for this pilot study which were identified to the same genus, or very close relatives, within each tribe. I also used modern taxa which have species identifications which are supported by more than just morphological data. I am confident in these identifications especially when using them with a smaller data set. Differences in complexity suggest that variability is more important at the generic and specific levels. Specialization to a niche or behavior at the specific level may explain these differences in complexity. The specialization of each taxon has more of an effect on complexity than the evolutionary baggage they inherit from their ancestors. If I had the same level of confidence in the taxonomy in the OEI study, I would expect to see the same result. Because of experimental design, we can rule out any effects from tooth position and body size in this part of the study: Tooth position was accounted for by limiting the study to only P3, and I performed a test of significance for the correlation between true occlusal area and *D* to test if *D* was truly independent of size. As expected, true occlusal area had no significant correlation to *D*; as fractal dimensionality of equid occlusal enamel is a metric that is clearly independent of body size. Results of this study suggest that species level behavior could represent response to climate differences.

Pitfalls and Further Analysis

There are a series of pitfalls when using a nested factor to simulate phylogeny (Famoso et al. *in revision*). I only partially accounted for the effect of evolutionary relationships on OEI and *D* when using nested factors. I believe that the analysis would be improved by a comparative method that completely accounts for the details of evolution (Stack et al. 2011, Cayuela et al. 2012). Taxonomy is a compartmental naming system that was created to explain how organisms are related to one another, and like most natural systems, phylogenetic relationships are more complicated than categories defined by man. The current phylogenetically-informed comparative methods utilize phylogenies with consistently-derived branch lengths, which are easy to calculate with a molecular phylogeny, but the method is not yet available with morphology-dependent fossil phylogeny.

In future analyses, I want to increase sample size for under-sampled regions and NALMAs for both OEI and *D*, to yield better results and better resolution. Randomly resampling and standardizing the sample size between the categories would assist in removing the effects of low sample size in some categories. I considered the removal of categories with extremely low sample size but chose not to, so that I could retain resolution. For future studies utilizing *D*, I would like to increase the number of variables and sample size to a level comparable to that of the OEI study. Including isotope and microwear data with the OEI dataset would allow analysis of niche partitioning with respect to diet (MacFadden et al. 1999). I would also like to apply both of these methods to other megafauna which have adaptations to increased ingested abrasiveness, such as camels, rhinos, African large primates, and South American notoungulates. I would also like to test differences within Pio-Pleistocene *Equus* (e.g. caballine and stilt-legged horses), comparing them to Hipparionini genera to see if any equin horses are independently evolving complex enamel patterns similar to hipparionin horses.

I would also like to investigate more morphological characters in equid molars (Heywood 2010) as well as the arrangement of occlusal enamel bands with respect to phylogeny and diet (Kaiser et al. 2010) for horses and the other taxa mentioned earlier. These methods used along with OEI would better investigate not only the complexity, but the specific arrangement, shape, and thickness of occlusal enamel structures. Together these aspects of dental morphology can clarify how these animals adapted to increased ingested abrasion.

CHAPTER V

CONCLUSION

The results of my Occlusal Enamel Index (OEI) study suggest that the shape of the occlusal enamel of equid teeth is driven by evolutionary baggage, tooth position, time, and geography. The fractal dimensionality study suggests that the complexity of equid teeth is the product of behavior of the species. Equini seem to have an overall lower OEI than Hipparionini which supports the qualitative hypothesis that Equini have less occlusal enamel than Hipparionini.

This study shows that enamel band shapes are being driven by climate and controlled by evolutionary history. From the results of the fractal dimensionality pilot study, it appears complexity is driven by behavior at the species-level. Each species of horse fills different niches and has adaptations specific to those niches. Horses change their enamel complexity in response to increased tooth abrasion from the Miocene through the Recent.

APPENDIX A

OEI RAW DATA TABLE

Specimen #	Subfamily	Tribe	Genus	Species	Element	Formation	Member
AMNH F:AM 100077	Equinae	Equini	*Onohippidium*	*galushai*	P3	Big Sandy	
AMNH F:AM 104769	Equinae	"Merychippini"	*Merychippus*	sp.	P3	Valentine	Burge
AMNH F:AM 107596	Anchitheriinae	"Anchitheriini"	*Hypohippus*	sp.	P3	Valentine	Burge
AMNH F:AM 108233	Equinae	Hipparionini	*Cormohipparion*	*sphenodus*	P3	Tesuque	
AMNH F:AM 109883	Equinae	Hipparionini	*"Hipparion"*	sp.	P3	San Jacinto	
AMNH F:AM 110131	Equinae	Equini	*Parapliohippus*	*carrizoensis*	P3	Barstow	
AMNH F:AM 110222	Equinae	Equini	*Merychippus*	sp.	P3	Barstow	
AMNH F:AM 110234	Equinae	Equini	*Merychippus*	sp.	P3	Barstow	
AMNH F:AM 110343	Anchitheriinae	"Anchitheriini"	*Hypohippus*	*equinus*	P3	Olcott	
AMNH F:AM 111728	Equinae	Equini	*Protohippus*	*supremus*	P3	Clarendon	
AMNH F:AM 114169	Equinae	Equini	*Protohippus*	*supremus*	P3	Clarendon	
AMNH F:AM 116143	Equinae	Equini	*Equus*	sp.	P3	Itchetucknee River	
AMNH F:AM 116148	Equinae	Equini	*Equus*	sp.	M2	Indio Hills	
AMNH F:AM 116150	Equinae	Equini	*Equus*	sp.	M2		
AMNH F:AM 116156	Equinae	Equini	*Equus*	*simplicidens*	P3		
AMNH F:AM 116161	Equinae	Equini	*Equus*	*scotti*	P3	Las Cruces	
AMNH F:AM 116164	Equinae	Equini	*Dinohippus*	*interpolatus*	P3	Ogallala	
AMNH F:AM 116179	Equinae	Equini	*Equus*	*scotti*	P3		
AMNH F:AM 116194	Equinae	Equini	*Dinohippus*	*leidyanus*	P3	Ogallala	
AMNH F:AM 116792	Equinae	Equini	*Dinohippus*	*leidyanus*	P3	Ogallala	
AMNH F:AM 116868	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	P3	Valentine	
AMNH F:AM 117045	Equinae	Hipparionini	*Nannippus*	sp.	P3	Ash Hollow	Merrit Dam
AMNH F:AM 118223	Equinae	Equini	*Calippus*	*placidus*	P3	Ogallala	
AMNH F:AM 125218	Equinae	Equini	*Calippus*	*martini*	P3	Ash Hollow	

AMNH F:AM 125488	Equinae	Equini	*Calippus*	*martini*	P3	Ogallala	
AMNH F:AM 125995	Equinae	"Merychippini"	*Merychippus*	*calamarius*	P3	Pawnee Creek	
AMNH F:AM 126899	Equinae	"Merychippini"	*Merychippus*	sp.	P3	Valentine	Devils Gulch
AMNH F:AM 127207	Equinae	Hipparionini	*Protohippus*	sp.	P3	Sheep Creek	
AMNH F:AM 127263	Equinae	Equini	*Scaphohippus*	*sumani*	P3	Barstow	
AMNH F:AM 127569	Equinae	Hipparionini	*Pseudhipparion*	sp.	P3	Ogallala	
AMNH F:AM 127992	Equinae	"Merychippini"	*Merychippus*	sp.	P3	Pawnee Creek	
AMNH F:AM 128091	Equinae	Equini	*Astrohippus*	*ansae*	P3	Ogallala	
AMNH F:AM 128092	Equinae	Equini	*Astrohippus*	*ansae*	P3	Ogallala	
AMNH F:AM 128154	Equinae	"Merychippini"	*Merychippus*	*calamarius*	P3	Tesuque	
AMNH F:AM 128270	Equinae	Equini	*Dinohippus*	*leidyanus*	P3	Ogallala	
AMNH F:AM 128444	Equinae	Equini	*Dinohippus*	*leidyanus*	P3	Ogallala	
AMNH F:AM 142515	Equinae	Equini	*Merychippus*	n. sp.	P3	Olcott	
AMNH F:AM 143268	Equinae	Hipparionini	*Neohipparion*	*affine*	P3	Ogallala	
AMNH F:AM 143273	Equinae	"Merychippini"	*Merychippus*	sp.	P3	Tesuque	
AMNH F:AM 14396	Equinae	Equini	*Equus*	*occidentalis*	P3	Rancho La Brea Asphalt	
AMNH F:AM 20077	Equinae	Equini	*Equus*	*simplicidens*	P3	Blanco	
AMNH F:AM 21085	Anchitheriinae	"Anchitheriini"	*Megahippus*	sp.	P3	Barstow	
AMNH F:AM 30702	Equinae	Equini	*Equus*	sp.	P3	Fairbanks	
AMNH F:AM 30703	Equinae	Equini	*Equus*	sp.	P3	Fairbanks	
AMNH F:AM 42810	Equinae	Equini	*Equus*	sp.	P3	Papago Spring Cave	
AMNH F:AM 42811	Equinae	Equini	*Equus*	sp.	P3	Papago Spring Cave	
AMNH F:AM 60061	Equinae	Equini	*Equus*	sp.	P3	Fairbanks Creek	
AMNH F:AM 60062	Equinae	Equini	*Equus*	sp.	P3	Fairbanks Creek	
AMNH F:AM 60066	Equinae	Equini	*Equus*	sp.	P3	Fairbanks Creek	
AMNH F:AM 60300	Equinae	Equini	*Merychippus*	n. sp.	P3	Ash Hollow	
AMNH F:AM 60327	Equinae	Equini	*Merychippus*	n. sp.	P3	Clarendon	

AMNH F:AM 60420	Equinae	Equini	*Calippus*	*regulus*	P3	Ogallala	
AMNH F:AM 60500	Anchitheriinae	"Anchitheriini"	*Hypohippus*	n. sp.	P3	Ash Hollow	
AMNH F:AM 60561	Anchitheriinae	"Anchitheriini"	*Hypohippus*	sp.	P3	Valentine	Burge
AMNH F:AM 60618	Anchitheriinae	"Anchitheriini"	*Hypohippus*	sp.	P3	Olcott	
AMNH F:AM 60627	Anchitheriinae	"Anchitheriini"	*Hypohippus*	sp.	P3		
AMNH F:AM 60700	Anchitheriinae	"Anchitheriini"	*Megahippus*	*matthewi*	P3	Valentine	Burge
AMNH F:AM 60720	Anchitheriinae	"Anchitheriini"	*Megahippus*	sp.	P3	Pawnee Creek	
AMNH F:AM 60878	Equinae	Equini	*Pliohippus*	*pernix*	P3	Clarendon	
AMNH F:AM 60880	Equinae	Equini	*Pliohippus*	sp.	P3	Clarendon	
AMNH F:AM 60904	Equinae	Equini	*Pliohippus*	sp.	P3	Clarendon	
AMNH F:AM 60905	Equinae	Equini	*Pliohippus*	sp.	P3	Tesuque	
AMNH F:AM 69500	Equinae	"Merychippini"	*Merychippus*	*coloradense*	P3	Tesuque	Chamael Rito
AMNH F:AM 69503	Equinae	"Merychippini"	*Merychippus*	*coloradense*	P3	Sante Fe	
AMNH F:AM 69506	Equinae	"Merychippini"	*Merychippus*	*coloradense*	P3	Ogallala	
AMNH F:AM 69550	Equinae	"Merychippini"	*Merychippus*	sp.	P3		
AMNH F:AM 69560	Equinae	Equini	*Pliohippus*	sp.	P3	Olcott	
AMNH F:AM 69604	Equinae	Hipparionini	*Merychippus*	n. sp.	P3	Ash Hollow	
AMNH F:AM 70003	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	P3	Valentine	Burge
AMNH F:AM 70112	Equinae	Hipparionini	*Pseudhipparion*	*skinneri*	P3		
AMNH F:AM 70439	Equinae	Hipparionini	*Pseudhipparion*	sp.	P3	Ogallala	
AMNH F:AM 71369	Equinae	Equini	*Pliohippus*	sp.	P3	Flint Creek Beds	
AMNH F:AM 71377	Equinae	Equini	*Pliohippus*	sp.	P3		
AMNH F:AM 71405	Equinae	Equini	*Equus*	sp.	P3	Gold Hill	
AMNH F:AM 71463	Equinae	Equini	*Equus*	sp.	P3	Dome Creek	
AMNH F:AM 71502	Anchitheriinae	"Anchitheriini"	*Desmatippus*	*integer*	P3	Olcott	
AMNH F:AM 71508	Anchitheriinae	"Anchitheriini"	*Desmatippus*	sp.	P3	Olcott	
AMNH F:AM 71592	Anchitheriinae	"Anchitheriini"	*Desmatippus*	sp.	P3	Pawnee Creek	

AMNH F:AM 71887	Equinae	Hipparionini	*Hipparion*	*forcei*	P3	Snake Creek	
AMNH F:AM 71891	Equinae	Hipparionini	*"Cormohipparion"*	*quinni*	P3		
AMNH F:AM 73940	Equinae	Hipparionini	*Cormohipparion*	*goorisi*	P3		
AMNH F:AM 73950	Equinae	Hipparionini	*Hipparion*	*shirleyi*	P3		
AMNH F:AM 73951	Equinae	Hipparionini	*Hipparion*	*shirleyi*	P3	San Jacinto	
AMNH F:AM 74230	Equinae	Equini	*Astrohippus*	*ansae*	P3	Chamita	
AMNH F:AM 74273	Equinae	Equini	*Astrohippus*	*stockii*	P3	Ogallala	
AMNH F:AM 74274	Equinae	Equini	*Astrohippus*	*stockii*	P3	Ogallala	
AMNH F:AM 74404	Equinae	Hipparionini	*Nannippus*	*lenticulare*	P3		
AMNH F:AM 74416	Equinae	Hipparionini	*Nannippus*	*lenticulare*	P3		
AMNH F:AM 8105	Equinae	"Merychippini"	*Merychippus*	sp.	P3	Deep River	
AMNH F:AM 87201	Equinae	Equini	*Dinohippus*	*leidyanus*	P2	Ogallala	
AMNH F:AM 87201	Equinae	Equini	*Dinohippus*	*leidyanus*	P3	Ogallala	
AMNH F:AM 87201	Equinae	Equini	*Dinohippus*	*leidyanus*	P4	Ogallala	
AMNH F:AM 87201	Equinae	Equini	*Dinohippus*	*leidyanus*	M1	Ogallala	
AMNH F:AM 87201	Equinae	Equini	*Dinohippus*	*leidyanus*	M2	Ogallala	
AMNH F:AM 87201	Equinae	Equini	*Dinohippus*	*leidyanus*	M3	Ogallala	
AMNH F:AM 87301	Equinae	Equini	*Scaphohippus*	*intermontanus*	P3	Olcott	
AMNH F:AM 87429	Equinae	Equini	*Equus*	*simplicidens*	P3	Keim	
AMNH F:AM 92470	Equinae	Equini	*Equus*	*fraternus*	P4		
AMNH F:AM 95588	Equinae	Equini	*Equus*	*fraternus*	P3	Pool Creek	
AMNH F:AM 99247	Equinae	Equini	*Equus*	*simplicidens*	P3		
AMNH FM 10584	Equinae	Hipparionini	*Nannippus*	*lenticulare*	P3	Clarendon	
AMNH FM 10607	Equinae	Equini	*Equus*	*scotti*	P3	Rock Creek Beds	
AMNH FM 10612	Equinae	Equini	*Equus*	*scotti*	P3	Rock Creek	
AMNH FM 10628	Equinae	Equini	*Equus*	*scotti*	P3	Rock Creek	
AMNH FM 10865	Equinae	Hipparionini	*Neohipparion*	sp.	P3		

AMNH FM 109855	Equinae	"Merychippini"	*Merychippus*	sp.	P3	Tesuque	
AMNH FM 127671	Equinae	Equini	*Equus*	sp.			
AMNH FM 13714	Equinae	Equini	*Equus*	sp.		Phosphate Workings	
AMNH FM 13770	Anchitheriinae	"Anchitheriini"	*Parahippus*	*nebrascensis*	P3		
AMNH FM 140736	Equinae	Equini	*Scaphohippus*	sp.	P3	Tesuque	
AMNH FM 14180	Equinae	"Merychippini"	*Merychippus*	sp.	P3		
AMNH FM 142647	Equinae	Equini	*Scaphohippus*	sp.	P3	Tesuque	
AMNH FM 14296	Equinae	Equini	*Equus*	*complicatus*	P2	Gravel	
AMNH FM 143258	Equinae	"Merychippini"	*Merychippus*	sp.	P3	Barstow	
AMNH FM 15549	Equinae	Equini	*Equus*	sp.	M2		
AMNH FM 17224	Equinae	Equini	*Dinohippus*	*leidyanus*	P3		
AMNH FM 18297	Equinae	"Merychippini"	*Merychippus*	*insignis*	P3	Olcott	
AMNH FM 18299	Equinae	"Merychippini"	*Merychippus*	*insignis*	P3	Olcott	
AMNH FM 18655	Equinae	Equini	*Equus*	*simplicidens*	P3		
AMNH FM 18972	Equinae	Equini	*Dinohippus*	*leidyanus*	P3	Snake Creek	
AMNH FM 22733	Equinae	Equini	*Equus*	*intermedius*	P3	Avery Island	
AMNH FM 27834	Equinae	Equini	*Equus*	*complicatus*		Avery Island	
AMNH FM 32551	Equinae	Equini	*Equus*	*simplicidens*	P3	Glenns Ferry	
AMNH FM 39407	Equinae	Equini	*Equus*	*complicatus*	P3		
AMNH FM 55595	Equinae	Equini	*Equus*	*fraternus*		Phosphate Workings	
AMNH FM 8175	Equinae	"Merychippini"	*Acritohippus*	sp.	P3	Mascall	
AMNH FM 8347	Equinae	"Merychippini"	*Merychippus*	*republicanus*	P3		
AMNH FM 9201	Equinae	Equini	*Equus*	sp.		Phosphate Workings	
AMNH FM 9203	Equinae	Equini	*Equus*	*fraternus*	P3	Phosphate Workings	
AMNH FM 9395	Anchitheriinae	"Anchitheriini"	*Hypohippus*	*osborni*	P3	Pawnee Buttes	
AMNH FM 9400	Equinae	Equini	*Merychippus*	n. sp.	P3	Pawnee Creek	
AMNH FM 9820	Equinae	Equini	*Protohippus*	*simus*	P3		

AMNH FM 9967	Equinae	Equini	*Equus*	sp.		Cave	
CIT 363	Equinae	Hipparionini	*Merychippus*	*seversus*	P2	Mascall	
CIT 363	Equinae	Hipparionini	*Merychippus*	*seversus*	P3	Mascall	
CIT 363	Equinae	Hipparionini	*Merychippus*	*seversus*	P4	Mascall	
CIT 363	Equinae	Hipparionini	*Merychippus*	*seversus*	M1	Mascall	
CIT 363	Equinae	Hipparionini	*Merychippus*	*seversus*	M2	Mascall	
CIT 363	Equinae	Hipparionini	*Merychippus*	*seversus*	M3	Mascall	
JODA 10014	Equinae	Hipparionini	*Hipparion*	sp.		Juntura	
JODA 10703	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.		Mascall	
JODA 1079, A	Equinae	Hipparionini	*Merychippus*	*seversus*	P2	Simtustus	
JODA 1079, A	Equinae	Hipparionini	*Merychippus*	*seversus*	P3	Simtustus	
JODA 1079, A	Equinae	Hipparionini	*Merychippus*	*seversus*	P4	Simtustus	
JODA 1079, A	Equinae	Hipparionini	*Merychippus*	*seversus*	M1	Simtustus	
JODA 1079, A	Equinae	Hipparionini	*Merychippus*	*seversus*	M2	Simtustus	
JODA 1316	Equinae	Hipparionini	*Merychippus*	*seversus*	P2	Mascall	
JODA 1316	Equinae	Hipparionini	*Merychippus*	*seversus*	P3	Mascall	
JODA 1316	Equinae	Hipparionini	*Merychippus*	*seversus*	P4	Mascall	
JODA 1316	Equinae	Hipparionini	*Merychippus*	*seversus*	M1	Mascall	
JODA 1316	Equinae	Hipparionini	*Merychippus*	*seversus*	M2	Mascall	
JODA 1316	Equinae	Hipparionini	*Merychippus*	*seversus*	M3	Mascall	
JODA 1318	Equinae	"Merychippini"	*Merychippus*	sp.	P3	Mascall	
JODA 1318	Equinae	"Merychippini"	*Merychippus*	sp.	P4	Mascall	
JODA 1318	Equinae	"Merychippini"	*Merychippus*	sp.	M1	Mascall	
JODA 1318	Equinae	"Merychippini"	*Merychippus*	sp.	M2	Mascall	
JODA 1318	Equinae	"Merychippini"	*Merychippus*	sp.	M3	Mascall	
JODA 1332	Anchitheriinae	"Anchitheriini"	*Archaeohippus*	sp.	P3	Mascall	
JODA 1332	Anchitheriinae	"Anchitheriini"	*Archaeohippus*	sp.	P4	Mascall	

JODA 1332	Anchitheriinae	"Anchitheriini"	*Archaeohippus*	sp.	M1	Mascall	
JODA 1332	Anchitheriinae	"Anchitheriini"	*Archaeohippus*	sp.	M2	Mascall	
JODA 1332	Anchitheriinae	"Anchitheriini"	*Archaeohippus*	sp.	M3	Mascall	
JODA 1333	Equinae	Equini	*Pliohippus*	sp.	P2	Rattlesnake	
JODA 1333	Equinae	Equini	*Pliohippus*	sp.	P3	Rattlesnake	
JODA 1333	Equinae	Equini	*Pliohippus*	sp.	P4	Rattlesnake	
JODA 1333	Equinae	Equini	*Pliohippus*	sp.	M1	Rattlesnake	
JODA 1333	Equinae	Equini	*Pliohippus*	sp.	M2	Rattlesnake	
JODA 1333	Equinae	Equini	*Pliohippus*	sp.	M3	Rattlesnake	
JODA 1979	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 1980	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 1981	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 1982	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 1987	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 1988	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 1990	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 1997	Equinae	"Merychippini"	*Merychippus*	sp.	P2	Mascall	
JODA 1998	Equinae	"Merychippini"	*Merychippus*	sp.	P2	Mascall	
JODA 2001	Equinae	Hipparionini	*Hipparion*	sp.		Rattlesnake	
JODA 2066	Equinae	Hipparionini	*Neohipparion*	sp.		Rattlesnake	
JODA 2069	Equinae	Equini	*Pliohippus*	sp.		Rattlesnake	
JODA 2072	Equinae	Equini	*Pliohippus*	sp.	P2	Rattlesnake	
JODA 2402	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.		Mascall	
JODA 2405	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.		Mascall	
JODA 2406	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.		Mascall	
JODA 2407	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.		Mascall	
JODA 2408	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.		Mascall	

JODA 2409	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.		Mascall	
JODA 2428			?			Mascall	
JODA 2435	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.	P2	Mascall	
JODA 2435	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.	P3	Mascall	
JODA 2435	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.	P4	Mascall	
JODA 2435	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.	M1	Mascall	
JODA 2435	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.	M2	Mascall	
JODA 2435	Anchitheriinae	"Anchitheriini"	*Parahippus*	sp.	M3	Mascall	
JODA 2446	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 2564	Equinae	Hipparionini	*Cormohipparion*	sp.		Rattlesnake	
JODA 293	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 294	Equinae	"Merychippini"	*Merychippus*	sp.		Mascall	
JODA 561	Equinae	Hipparionini	*Neohipparion*	sp.		Rattlesnake	
MVZ 117884	Equinae	Equini	*Equus*	*quagga*	P2		
MVZ 117884	Equinae	Equini	*Equus*	*quagga*	P3		
MVZ 117884	Equinae	Equini	*Equus*	*quagga*	P4		
MVZ 117884	Equinae	Equini	*Equus*	*quagga*	M1		
MVZ 117884	Equinae	Equini	*Equus*	*quagga*	M2		
MVZ 117884	Equinae	Equini	*Equus*	*quagga*	M3		
MVZ 117885	Equinae	Equini	*Equus*	*quagga*	P2		
MVZ 117885	Equinae	Equini	*Equus*	*quagga*	P3		
MVZ 117885	Equinae	Equini	*Equus*	*quagga*	P4		
MVZ 117885	Equinae	Equini	*Equus*	*quagga*	M1		
MVZ 117885	Equinae	Equini	*Equus*	*quagga*	M2		
MVZ 117885	Equinae	Equini	*Equus*	*quagga*	M3		
MVZ 117887	Equinae	Equini	*Equus*	*quagga*	P2		
MVZ 117887	Equinae	Equini	*Equus*	*quagga*	P3		

MVZ 117887	Equinae	Equini	*Equus*	*quagga*	P4		
MVZ 117887	Equinae	Equini	*Equus*	*quagga*	M1		
MVZ 117887	Equinae	Equini	*Equus*	*quagga*	M2		
MVZ 117887	Equinae	Equini	*Equus*	*quagga*	M3		
MVZ 117888	Equinae	Equini	*Equus*	*quagga*	P2		
MVZ 117888	Equinae	Equini	*Equus*	*quagga*	P3		
MVZ 117888	Equinae	Equini	*Equus*	*quagga*	P4		
MVZ 117888	Equinae	Equini	*Equus*	*quagga*	M1		
MVZ 117888	Equinae	Equini	*Equus*	*quagga*	M2		
MVZ 117888	Equinae	Equini	*Equus*	*quagga*	M3		
MVZ 154358	Equinae	Equini	*Equus*	*asinus*	P2		
MVZ 154358	Equinae	Equini	*Equus*	*asinus*	P3		
MVZ 154358	Equinae	Equini	*Equus*	*asinus*	P4		
MVZ 154358	Equinae	Equini	*Equus*	*asinus*	M1		
MVZ 154358	Equinae	Equini	*Equus*	*asinus*	M2		
MVZ 154358	Equinae	Equini	*Equus*	*asinus*	M3		
MVZ 55150	Equinae	Equini	*Equus*	*grevyi*	P2		
MVZ 55150	Equinae	Equini	*Equus*	*grevyi*	P3		
MVZ 55150	Equinae	Equini	*Equus*	*grevyi*	P4		
MVZ 55150	Equinae	Equini	*Equus*	*grevyi*	M1		
MVZ 55150	Equinae	Equini	*Equus*	*grevyi*	M2		
MVZ 55150	Equinae	Equini	*Equus*	*grevyi*	M3		
SDSM 12195	Equinae	Equini	*Equus*	*calobatus*			
SDSM 22027	Equinae	Equini	*Equus*	*simplicidens*	P2	Savage Island? Ringold?	
SDSM 22032	Equinae	Equini	*Equus*	*simplicidens*		Savage Island? Ringold?	
SDSM 505	Equinae	"Merychippini"	*Merychippus*	c.f. *sejunctus*	P2	Lower Snake Creek	
SDSM 505	Equinae	"Merychippini"	*Merychippus*	c.f. *sejunctus*	P3	Lower Snake Creek	

SDSM 505	Equinae	"Merychippini"	*Merychippus*	c.f. *sejunctus*	P4	Lower Snake Creek	
SDSM 505	Equinae	"Merychippini"	*Merychippus*	c.f. *sejunctus*	M1	Lower Snake Creek	
SDSM 505	Equinae	"Merychippini"	*Merychippus*	c.f. *sejunctus*	M2	Lower Snake Creek	
SDSM 505	Equinae	"Merychippini"	*Merychippus*	c.f. *sejunctus*	M3	Lower Snake Creek	
SDSM 5057	Equinae	"Merychippini"	*Merychippus*	sp.		Lower Snake Creek	
SDSM 5057	Equinae	"Merychippini"	*Merychippus*	sp.		Lower Snake Creek	
SDSM 53217	Equinae	Hipparionini	*Pseudhipparion*	sp.		Ash Hollow	
SDSM 53217 F1	Equinae	Hipparionini	*Pseudhipparion*	sp.		Ash Hollow	
SDSM 53217-12	Equinae	Hipparionini	*Cormohipparion*	sp.		Ash Hollow	
SDSM 53217-17	Equinae	Hipparionini	*Neohipparion*	sp.		Ash Hollow	
SDSM 53217-3	Equinae	Hipparionini	*Cormohipparion*	sp.		Ash Hollow	
SDSM 53217-30	Equinae	Hipparionini	*Cormohipparion*	sp.		Ash Hollow	
SDSM 53217-31	Equinae	Hipparionini	*Neohipparion*	sp.		Ash Hollow	
SDSM 53217-34	Equinae	Hipparionini	*Cormohipparion*	sp.		Ash Hollow	
SDSM 53217-40	Equinae	Hipparionini	*Cormohipparion*	sp.		Ash Hollow	
SDSM 53217-5	Equinae	Equini	*Pliohippus*	sp.		Ash Hollow	
SDSM 53217-9	Equinae	Hipparionini	*Neohipparion*	sp.		Ash Hollow	
SDSM 53217-D	Equinae	Hipparionini	*Neohipparion*	sp.		Ash Hollow	
SDSM 53217-E	Equinae	Hipparionini	*Neohipparion*	sp.		Ash Hollow	
SDSM 53218 E	Equinae	Equini	*Pliohippus*	sp.		Ash Hollow	
SDSM 53218 K	Equinae	Equini	*Calippus*	sp.	P2	Ash Hollow	
SDSM 53219	Equinae	Hipparionini	*Pseudhipparion*	sp.		Ash Hollow	
SDSM 53219 AG	Equinae	Hipparionini	*Pseudhipparion*	sp.		Ash Hollow	
SDSM 53219 AR	Equinae	Hipparionini	*Pseudhipparion*	sp.		Ash Hollow	
SDSM 53219 CJ	Equinae	Hipparionini	*Pseudhipparion*	sp.		Ash Hollow	
SDSM 53219 CZ	Equinae	Hipparionini	*Neohipparion*	sp.		Ash Hollow	
SDSM 53219 DS	Equinae	Hipparionini	*Pseudhipparion*	sp.		Ash Hollow	

SDSM 53219 X	Equinae	Hipparionini	*Pseudhipparion*	sp.		Ash Hollow	
SDSM 53219 Y	Equinae	Hipparionini	*Pseudhipparion*	sp.		Ash Hollow	
SDSM 53220	Equinae	Equini	*Pliohippus*	sp.		Ash Hollow	
SDSM 53220 A	Equinae	Equini	*Pliohippus*	sp.		Ash Hollow	
SDSM 53220 C	Equinae	Equini	*Pliohippus*	sp.		Ash Hollow	
SDSM 53220-01	Equinae	Equini	*Pliohippus*	sp.		Ash Hollow	
SDSM 5622	Equinae	"Merychippini"	*Merychippus*	sp.		Lower Snake Creek	
SDSM 5622	Equinae	"Merychippini"	*Merychippus*	sp.		Lower Snake Creek	
SDSM 577 Q	Equinae	Equini	*Calippus*	sp.		Ash Hollow	
SDSM 577P-03	Equinae	Equini	*Calippus*	sp.		Ash Hollow	
SDSM 62281	Equinae	Hipparionini	*Pseudhipparion*	sp.	P4	Ash Hollow	
SDSM 62281	Equinae	Hipparionini	*Pseudhipparion*	sp.	M1	Ash Hollow	
SDSM 62281	Equinae	Hipparionini	*Pseudhipparion*	sp.	M2	Ash Hollow	
SDSM 62290	Equinae	Equini	*Equus*	sp.			
SDSM 65125	Equinae	Hipparionini	*Merychippus*	sp.	P2	Lower Snake Creek	
SDSM 65125	Equinae	Hipparionini	*Merychippus*	sp.		Lower Snake Creek	
SDSM 7861	Equinae	Hipparionini	*Pseudhipparion*	sp.	P3	Ash Hollow	
SDSM 7861	Equinae	Hipparionini	*Pseudhipparion*	sp.	P4	Ash Hollow	
SDSM 7861	Equinae	Hipparionini	*Pseudhipparion*	sp.	M1	Ash Hollow	
SDSM 7861	Equinae	Hipparionini	*Pseudhipparion*	sp.	M2	Ash Hollow	
UCMP 124927	Equinae	Equini	*Pliohippus*	sp.	P2	Mehrten	
UCMP 124927	Equinae	Equini	*Pliohippus*	sp.	P3	Mehrten	
UCMP 124927	Equinae	Equini	*Pliohippus*	sp.	P4	Mehrten	
UCMP 124927	Equinae	Equini	*Pliohippus*	sp.	M1	Mehrten	
UCMP 124927	Equinae	Equini	*Pliohippus*	sp.	M2	Mehrten	
UCMP 124927	Equinae	Equini	*Pliohippus*	sp.	M3	Mehrten	
UCMP 21422	Equinae	Equini	*Scaphohippus*	*sumani*	P3	Barstow	

UCMP 21422	Equinae	Equini	*Scaphohippus*	*sumani*	P4	Barstow	
UCMP 21422	Equinae	Equini	*Scaphohippus*	*sumani*	M1	Barstow	
UCMP 21422	Equinae	Equini	*Scaphohippus*	*sumani*	M2	Barstow	
UCMP 23088	Equinae	Hipparionini	*Merychippus*	*seversus*	P2	Mascall	
UCMP 23088	Equinae	Hipparionini	*Merychippus*	*seversus*	P3	Mascall	
UCMP 23088	Equinae	Hipparionini	*Merychippus*	*seversus*	P4	Mascall	
UCMP 23088	Equinae	Hipparionini	*Merychippus*	*seversus*	M1	Mascall	
UCMP 23088	Equinae	Hipparionini	*Merychippus*	*seversus*	M2	Mascall	
UCMP 23088	Equinae	Hipparionini	*Merychippus*	*seversus*	M3	Mascall	
UCMP 27126	Equinae	Hipparionini	*Neohipparion*	*leptode*	P2	Thousand Creek	
UCMP 27126	Equinae	Hipparionini	*Neohipparion*	*leptode*	P3	Thousand Creek	
UCMP 27126	Equinae	Hipparionini	*Neohipparion*	*leptode*	P4	Thousand Creek	
UCMP 27126	Equinae	Hipparionini	*Neohipparion*	*leptode*	M1	Thousand Creek	
UCMP 27126	Equinae	Hipparionini	*Neohipparion*	*leptode*	M2	Thousand Creek	
UCMP 27126	Equinae	Hipparionini	*Neohipparion*	*leptode*	M3	Thousand Creek	
UCMP 30200	Equinae	Equini	*Dinohippus*	*interpolatus*	P2	Ogallala	
UCMP 30200	Equinae	Equini	*Dinohippus*	*interpolatus*	P3	Ogallala	
UCMP 30200	Equinae	Equini	*Dinohippus*	*interpolatus*	P4	Ogallala	
UCMP 30200	Equinae	Equini	*Dinohippus*	*interpolatus*	M1	Ogallala	
UCMP 30200	Equinae	Equini	*Dinohippus*	*interpolatus*	M2	Ogallala	
UCMP 30200	Equinae	Equini	*Dinohippus*	*interpolatus*	M3	Ogallala	
UCMP 30225	Equinae	Equini	*Astrohippus*	*ansae*	P2	Ogallala	
UCMP 30225	Equinae	Equini	*Astrohippus*	*ansae*	P3	Ogallala	
UCMP 30225	Equinae	Equini	*Astrohippus*	*ansae*	P4	Ogallala	
UCMP 30225	Equinae	Equini	*Astrohippus*	*ansae*	M1	Ogallala	
UCMP 30225	Equinae	Equini	*Astrohippus*	*ansae*	M2	Ogallala	
UCMP 30225	Equinae	Equini	*Astrohippus*	*ansae*	M3	Ogallala	

UCMP 30813	Equinae	Equini	*Dinohippus*	*interpolatus*	P2	Ogallala	
UCMP 30813	Equinae	Equini	*Dinohippus*	*interpolatus*	P3	Ogallala	
UCMP 30813	Equinae	Equini	*Dinohippus*	*interpolatus*	P4	Ogallala	
UCMP 30813	Equinae	Equini	*Dinohippus*	*interpolatus*	M1	Ogallala	
UCMP 30813	Equinae	Equini	*Dinohippus*	*interpolatus*	M2	Ogallala	
UCMP 30813	Equinae	Equini	*Dinohippus*	*interpolatus*	M3	Ogallala	
UCMP 31256	Equinae	Hipparionini	*Neohipparion*	*eurystyle*	P2	Ogallala	
UCMP 31256	Equinae	Hipparionini	*Neohipparion*	*eurystyle*	P3	Ogallala	
UCMP 31256	Equinae	Hipparionini	*Neohipparion*	*eurystyle*	P4	Ogallala	
UCMP 31256	Equinae	Hipparionini	*Neohipparion*	*eurystyle*	M1	Ogallala	
UCMP 31256	Equinae	Hipparionini	*Neohipparion*	*eurystyle*	M2	Ogallala	
UCMP 31256	Equinae	Hipparionini	*Neohipparion*	*eurystyle*	M3	Ogallala	
UCMP 31875	Equinae	Equini	*Pliohippus*	*tantalus*	P2	Mehrten	
UCMP 31875	Equinae	Equini	*Pliohippus*	*tantalus*	P3	Mehrten	
UCMP 31875	Equinae	Equini	*Pliohippus*	*tantalus*	P4	Mehrten	
UCMP 31875	Equinae	Equini	*Pliohippus*	*tantalus*	M1	Mehrten	
UCMP 31875	Equinae	Equini	*Pliohippus*	*tantalus*	M2	Mehrten	
UCMP 31875	Equinae	Equini	*Pliohippus*	*tantalus*	M3	Mehrten	
UCMP 32306	Equinae	Equini	*Pliohippus*	cf. *pernix*	P2	Ogallala	
UCMP 32306	Equinae	Equini	*Pliohippus*	cf. *pernix*	P3	Ogallala	
UCMP 32306	Equinae	Equini	*Pliohippus*	cf. *pernix*	P4	Ogallala	
UCMP 32306	Equinae	Equini	*Pliohippus*	cf. *pernix*	M1	Ogallala	
UCMP 32306	Equinae	Equini	*Pliohippus*	cf. *pernix*	M2	Ogallala	
UCMP 32306	Equinae	Equini	*Pliohippus*	cf. *pernix*	M3	Ogallala	
UCMP 32503	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	P4	Valentine	Burge
UCMP 32503	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	M1	Valentine	Burge
UCMP 32503	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	M2	Valentine	Burge

UCMP 32503	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	M3	Valentine	Burge
UCMP 32503	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	P2	Valentine	Burge
UCMP 32503	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	P3	Valentine	Burge
UCMP 32504	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	P2	Valentine	Burge
UCMP 32504	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	P3	Valentine	Burge
UCMP 32504	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	P4	Valentine	Burge
UCMP 32504	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	M1	Valentine	Burge
UCMP 32504	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	M2	Valentine	Burge
UCMP 32504	Equinae	Hipparionini	*Pseudhipparion*	*retrusum*	M3	Valentine	Burge
UCMP 32773	Equinae	Equini	*Calippus*	*regulus*	P2	Ogallala	
UCMP 32773	Equinae	Equini	*Calippus*	*regulus*	P3	Ogallala	
UCMP 32773	Equinae	Equini	*Calippus*	*regulus*	P4	Ogallala	
UCMP 32773	Equinae	Equini	*Calippus*	*regulus*	M1	Ogallala	
UCMP 32773	Equinae	Equini	*Calippus*	*regulus*	M2	Ogallala	
UCMP 32773	Equinae	Equini	*Calippus*	*regulus*	M3	Ogallala	
UCMP 32814	Equinae	Equini	*Calippus*	*martini*	P2	Laverne	
UCMP 32814	Equinae	Equini	*Calippus*	*martini*	P3	Laverne	
UCMP 32814	Equinae	Equini	*Calippus*	*martini*	P4	Laverne	
UCMP 32814	Equinae	Equini	*Calippus*	*martini*	M1	Laverne	
UCMP 32814	Equinae	Equini	*Calippus*	*martini*	M2	Laverne	
UCMP 32814	Equinae	Equini	*Calippus*	*martini*	M3	Laverne	
UCMP 33481	Equinae	Equini	*Pliohippus*	sp.	P2	Ogallala	
UCMP 33481	Equinae	Equini	*Pliohippus*	sp.	P3	Ogallala	
UCMP 33481	Equinae	Equini	*Pliohippus*	sp.	P4	Ogallala	
UCMP 33481	Equinae	Equini	*Pliohippus*	sp.	M1	Ogallala	
UCMP 33481	Equinae	Equini	*Pliohippus*	sp.	M2	Ogallala	
UCMP 33481	Equinae	Equini	*Pliohippus*	sp.	M3	Ogallala	

UCMP 34032	Equinae	Equini	*Equus*	*simplicedens*	P2	Glenns Ferry	
UCMP 34032	Equinae	Equini	*Equus*	*simplicedens*	P3	Glenns Ferry	
UCMP 34032	Equinae	Equini	*Equus*	*simplicedens*	P4	Glenns Ferry	
UCMP 34032	Equinae	Equini	*Equus*	*simplicedens*	M1	Glenns Ferry	
UCMP 34032	Equinae	Equini	*Equus*	*simplicedens*	M2	Glenns Ferry	
UCMP 34032	Equinae	Equini	*Equus*	*simplicedens*	M3	Glenns Ferry	
UCMP 34511	Equinae	Hipparionini	*Hipparion*	sp.	P3	Green Valley	
UCMP 34511	Equinae	Hipparionini	*Hipparion*	sp.	P4	Green Valley	
UCMP 34511	Equinae	Hipparionini	*Hipparion*	sp.	M1	Green Valley	
UCMP 34511	Equinae	Hipparionini	*Hipparion*	sp.	M2	Green Valley	
UCMP 34511	Equinae	Hipparionini	*Hipparion*	sp.	M3	Green Valley	
UCMP 50750	Equinae	Equini	*Scaphohippus*	*sumani*	P2	Caliente	
UCMP 50750	Equinae	Equini	*Scaphohippus*	*sumani*	P3	Caliente	
UCMP 50750	Equinae	Equini	*Scaphohippus*	*sumani*	P4	Caliente	
UCMP 50750	Equinae	Equini	*Scaphohippus*	*sumani*	M1	Caliente	
UCMP 50750	Equinae	Equini	*Scaphohippus*	*sumani*	M2	Caliente	
UCMP 50750	Equinae	Equini	*Scaphohippus*	*sumani*	M3	Caliente	
UCMP 50950	Equinae	Equini	*Scaphohippus*	*sumani*	P2	Caliente	
UCMP 50950	Equinae	Equini	*Scaphohippus*	*sumani*	P3	Caliente	
UCMP 50950	Equinae	Equini	*Scaphohippus*	*sumani*	P4	Caliente	
UCMP 50950	Equinae	Equini	*Scaphohippus*	*sumani*	M1	Caliente	
UCMP 50950	Equinae	Equini	*Scaphohippus*	*sumani*	M2	Caliente	
UCMP 50950	Equinae	Equini	*Scaphohippus*	*sumani*	M3	Caliente	
UCMP 51000	Equinae	Equini	*Scaphohippus*	*sumani*	P2	Caliente	
UCMP 51000	Equinae	Equini	*Scaphohippus*	*sumani*	P3	Caliente	
UCMP 51000	Equinae	Equini	*Scaphohippus*	*sumani*	P4	Caliente	
UCMP 51000	Equinae	Equini	*Scaphohippus*	*sumani*	M1	Caliente	

UCMP 51000	Equinae	Equini	*Scaphohippus*	*sumani*	M2	Caliente	
UCMP 51000	Equinae	Equini	*Scaphohippus*	*sumani*	M3	Caliente	
UCMP 56278	Equinae	Equini	*Pliohippus*	sp.	P2	Green Valley	
UCMP 56278	Equinae	Equini	*Pliohippus*	sp.	P3	Green Valley	
UCMP 56278	Equinae	Equini	*Pliohippus*	sp.	P4	Green Valley	
UCMP 56278	Equinae	Equini	*Pliohippus*	sp.	M1	Green Valley	
UCMP 56278	Equinae	Equini	*Pliohippus*	sp.	M2	Green Valley	
UCMP 56278	Equinae	Equini	*Pliohippus*	sp.	M3	Green Valley	
UCMP 64609	Equinae	Hipparionini	*Neohipparion*	*floresi*	P2		
UCMP 64609	Equinae	Hipparionini	*Neohipparion*	*floresi*	P3		
UCMP 64609	Equinae	Hipparionini	*Neohipparion*	*floresi*	P4		
UCMP 64609	Equinae	Hipparionini	*Neohipparion*	*floresi*	M1		
UCMP 64609	Equinae	Hipparionini	*Neohipparion*	*floresi*	M2		
UCMP 64609	Equinae	Hipparionini	*Neohipparion*	*floresi*	M3		
UCMP 69575	Equinae	Hipparionini	*Hipparion*	*forcei*	P2	Ricardo	
UCMP 69575	Equinae	Hipparionini	*Hipparion*	*forcei*	P3	Ricardo	
UCMP 69575	Equinae	Hipparionini	*Hipparion*	*forcei*	P4	Ricardo	
UCMP 69575	Equinae	Hipparionini	*Hipparion*	*forcei*	M1	Ricardo	
UCMP 69575	Equinae	Hipparionini	*Hipparion*	*forcei*	M2	Ricardo	
UCMP 69575	Equinae	Hipparionini	*Hipparion*	*forcei*	M3	Ricardo	
UCMP 97903	Equinae	Equini	*Protohippus*	*perditus*	P2	Valentine	Devil's Gulch
UCMP 97903	Equinae	Equini	*Protohippus*	*perditus*	P3	Valentine	Devil's Gulch
UCMP 97903	Equinae	Equini	*Protohippus*	*perditus*	P4	Valentine	Devil's Gulch
UCMP 97903	Equinae	Equini	*Protohippus*	*perditus*	M1	Valentine	Devil's Gulch
UCMP 97903	Equinae	Equini	*Protohippus*	*perditus*	M2	Valentine	Devil's Gulch
UCMP 97903	Equinae	Equini	*Protohippus*	*perditus*	M3	Valentine	Devil's Gulch
UF 32300	Equinae	Hipparionini	*Cormohipparion*	sp.	P2	Love Bone Bed	

UF 32300	Equinae	Hipparionini	*Cormohipparion*	sp.	P3	Love Bone Bed	
UF 32300	Equinae	Hipparionini	*Cormohipparion*	sp.	P4	Love Bone Bed	
UF 32300	Equinae	Hipparionini	*Cormohipparion*	sp.	M1	Love Bone Bed	
UF 32300	Equinae	Hipparionini	*Cormohipparion*	sp.	M2	Love Bone Bed	
UF 32300	Equinae	Hipparionini	*Cormohipparion*	sp.	M3	Love Bone Bed	
UF 57343	Equinae	Hipparionini	*Pseudhipparion*	*simpsoni*	P4	Bone Valley	
UF 57343	Equinae	Hipparionini	*Pseudhipparion*	*simpsoni*	P4	Bone Valley	
UF 57343	Equinae	Hipparionini	*Pseudhipparion*	*simpsoni*	P4	Bone Valley	
UF 57343	Equinae	Hipparionini	*Pseudhipparion*	*simpsoni*	P4	Bone Valley	
UF 58311	Equinae	Hipparionini	*Pseudhipparion*	*simpsoni*	P4	Ft Green Mine	
UF 58311	Equinae	Hipparionini	*Pseudhipparion*	*simpsoni*	P4	Ft Green Mine	
UF 58311	Equinae	Hipparionini	*Pseudhipparion*	*simpsoni*	P4	Ft Green Mine	
UF 58311	Equinae	Hipparionini	*Pseudhipparion*	*simpsoni*	P4	Ft Green Mine	
UNSM 113025	Equinae	Equini	*Equus*	*calobutus*	M3		
UNSM 113026	Equinae	Equini	*Equus*	*calobutus*	P4		
UNSM 113091	Equinae	Equini	*Equus*	*calobutus*	M1		
UNSM 118794	Equinae	Equini	*Equus*	*calobutus*	P2		
UNSM 118794	Equinae	Equini	*Equus*	*calobutus*	P3		
UNSM 118794	Equinae	Equini	*Equus*	*calobutus*	P4		
UNSM 118794	Equinae	Equini	*Equus*	*calobutus*	M1		
UNSM 118794	Equinae	Equini	*Equus*	*calobutus*	M2		
UNSM 123506	Equinae	Equini	*Equus*	sp.		Loess	
UNSM 123506	Equinae	Equini	*Equus*	sp.		Loess	
UNSM 123506	Equinae	Equini	*Equus*	sp.		Loess	
UNSM 123613	Equinae	Equini	*Equus*	sp.		cave	
UNSM 123657	Equinae	Equini	*Equus*	spp.	M3		
UNSM 123658	Equinae	Equini	*Equus*	spp.			

UNSM 125528	Equinae	Equini	*Protohippus*	*perditus*	P3	Valentine	
UNSM 125529	Equinae	Equini	*Protohippus*	*perditus*	P3	Valentine	
UNSM 125530	Equinae	Hipparionini	*Neohipparion*	*republicanus*	P3	Valentine	
UNSM 125531	Equinae	Hipparionini	*Pseudhipparion*	sp.	P3	Valentine	
UNSM 125532	Anchitheriinae	"Anchitheriini"	*Hypohippus*	sp.	P3	Valentine	
UNSM 125533	Equinae	Hipparionini	*Neohipparion*	*republicanus*	P3	Valentine	
UNSM 125534	Equinae	Equini	*Calippus*	placidus	P3	Valentine	
UNSM 129108	Equinae	Equini	*Equus*	*scotti*			
UNSM 133050	Equinae	Equini	*Equus*	sp.		cave	
UNSM 133051	Equinae	Equini	*Equus*	sp.		cave	
UNSM 133052	Equinae	Equini	*Equus*	spp.			
UNSM 133053	Equinae	Equini	*Equus*	*complicatus*	M3		
UNSM 133054	Equinae	Equini	*Equus*	spp.			
UNSM 133055	Equinae	Equini	*Equus*	spp.			
UNSM 133056	Equinae	Equini	*Equus*	*scotti*			
UNSM 133057	Equinae	Equini	*Equus*	*scotti*			
UNSM 133058	Equinae	Equini	*Equus*	sp.		High Terrace	
UNSM 133059	Equinae	Equini	*Equus*	*excelsus*	P2		
UNSM 133059	Equinae	Equini	*Equus*	*excelsus*	P3		
UNSM 133059	Equinae	Equini	*Equus*	*excelsus*	P4		
UNSM 133060	Equinae	Equini	*Equus*	*idahoensis*	M2	Long Pine	
UNSM 133061	Equinae	Equini	*Equus*	*idahoensis*	P3	Long Pine	
UNSM 133061	Equinae	Equini	*Equus*	*idahoensis*	P4	Long Pine	
UNSM 133061	Equinae	Equini	*Equus*	*idahoensis*	M1	Long Pine	
UNSM 133061	Equinae	Equini	*Equus*	*idahoensis*	M2	Long Pine	
UNSM 133061	Equinae	Equini	*Equus*	*idahoensis*	M3	Long Pine	
UNSM 133063	Equinae	Equini	*Equus*	*simplicidens*	P2	Broadwater	

UNSM 133063	Equinae	Equini	*Equus*	*simplicidens*	P3	Broadwater	
UNSM 133063	Equinae	Equini	*Equus*	*simplicidens*	P4	Broadwater	
UNSM 133063	Equinae	Equini	*Equus*	*simplicidens*	M1	Broadwater	
UNSM 133063	Equinae	Equini	*Equus*	*simplicidens*	M2	Broadwater	
UNSM 133063	Equinae	Equini	*Equus*	*simplicidens*	M3	Broadwater	
UNSM 1349	Equinae	Equini	*Equus*	*scotti*	P2		
UNSM 1349	Equinae	Equini	*Equus*	*scotti*	P3		
UNSM 1349	Equinae	Equini	*Equus*	*scotti*	P4		
UNSM 1349	Equinae	Equini	*Equus*	*scotti*	M1		
UNSM 1349	Equinae	Equini	*Equus*	*scotti*	M2		
UNSM 1349	Equinae	Equini	*Equus*	*scotti*	M3		
UNSM 1350	Equinae	Equini	*Equus*	*simplicidens*	P2	Glenns Ferry	
UNSM 1350	Equinae	Equini	*Equus*	*simplicidens*	P3	Glenns Ferry	
UNSM 1350	Equinae	Equini	*Equus*	*simplicidens*	P4	Glenns Ferry	
UNSM 1350	Equinae	Equini	*Equus*	*simplicidens*	M1	Glenns Ferry	
UNSM 1350	Equinae	Equini	*Equus*	*simplicidens*	M2	Glenns Ferry	
UNSM 1350	Equinae	Equini	*Equus*	*simplicidens*	M3	Glenns Ferry	
UNSM 1352	Equinae	Hipparionini	*Pseudhipparion*	sp.	P3	Valentine	
UNSM 238941	Equinae	Hipparionini	*Neohipparion*	*affine*	P3	Ash Hollow	
UNSM 2626	Equinae	Hipparionini	*Neohipparion*	*leptode*		Ash Hollow	
UNSM 2634	Equinae	Equini	*Protohippus*	sp.	P3	Ash Hollow	
UNSM 2672	Equinae	Hipparionini	*Neohipparion*	sp.	P3	Valentine	
UNSM 27799	Equinae	Equini	*Calippus*	sp.	P3	Ash Hollow	
UNSM 27845	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	P2	Ash Hollow	Cap Rock
UNSM 27845	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	P3	Ash Hollow	Cap Rock
UNSM 27845	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	P4	Ash Hollow	Cap Rock
UNSM 27845	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	M1	Ash Hollow	Cap Rock

UNSM 27845	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	M2	Ash Hollow	Cap Rock
UNSM 27845	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	M3	Ash Hollow	Cap Rock
UNSM 27860	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P2	Ash Hollow	Cap Rock
UNSM 27860	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P3	Ash Hollow	Cap Rock
UNSM 27860	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P4	Ash Hollow	Cap Rock
UNSM 27860	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	M1	Ash Hollow	Cap Rock
UNSM 27860	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	M2	Ash Hollow	Cap Rock
UNSM 27860	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	M3	Ash Hollow	Cap Rock
UNSM 27861	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P2	Ash Hollow	Cap Rock
UNSM 27861	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P3	Ash Hollow	Cap Rock
UNSM 27861	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P4	Ash Hollow	Cap Rock
UNSM 27861	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	M1	Ash Hollow	Cap Rock
UNSM 27861	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	M2	Ash Hollow	Cap Rock
UNSM 27861	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	M3	Ash Hollow	Cap Rock
UNSM 27864	Equinae	Equini	*Pliohippus*	*pernix*	P2	Ash Hollow	Cap Rock
UNSM 27864	Equinae	Equini	*Pliohippus*	*pernix*	P3	Ash Hollow	Cap Rock
UNSM 27864	Equinae	Equini	*Pliohippus*	*pernix*	P4	Ash Hollow	Cap Rock
UNSM 27864	Equinae	Equini	*Pliohippus*	*pernix*	M1	Ash Hollow	Cap Rock
UNSM 27864	Equinae	Equini	*Pliohippus*	*pernix*	M2	Ash Hollow	Cap Rock
UNSM 27864	Equinae	Equini	*Pliohippus*	*pernix*	M3	Ash Hollow	Cap Rock
UNSM 27865	Equinae	Equini	*Pliohippus*	*pernix*	P2	Ash Hollow	Cap Rock
UNSM 27865	Equinae	Equini	*Pliohippus*	*pernix*	P3	Ash Hollow	Cap Rock
UNSM 27865	Equinae	Equini	*Pliohippus*	*pernix*	P4	Ash Hollow	Cap Rock
UNSM 27865	Equinae	Equini	*Pliohippus*	*pernix*	M1	Ash Hollow	Cap Rock
UNSM 27865	Equinae	Equini	*Pliohippus*	*pernix*	M2	Ash Hollow	Cap Rock
UNSM 27875	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	P2	Ash Hollow	Cap Rock
UNSM 27875	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	P3	Ash Hollow	Cap Rock

UNSM 27875	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	P4	Ash Hollow	Cap Rock
UNSM 27875	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	M1	Ash Hollow	Cap Rock
UNSM 27875	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	M2	Ash Hollow	Cap Rock
UNSM 27875	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	M3	Ash Hollow	Cap Rock
UNSM 2997	Equinae	Hipparionini	*Neohipparion*	sp.	P3	Ash Hollow	
UNSM 33162	Equinae	Equini	*Equus*	sp.			
UNSM 33508	Equinae	Equini	*Equus*	*excelsus*	P3		
UNSM 33508	Equinae	Equini	*Equus*	*excelsus*	P4		
UNSM 33527	Equinae	Equini	*Equus*	*excelsus*	M3		
UNSM 41996	Equinae	Equini	*Equus*	*simplicidens*	P3	Broadwater	
UNSM 41996	Equinae	Equini	*Equus*	*simplicidens*	P4	Broadwater	
UNSM 41996	Equinae	Equini	*Equus*	*simplicidens*	M1	Broadwater	
UNSM 41996	Equinae	Equini	*Equus*	*simplicidens*	M2	Broadwater	
UNSM 41996	Equinae	Equini	*Equus*	*simplicidens*	M3	Broadwater	
UNSM 42087	Equinae	Equini	*Equus*	*simplicidens*	P2	Broadwater	
UNSM 42087	Equinae	Equini	*Equus*	*simplicidens*	P3	Broadwater	
UNSM 42087	Equinae	Equini	*Equus*	*simplicidens*	P4	Broadwater	
UNSM 42087	Equinae	Equini	*Equus*	*simplicidens*	M1	Broadwater	
UNSM 42087	Equinae	Equini	*Equus*	*simplicidens*	M2	Broadwater	
UNSM 42087	Equinae	Equini	*Equus*	*simplicidens*	M3	Broadwater	
UNSM 42346	Equinae	Equini	*Equus*	*simplicidens*	P2	Broadwater	
UNSM 42346	Equinae	Equini	*Equus*	*simplicidens*	P3	Broadwater	
UNSM 42346	Equinae	Equini	*Equus*	*simplicidens*	P4	Broadwater	
UNSM 42346	Equinae	Equini	*Equus*	*simplicidens*	M1	Broadwater	
UNSM 42346	Equinae	Equini	*Equus*	*simplicidens*	M2	Broadwater	
UNSM 42346	Equinae	Equini	*Equus*	*simplicidens*	M3	Broadwater	
UNSM 42351	Equinae	Equini	*Equus*	*simplicidens*	P2	Broadwater	

UNSM 42351	Equinae	Equini	*Equus*	*simplicidens*	P3	Broadwater	
UNSM 42351	Equinae	Equini	*Equus*	*simplicidens*	P4	Broadwater	
UNSM 42351	Equinae	Equini	*Equus*	*simplicidens*	M1	Broadwater	
UNSM 42351	Equinae	Equini	*Equus*	*simplicidens*	M2	Broadwater	
UNSM 42351	Equinae	Equini	*Equus*	*simplicidens*	M3	Broadwater	
UNSM 42431	Equinae	Equini	*Calippus*	*placidus*	P3	Valentine	
UNSM 42433	Equinae	Equini	*Pliohippus*	sp.	P3	Ash Hollow	Burge
UNSM 42440	Equinae	Hipparionini	*Neohipparion*	*affine*	P3	Valentine	
UNSM 42442	Equinae	Hipparionini			P3	Valentine	Crookston Bridge
UNSM 42447	Equinae	Hipparionini	*Neohipparion*	*affine*	P3	Valentine	
UNSM 42452	Equinae	Hipparionini	*Neohipparion*	sp.	P3	Valentine	
UNSM 42453	Equinae	Equini	*Pliohippus*	sp.	M2	Ash Hollow	Burge
UNSM 42454	Equinae	Equini	*Pliohippus*	sp.	P3	Ash Hollow	Burge
UNSM 42456	Equinae	Equini	*Protohippus*	sp.	P3	Valentine	
UNSM 42468	Equinae	Hipparionini	*Pseudhipparion*	sp.	P3	Ash Hollow	Burge
UNSM 4289	Equinae	Hipparionini	*Neohipparion*	sp.	P3	Ash Hollow	
UNSM 46810	Equinae	Equini	*Equus*	*idahoensis*	M3	Long Pine	
UNSM 49318	Equinae	Equini	*Equus*	*scotti*			
UNSM 49417	Equinae	Equini	*Equus*	*hemionus*	M3		
UNSM 52296	Equinae	Hipparionini	*Neohipparion*	*affine*	P2	Ash Hollow	Cap Rock
UNSM 52296	Equinae	Hipparionini	*Neohipparion*	*affine*	P3	Ash Hollow	Cap Rock
UNSM 52296	Equinae	Hipparionini	*Neohipparion*	*affine*	P4	Ash Hollow	Cap Rock
UNSM 52296	Equinae	Hipparionini	*Neohipparion*	*affine*	M1	Ash Hollow	Cap Rock
UNSM 52296	Equinae	Hipparionini	*Neohipparion*	*affine*	M2	Ash Hollow	Cap Rock
UNSM 52296	Equinae	Hipparionini	*Neohipparion*	*affine*	M3	Ash Hollow	Cap Rock
UNSM 52300	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P2	Ash Hollow	Cap Rock
UNSM 52300	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P3	Ash Hollow	Cap Rock

UNSM 52300	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P4	Ash Hollow	Cap Rock
UNSM 52300	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	M1	Ash Hollow	Cap Rock
UNSM 52300	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	M2	Ash Hollow	Cap Rock
UNSM 52300	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	M3	Ash Hollow	Cap Rock
UNSM 54835	Equinae	Equini	*Equus*	*idahoensis*	M1	Long Pine	
UNSM 54837	Equinae	Equini	*Equus*	*idahoensis*	M1	Long Pine	
UNSM 54839	Equinae	Equini	*Equus*	*idahoensis*	M3	Long Pine	
UNSM 54840	Equinae	Equini	*Equus*	*idahoensis*	P2	Long Pine	
UNSM 56653	Equinae	Equini	*Protohippus*	sp.	P3	Valentine	
UNSM 59261	Equinae	Equini	*Calippus*	sp.	P3	Ash Hollow	
UNSM 59443	Equinae	Hipparionini	*Neohipparion*	sp.	M2	Ash Hollow	
UNSM 5978	Equinae	Equini	*Equus*	*excelsus*	P2		
UNSM 5978	Equinae	Equini	*Equus*	*excelsus*	P3		
UNSM 5978	Equinae	Equini	*Equus*	*excelsus*	P4		
UNSM 5978	Equinae	Equini	*Equus*	*excelsus*	M1		
UNSM 5978	Equinae	Equini	*Equus*	*excelsus*	M2		
UNSM 6023	Equinae	Equini	*Equus*	*semiplicatus*	P3		
UNSM 6023	Equinae	Equini	*Equus*	*semiplicatus*	P4		
UNSM 6023	Equinae	Equini	*Equus*	*semiplicatus*	M1		
UNSM 6023	Equinae	Equini	*Equus*	*semiplicatus*	M2		
UNSM 6023	Equinae	Equini	*Equus*	*semiplicatus*	M3		
UNSM 6027	Equinae	Equini	*Equus*	*fraternus*	P4		
UNSM 6027	Equinae	Equini	*Equus*	*fraternus*	M1		
UNSM 6027	Equinae	Equini	*Equus*	*fraternus*	M2		
UNSM 6027	Equinae	Equini	*Equus*	*fraternus*	M3		
UNSM 62895	Equinae	Equini	*Equus*	*idahoensis*	M2	Long Pine	
UNSM 84000	Equinae	Hipparionini	*Neohipparion*	*republicanus*	P3	Valentine	

UNSM 8515	Equinae	Equini	*Protohippus*	perditus	P3	Valentine	
UNSM 8633	Equinae	Hipparionini	*Neohipparion*	sp.	P3	Ash Hollow	
UNSM 90576	Anchitheriinae	"Anchitheriini"	*Parahippus*	cognatus	P3	Valentine	
UNSM 90641	Equinae	Equini	*Protohippus*	sp.	P3	Ash Hollow	
UNSM 94445	Equinae	Equini	*Pliohippus*	*noblis*		Ash Hollow	
UNSM 96997	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P3	Valentine	
UNSM 96999	Equinae	Hipparionini	*Pseudhipparion*	sp.	P3	Valentine	
UNSM 9798	Equinae	Equini	*Protohippus*	*perditus*	P3	Valentine	
UNSM 9800	Equinae	Equini	*Protohippus*	*perditus*	M2	Valentine	
UNSM 98405	Equinae	Equini	*Pliohippus*	*mirabilis*	M1	Valentine	
UNSM 98406	Equinae	Equini	*Pliohippus*	*mirabilis*	M1	Valentine	
UOMNCH B-4028	Equinae	Equini	*Equus*	*caballus*	P2		
UOMNCH B-4028	Equinae	Equini	*Equus*	*caballus*	P3		
UOMNCH B-4028	Equinae	Equini	*Equus*	*caballus*	P4		
UOMNCH B-4028	Equinae	Equini	*Equus*	*caballus*	M1		
UOMNCH B-4028	Equinae	Equini	*Equus*	*caballus*	M2		
UOMNCH B-4028	Equinae	Equini	*Equus*	*caballus*	M3		
UOMNCH B-8698	Equinae	Equini	*Equus*	*caballus*	P2		
UOMNCH B-8698	Equinae	Equini	*Equus*	*caballus*	P3		
UOMNCH B-8698	Equinae	Equini	*Equus*	*caballus*	P4		
UOMNCH B-8698	Equinae	Equini	*Equus*	*caballus*	M1		
UOMNCH B-8698	Equinae	Equini	*Equus*	*caballus*	M2		
UOMNCH B-8698	Equinae	Equini	*Equus*	*caballus*	M3		
UOMNCH B-8700	Equinae	Equini	*Equus*	*caballus*	P2		
UOMNCH B-8700	Equinae	Equini	*Equus*	*caballus*	P3		
UOMNCH B-8700	Equinae	Equini	*Equus*	*caballus*	P4		
UOMNCH B-8700	Equinae	Equini	*Equus*	*caballus*	M1		
UOMNCH B-8700	Equinae	Equini	*Equus*	*caballus*	M2		

UOMNCH B-8700	Equinae	Equini	*Equus*	*caballus*	M3		
UOMNCH B-9092	Equinae	Equini	*Equus*	*caballus*	P2		
UOMNCH B-9092	Equinae	Equini	*Equus*	*caballus*	P3		
UOMNCH B-9092	Equinae	Equini	*Equus*	*caballus*	P4		
UOMNCH B-9092	Equinae	Equini	*Equus*	*caballus*	M1		
UOMNCH B-9092	Equinae	Equini	*Equus*	*caballus*	M2		
UOMNCH B-9092	Equinae	Equini	*Equus*	*caballus*	M3		
UOMNCH F-21828	Equinae	Equini	*Equus*	sp.		Fossil Lake	
USNM 10314	Equinae	Equini	*Equus*	sp.	P3	Dragon Mountains	
USNM 10482	Equinae	Equini	*Equus*	*"nevadanus"*	P3	Gravel	
USNM 10571	Equinae	Equini	*Equus*	*leidyi*		Tampa Bay	
USNM 10622	Equinae	Equini	*Equus*	*leidyi*	M3	Tampa Bay	
USNM 11160	Equinae	Equini	*Equus*	*lambei*	P3	Hunker Creek	
USNM 11190	Equinae	Equini	*Equus*	*leidyi*		Melbourne	
USNM 11192	Equinae	Equini	*Equus*	*fraternus*	P2	Melbourne	
USNM 11200	Equinae	Equini	*Equus*	*leidyi*		Melbourne	
USNM 11351	Equinae	Equini	*Equus*	*scotti*		Sulpher Springs Valley	
USNM 11372	Equinae	Equini	*Equus*	*complicatus*			
USNM 11374	Equinae	Equini	*Equus*	*complicatus*	M3		
USNM 11412	Equinae	Equini	*Equus*	*leidyi*	M3		
USNM 11623	Equinae	Equini	*Equus*	*complicatus*			
USNM 11658	Equinae	Equini	*Equus*	sp.	P3		
USNM 1172	Equinae	Equini	*Equus*	sp.		Phosphate Bed	
USNM 11745	Equinae	Hipparionini	*Nannippus*	*phlegon*		San Pedro Valley	
USNM 11746	Equinae	Hipparionini	*Hipparion*	sp.		San Pedro Valley	
USNM 11819	Equinae	Equini	*Equus*	*leidyi*		Savannah	
USNM 11986	Equinae	Equini	*Equus*	*simplicidens*	P3	Glenns Ferry	

USNM 12146	Equinae	Equini	*Equus*	*lambei*	P3	Sullivan Creek	
USNM 12804	Equinae	Equini	*Equus*	*lambei*	P3	Skull Cliff	
USNM 12875	Equinae	Equini	*Equus*	sp.		San Pedro Valley	
USNM 13682	Equinae	Equini	*Equus*	sp.		Lake Chetek	
USNM 14417	Equinae	Equini	*Equus*	sp.	P3	Twin Falls	
USNM 15219	Equinae	Equini	*Equus*	*leidyi*		Lake Okechobee	
USNM 15389	Equinae	Equini	*Equus*	sp.			
USNM 17082	Equinae	Equini	*Equus*	sp.	P2		
USNM 171045	Equinae	Hipparionini	*Cormohipparion*	*emsliei*		Maurilla	
USNM 173623	Equinae	Hipparionini	*Neohipparion*	*eurystyle*	P3	Maurilla	
USNM 17922	Equinae	Equini	*Equus*	sp.	M3	Cave	
USNM 18205	Equinae	Equini	*Equus*	sp.		Bone Valley	
USNM 18206	Equinae	Hipparionini	*Nannippus*	*minor*	M3	Bone Valley	
USNM 18207	Equinae	Hipparionini	*Nannippus*	*minor*	P2	Bone Valley	
USNM 18208	Equinae	Hipparionini	*Nannippus*	*minor*		Bone Valley	
USNM 18212	Equinae	Hipparionini	*Neohipparion*	*phosphorum*	M3	Bone Valley	
USNM 182197	Equinae	Hipparionini	*Nannippus*	sp.		Lee Creek	
USNM 18234	Equinae	Hipparionini	*Nannippus*	*minor*	P2	Bone Valley	
USNM 18236	Equinae	Hipparionini	*Nannippus*	*minor*		Bone Valley	
USNM 18243	Equinae	Hipparionini	*Nannippus*	*minor*		Bone Valley	
USNM 18244	Equinae	Hipparionini	*Nannippus*	*minor*		Bone Valley	
USNM 18250	Equinae	Hipparionini	*Neohipparion*	*phosphorum*		Bone Valley	
USNM 187652	Equinae	Equini	*Equus*	sp.			
USNM 1907	Equinae	Equini	*Equus*	*complicatus*		Lander's Mill	
USNM 1932	Equinae	Equini	*Protohippus*	*fossulatus*	M2	Loup Fork	
USNM 1933	Equinae	Equini	*Protohippus*	*mirabilis*	P3	Loup Fork	
USNM 20105	Equinae	Hipparionini	*Neohipparion*	*phosphorum*		Bone Valley	

USNM 23892	Equinae	Hipparionini	*Hipparion*	*forcei*		Santa Margarita SS	
USNM 23903	Equinae	Equini	*Equus*	*simplicidens*	P3	Glenns Ferry	
USNM 244299	Equinae	Hipparionini	*Neohipparion*	sp.		Valentine	
USNM 25142	Anchitheriinae	"Anchitheriini"	*Archaeohippus*	*minimus*	P3	Madison Valley	
USNM 25583	Equinae	Equini	*Equus*	*littoralis*		Melbourne	
USNM 25683	Equinae	Equini	*Equus*	sp.		Pearl River	
USNM 2572	Equinae	Hipparionini	*Hippotherium*	sp.	P3	Tesuque	
USNM 2573	Equinae	"Merychippini"	*Merychippus*	sp.	M2	Pawnee Creek	
USNM 262545	Equinae	Equini	*Equus*	sp.	P3	Lost Chicken Creek	
USNM 26324	Equinae	Equini	*Equus*	*complicatus*		Brunswick	
USNM 299566	Equinae	Hipparionini	*Cormohipparion*	sp.		Parker Creek	
USNM 3292	Equinae	Hipparionini	*Hipparion*	*plicatile*			
USNM 330994	Equinae	Equini	*Protohippus*	*gidleyi*	P2	Maurilla	
USNM 351924	Anchitheriinae	"Anchitheriini"	*Megahippus*	*mckennai*	P4	Valentine	
USNM 390722	Equinae	Hipparionini	*Cormohipparion*	*emsliei*		Maurilla	
USNM 391594	Equinae	Equini	*Protohippus*	*gidleyi*		Maurilla	
USNM 391852	Equinae	Hipparionini	*Nannippus*	*phlegon*		Neuse River	
USNM 391854	Equinae	Hipparionini	*Nannippus*	*phlegon*		Neuse River	
USNM 391855	Equinae	Hipparionini	*Nannippus*	*phlegon*		Neuse River	
USNM 391856	Equinae	Hipparionini	*Nannippus*	*phlegon*		Neuse River	
USNM 391864	Equinae	Hipparionini	*Nannippus*	*phlegon*		Neuse River	
USNM 391865	Equinae	Hipparionini	*Nannippus*	*phlegon*	M3	Neuse River	
USNM 413207	Equinae	Hipparionini	*Hipparion*	sp.	M3		
USNM 413212	Equinae	Hipparionini	*Hipparion*	sp.			
USNM 413671	Equinae	"Merychippini"	*Merychippus*	sp.	M2	Willow Grove	
USNM 416338/UF 17570	Equinae	Hipparionini	*Nannippus*	*minor*	P3	Bone Valley	
USNM 420682	Equinae	Hipparionini	*Nannippus*	*gratus*	P2	Clarendon	

USNM 4999	Equinae	Equini	*Equus*	*scotti*	P3	Hay Spring	
USNM 520	Equinae	Equini	*Equus*	*leidyi*			
USNM 521290	Equinae	Equini	*Protohippus*	*gidleyi*		Maurilla	
USNM 540677	Equinae	Equini	*Equus*	sp.	M3	El Hatillo	
USNM 5446	Equinae	Hipparionini	*Pseudhipparion*	*gratum*	M3		
USNM 5447	Equinae	Hipparionini	*Pseudhipparion*	*gratum*			
USNM 555	Equinae	Equini	*Equus*	sp.			
USNM 557	Equinae	Equini	*Equus*	*pacificus*	P3	Summer Lake	
USNM 569	Equinae	Equini	*Pliohippus*	*mirabilis*		Valentine	
USNM 573	Anchitheriinae	"Anchitheriini"	*Hypohippus*	*affinis*		Valentine	
USNM 584	Equinae	Hipparionini	*Hipparion*	*affine*			
USNM 587	Equinae	Hipparionini	*Pseudhipparion*	*gratum*			
USNM 619	Equinae	Equini	*Protohippus*	*perditus*	M2	Valentine	
USNM 667	Equinae	Equini	*Equus*	*excelsus*	M2	Platte River Gravel	
USNM 7084	Equinae	Equini	*Equus*	*complicatus*		Avery Island	
USNM 726	Equinae	Equini	*Equus*	*complicatus*	P2	Avery Island	
USNM 7507	Equinae	Equini	*Protohippus*	*placidus*	P3	Ogallala	
USNM 7514	Equinae	Hipparionini	*Cormohipparion*	sp.		Ogallala	
USNM 7530	Equinae	Hipparionini	*Neohipparion*	*affine*		Ogallala	
USNM 7700	Equinae	Equini	*Equus*	*scotti*	P3	Yukon River	
USNM 7868	Equinae	Equini	*Equus*	*hatcheri*	P3	Hay Springs	
USNM 7935	Equinae	Equini	*Equus*	*scotti*			
USNM 8265	Equinae	Hipparionini	*Hipparion*	*plicatile*	M2	Bone Valley	
USNM 8268	Equinae	Equini	*Equus*	sp.		Palmetto	
USNM 8426	Equinae	Equini	*Equus*	*lambei*	P3		
USNM 8642	Equinae	Equini	*Equus*	*holmesi*	P3	Sulpher Spring	
USNM 876	Equinae	Equini	*Equus*	*scotti*			

USNM 8813	Equinae	Equini	*Equus*	sp.				
USNM 882	Equinae	Equini	*Equus*	*fraternus*				
USNM 8945	Equinae	Equini	*Equus*	*leidyi*				
USNM 9464	Equinae	Equini	*Equus*	*pacificus*				
UWBM 17938	Equinae	"Merychippini"	*Merychippus*	sp.		Virgin Valley		
UWBM 19200	Equinae	Equini	*Equus*	*lambei*				
UWBM 19201	Equinae	Equini	*Equus*	*lambei*				
UWBM 19202	Equinae	Equini	*Equus*	*lambei*				
UWBM 19203	Equinae	Equini	*Equus*	*lambei*				
UWBM 22278	Equinae	Equini	*Equus*	*simplicidens*	P2	Tehama		
UWBM 22296	Equinae	Equini	*Equus*	*simplicidens*		Tehama		
UWBM 22297	Equinae	Equini	*Equus*	*simplicidens*	M2	Tehama		
UWBM 22298	Equinae	Equini	*Equus*	*simplicidens*		Tehama		
UWBM 22299	Equinae	Equini	*Equus*	*simplicidens*	P3	Tehama		
UWBM 22300	Equinae	Equini	*Equus*	*simplicidens*	P4	Tehama		
UWBM 28027	Equinae	Equini	*Equus*	sp.				
UWBM 28027	Equinae	Equini	*Equus*	sp.				
UWBM 40927	Anchitheriinae	"Anchitheriini"	*Desmatippus*	sp.		Mascall		
UWBM 40927	Anchitheriinae	"Anchitheriini"	*Desmatippus*	sp.		Mascall		
UWBM 42136	Equinae	Equini	*Equus*	*simplicedens*		Ringold		
UWBM 42323	Equinae	Equini	*Equus*	*simplicedens*	M3	Ringold		
UWBM 42331	Equinae	Equini	*Equus*	*simplicedens*		Ringold		
UWBM 45033	Equinae	Equini	*Equus*	*simplicedens*	M1	Ringold		
UWBM 45033	Equinae	Equini	*Equus*	*simplicedens*	M2	Ringold		
UWBM 45033	Equinae	Equini	*Equus*	*simplicedens*	M3	Ringold		
UWBM 45102	Equinae	Equini	*Equus*	*simplicedens*		Ringold		
UWBM 48724	Equinae	Hipparionini	*Hipparion*	sp.		Shutler		

UWBM 50008	Equinae	Equini	*Equus*	sp.	M3		
UWBM 50008	Equinae	Equini	*Equus*	sp.	M3		
UWBM 58727	Equinae	Equini	*Equus*	*simplicedens*		Glenns Ferry	
UWBM 58727	Equinae	Equini	*Equus*	*simplicedens*	P3	Glenns Ferry	
UWBM 58727	Equinae	Equini	*Equus*	*simplicedens*	M1	Glenns Ferry	
UWBM 58727	Equinae	Equini	*Equus*	*simplicedens*	M2	Glenns Ferry	
UWBM 58727	Equinae	Equini	*Equus*	*simplicedens*	M3	Glenns Ferry	
UWBM 59241	Equinae	Hipparionini	*Nannippus*	sp.	P3	Dalles Group	
UWBM 59241	Equinae	Hipparionini	*Nannippus*	sp.	P4	Dalles Group	
UWBM 59241	Equinae	Hipparionini	*Nannippus*	sp.	M2	Dalles Group	
UWBM 59241	Equinae	Hipparionini	*Nannippus*	sp.	M3	Dalles Group	
UWBM 61573	Equinae	Hipparionini	*Nannippus*	sp.	P2	McKay	
UWBM 71401	Equinae	"Merychippini"	*Merychippus*	sp.		Flint Creek	
UWBM 71401	Equinae	"Merychippini"	*Merychippus*	sp.		Flint Creek	
UWBM 75621	Equinae	Equini	*Equus*	sp.		Fossil Lake	
UWBM 80705	Equinae	Equini	*Equus*	*simplicedens*		Ringold	
UWBM 87138	Equinae	Equini	*Equus*	sp.	P4		
UWBM 87138	Equinae	Equini	*Equus*	sp.	M2		
UWBM 87138	Equinae	Equini	*Equus*	sp.	M3		

Specimen #	State	Region	Epoch	NALMA	True Area (cm^2)	Enamel Length (cm)	OEI
AMNH F:AM 100077	Arizona	Great Basin	Miocene	Hemphillian	6.997	24.462	9.248
AMNH F:AM 104769	Nebraska	Great Plains	Miocene	Clarendonian	2.842	18.971	11.253
AMNH F:AM 107596	Nebraska	Great Plains	Miocene	Clarendonian	6.41	19.674	7.771
AMNH F:AM 108233	New Mexico	Great Basin	Miocene	Barstovian	5.315	23.296	10.105
AMNH F:AM 109883	Texas	Great Plains	Miocene	Barstovian	3.411	18.36	9.941
AMNH F:AM 110131	California	Great Basin	Miocene	Barstovian	2.561	16.218	10.134
AMNH F:AM 110222	California	Great Basin	Miocene	Barstovian	5.547	23.636	10.036
AMNH F:AM 110234	California	Great Basin	Miocene	Barstovian	3.169	17.18	9.651
AMNH F:AM 110343	Nebraska	Great Plains	Miocene	Barstovian	4.804	17.822	8.131
AMNH F:AM 111728	Texas	Great Plains	Miocene	Clarendonian	6.421	24.598	9.707
AMNH F:AM 114169	Texas	Great Plains	Miocene	Clarendonian	6.218	23.545	9.442
AMNH F:AM 116143	Florida	Gulf Coast	Pleistocene	Irv/Rancho	5.162	22.999	10.123
AMNH F:AM 116148	California	Great Basin	Pleistocene	Irv/Rancho	5.962	22.424	9.184
AMNH F:AM 116150	Mexico	Gulf Coast	Pleistocene	Irv/Rancho	7.347	20.957	7.732
AMNH F:AM 116156	Texas	Great Plains	Pleistocene	Irv/Rancho	7.392	23.748	8.735
AMNH F:AM 116161	New Mexico	Great Basin	Pleistocene	Irv/Rancho	8.871	25.924	8.704
AMNH F:AM 116164	Texas	Great Plains	Miocene	Hemphillian	8.395	25.486	8.796
AMNH F:AM 116179	New Mexico	Great Basin	Pleistocene	Irv/Rancho	9.934	30.75	9.756
AMNH F:AM 116194	Oklahoma	Great Plains	Miocene	Hemphillian	4.572	22.46	10.504
AMNH F:AM 116792	Oklahoma	Great Plains	Miocene	Hemphillian	7.816	29.622	10.596
AMNH F:AM 116868	Nebraska	Great Plains	Miocene	Barstovian	2.653	17.784	10.918
AMNH F:AM 117045	Nebraska	Great Plains	Miocene	Clarendonian	2.9	20.879	12.261

AMNH F:AM 118223	Texas	Great Plains	Miocene	Clarendonian	2.33	13.004	8.519
AMNH F:AM 125218	South Dakota	Great Plains	Miocene	Clarendonian	4.18	19.063	9.324
AMNH F:AM 125488	Texas	Great Plains	Miocene	Clarendonian	6.066	22.353	9.076
AMNH F:AM 125995	Colorado	Great Plains	Miocene	Barstovian	4.191	21.181	10.346
AMNH F:AM 126899	Nebraska	Great Plains	Miocene	Barstovian	3.516	19.557	10.430
AMNH F:AM 127207	Nebraska	Great Plains	Miocene	Hemphillian	1.799	11.825	8.816
AMNH F:AM 127263	California	Great Basin	Miocene	Barstovian	4.39	17.063	8.144
AMNH F:AM 127569	Texas	Great Plains	Miocene	Clarendonian	2.532	15.318	9.627
AMNH F:AM 127992	Colorado	Great Plains	Miocene	Clarendonian	3.262	17.418	9.644
AMNH F:AM 128091	Oklahoma	Great Plains	Miocene	Hemphillian	4.536	17.755	8.337
AMNH F:AM 128092	Oklahoma	Great Plains	Miocene	Hemphillian	4.139	18.327	9.008
AMNH F:AM 128154	New Mexico	Great Basin	Miocene	Barstovian	4.3	23.183	11.180
AMNH F:AM 128270	Oklahoma	Great Plains	Miocene	Hemphillian	5.791	20.689	8.597
AMNH F:AM 128444	Oklahoma	Great Plains	Miocene	Hemphillian	5.175	17.909	7.873
AMNH F:AM 142515	Nebraska	Great Plains	Miocene	Clarendonian	3.044	16.464	9.437
AMNH F:AM 143268	Texas	Great Plains	Miocene	Clarendonian	5.123	22.159	9.790
AMNH F:AM 143273	New Mexico	Great Basin	Miocene	Barstovian	5.73	26.763	11.180
AMNH F:AM 14396	California	California	Pleistocene	Irv/Rancho	8.263	28.303	9.846
AMNH F:AM 20077	Texas	Great Plains	Pliocene	Blancan	11.899	28.732	8.329
AMNH F:AM 21085	California	Great Basin	Miocene	Barstovian	6.117	18.358	7.423
AMNH F:AM 30702	Alaska	Polar	Pleistocene	Irv/Rancho	7.48	28.443	10.400
AMNH F:AM 30703	Alaska	Polar	Pleistocene	Irv/Rancho	6.128	25.975	10.493
AMNH F:AM 42810	Arizona	Great Basin	Pleistocene	Irv/Rancho	5.789	25.17	10.461
AMNH F:AM 42811	Arizona	Great Basin	Pleistocene	Irv/Rancho	6.068	22.448	9.113
AMNH F:AM 60061	Alaska	Polar	Pleistocene	Irv/Rancho	6.62	23.243	9.034

AMNH F:AM 60062	Alaska	Polar	Pleistocene	Irv/Rancho	6.638	26.301	10.208
AMNH F:AM 60066	Alaska	Polar	Pleistocene	Irv/Rancho	8.271	31.574	10.979
AMNH F:AM 60300	South Dakota	Great Plains	Miocene	Clarendonian	3.283	17.991	9.929
AMNH F:AM 60327	Texas	Great Plains	Miocene	Clarendonian	2.142	15.248	10.418
AMNH F:AM 60420	Texas	Great Plains	Miocene	Clarendonian	2.14	13.069	8.934
AMNH F:AM 60500	Nebraska	Great Plains	Miocene	Clarendonian	11.457	26.081	7.705
AMNH F:AM 60561	Nebraska	Great Plains	Miocene	Clarendonian	6.406	18.565	7.335
AMNH F:AM 60618	Nebraska	Great Plains	Miocene	Barstovian	5.28	18.249	7.942
AMNH F:AM 60627	Texas	Great Plains			3.389	15.931	8.654
AMNH F:AM 60700	Nebraska	Great Plains	Miocene	Clarendonian	7.699	22.95	8.271
AMNH F:AM 60720	Colorado	Great Plains	Miocene	Barstovian	4.452	18.377	8.710
AMNH F:AM 60878	Texas	Great Plains	Miocene	Clarendonian	6.859	27.391	10.459
AMNH F:AM 60880	Texas	Great Plains	Miocene	Clarendonian	5.003	24.383	10.901
AMNH F:AM 60904	Texas	Great Plains	Miocene	Clarendonian	7.996	25.258	8.932
AMNH F:AM 60905	New Mexico	Great Basin	Miocene	Barstovian	5.061	21.399	9.512
AMNH F:AM 69500	New Mexico	Great Basin	Miocene	Clarendonian	4.275	21.225	10.265
AMNH F:AM 69503	New Mexico	Great Basin	Miocene	Clarendonian	5.14	21.828	9.628
AMNH F:AM 69506	Colorado	Great Plains	Miocene	Barstovian	2.872	14.885	8.783
AMNH F:AM 69550	Texas	Great Plains			3.32	17.118	9.395
AMNH F:AM 69560	Nebraska	Great Plains	Miocene	Barstovian	3.307	19.032	10.466
AMNH F:AM 69604	Nebraska	Great Plains	Miocene	Clarendonian	3.505	17.432	9.311
AMNH F:AM 70003	Nebraska	Great Plains	Miocene	Clarendonian	3.164	16.09	9.046
AMNH F:AM 70112					1.954	12.615	9.025
AMNH F:AM 70439	Texas	Great Plains	Miocene	Clarendonian	2.653	17.434	10.704
AMNH F:AM 71369	Montana	Great Plains	Miocene	Barstovian	4.372	22.146	10.591

AMNH F:AM 71377	Nevada	Great Basin	Miocene	Hemphillian	3.36	14.878	8.117
AMNH F:AM 71405	Alaska	Polar	Pleistocene	Irv/Rancho	6.374	25.384	10.054
AMNH F:AM 71463	Alaska	Polar	Pleistocene	Irv/Rancho	5.265	23.796	10.371
AMNH F:AM 71502	Nebraska	Great Plains	Miocene	Barstovian	3.735	15.75	8.150
AMNH F:AM 71508	Nebraska	Great Plains	Miocene	Barstovian	1.854	12.793	9.395
AMNH F:AM 71592	Colorado	Great Plains	Miocene	Barstovian	1.0094	9.528	9.484
AMNH F:AM 71887	Nebraska	Great Plains	Miocene	Clarendonian	4.636	25.012	11.617
AMNH F:AM 71891					4.587	19.43	9.072
AMNH F:AM 73940	Texas	Great Plains			3.8	20.291	10.409
AMNH F:AM 73950					2.482	18.552	11.776
AMNH F:AM 73951	Texas	Great Plains	Miocene	Barstovian	2.192	15.083	10.187
AMNH F:AM 74230	New Mexico	Great Basin	Miocene	Hemphillian	5.624	21.297	8.980
AMNH F:AM 74273	Texas	Great Plains	Miocene	Hemphillian	3.866	16.185	8.232
AMNH F:AM 74274	Texas	Great Plains	Miocene	Hemphillian	2.778	13.342	8.005
AMNH F:AM 74404	Texas	Great Plains	Miocene	Clarendonian	3.271	15.811	8.742
AMNH F:AM 74416	Texas	Great Plains	Miocene	Clarendonian	3.662	18.575	9.707
AMNH F:AM 8105	Montana	Great Plains	Miocene	Barstovian	4.238	18.49	8.982
AMNH F:AM 87201	Kansas	Great Plains	Miocene	Hemphillian	6.086	17.473	7.083
AMNH F:AM 87201	Kansas	Great Plains	Miocene	Hemphillian	5.362	19.288	8.330
AMNH F:AM 87201	Kansas	Great Plains	Miocene	Hemphillian	4.917	18.999	8.568
AMNH F:AM 87201	Kansas	Great Plains	Miocene	Hemphillian	4.341	17.902	8.592
AMNH F:AM 87201	Kansas	Great Plains	Miocene	Hemphillian	4.231	18.117	8.808
AMNH F:AM 87201	Kansas	Great Plains	Miocene	Hemphillian	4.094	16.32	8.066
AMNH F:AM 87301	Nebraska	Great Plains	Miocene	Barstovian	3.458	17.272	9.288
AMNH F:AM 87429	Nebraska	Great Plains	Pliocene	Blancan	7.375	25.25	9.298

AMNH F:AM 92470	Florida	Gulf Coast	Pleistocene	Irv/Rancho	4.43	18.242	8.667
AMNH F:AM 95588	Florida	Gulf Coast	Pleistocene	Irv/Rancho	6.038	30.289	12.326
AMNH F:AM 99247	Florida	Gulf Coast	Pliocene	Blancan	5.438	22.284	9.556
AMNH FM 10584	Texas	Great Plains	Miocene	Clarendonian	3.963	19.236	9.663
AMNH FM 10607	Texas	Great Plains	Pleistocene	Irv/Rancho	8.239	26.481	9.226
AMNH FM 10612	Texas	Great Plains	Pleistocene	Irv/Rancho	7.566	22.859	8.310
AMNH FM 10628	Texas	Great Plains	Pleistocene	Irv/Rancho	9.787	35.83	11.453
AMNH FM 10865	South Dakota	Great Plains			5.769	25.951	10.804
AMNH FM 109855	New Mexico	Great Basin	Miocene	Barstovian	4.364	17.045	8.159
AMNH FM 127671	Honduras	Gulf Coast	Pleistocene	Irv/Rancho	5.968	26.764	10.956
AMNH FM 13714	South Carolina	Eastern US	Pleistocene	Irv/Rancho	6.036	31.946	13.003
AMNH FM 13770					6.972	19.189	7.267
AMNH FM 140736	New Mexico	Great Basin	Miocene	Barstovian	4.165	18.888	9.255
AMNH FM 14180					3.491	16.08	8.606
AMNH FM 142647	New Mexico	Great Basin	Miocene	Barstovian	4.249	21.476	10.419
AMNH FM 14296	Mississippi	Gulf Coast	Pleistocene	Irv/Rancho	9.368	34.475	11.264
AMNH FM 143258	California	Great Basin	Miocene	Barstovian	4.612	17.28	8.046
AMNH FM 15549	Mexico	Gulf Coast	Pleistocene	Irv/Rancho	4.671	23.741	10.985
AMNH FM 17224					6.648	24.88	9.650
AMNH FM 18297	Nebraska	Great Plains	Miocene	Barstovian	2.649	14.096	8.661
AMNH FM 18299	Nebraska	Great Plains	Miocene	Barstovian	3.109	16.651	9.443
AMNH FM 18655	Arizona	Great Basin	Pliocene	Blancan	10.924	30.577	9.251
AMNH FM 18972	Nebraska	Great Plains	Miocene	Hemphillian	4.626	18.603	8.649
AMNH FM 22733	Louisiana	Gulf Coast	Pleistocene	Irv/Rancho	6.657	27.172	10.531
AMNH FM 27834	Louisiana	Gulf Coast	Pleistocene	Irv/Rancho	7.077	31.232	11.740

AMNH FM 32551	Idaho	Columbia Plateau	Pliocene	Blancan	9.144	30.447	10.069
AMNH FM 39407	Missouri	Great Plains	Pleistocene	Irv/Rancho	6.081	27.783	11.267
AMNH FM 55595	South Carolina	Eastern US	Pleistocene	Irv/Rancho	5.761	25.552	10.646
AMNH FM 8175	Oregon	Columbia Plateau	Miocene	Barstovian	3.176	17.755	9.963
AMNH FM 8347	Nebraska	Great Plains	Miocene	Clarendonian	4.007	21.534	10.758
AMNH FM 9201	South Carolina	Eastern US	Pleistocene	Irv/Rancho	4.809	24.023	10.955
AMNH FM 9203	South Carolina	Eastern US	Pleistocene	Irv/Rancho	5.461	28.599	12.238
AMNH FM 9395	Colorado	Great Plains	Pleistocene	Barstovian	4.835	15.287	6.952
AMNH FM 9400	Colorado	Great Plains	Miocene	Clarendonian	2.7	14.844	9.034
AMNH FM 9820	South Dakota	Great Plains			5.233	19.251	8.415
AMNH FM 9967	Pennsylvania	Eastern US	Pleistocene	Irv/Rancho	5.201	23.84	10.454
CIT 363	Oregon	Columbia Plateau	Miocene	Barstovian	3.648	16.505	8.641
CIT 363	Oregon	Columbia Plateau	Miocene	Barstovian	4.008	15.656	7.820
CIT 363	Oregon	Columbia Plateau	Miocene	Barstovian	4.584	16.729	7.814
CIT 363	Oregon	Columbia Plateau	Miocene	Barstovian	4.638	17.339	8.051
CIT 363	Oregon	Columbia Plateau	Miocene	Barstovian	4.289	18.302	8.837
CIT 363	Oregon	Columbia Plateau	Miocene	Barstovian	3.726	17.244	8.933
JODA 10014	Oregon	Columbia Plateau	Miocene	Clarendonian	4.2	23.086	11.265
JODA 10703	Oregon	Columbia Plateau	Miocene	Barstovian	2.196	13.031	8.793
JODA 1079, A	Oregon	Columbia Plateau	Miocene	Barstovian	2.499	14.944	9.453
JODA 1079, A	Oregon	Columbia Plateau	Miocene	Barstovian	2.736	16.116	9.743
JODA 1079, A	Oregon	Columbia Plateau	Miocene	Barstovian	2.647	16.973	10.432
JODA 1079, A	Oregon	Columbia Plateau	Miocene	Barstovian	2.301	15.083	9.943
JODA 1079, A	Oregon	Columbia Plateau	Miocene	Barstovian	2.219	15.445	10.368
JODA 1316	Oregon	Columbia Plateau	Miocene	Barstovian	2.478	14.645	9.303

JODA 1316	Oregon	Columbia Plateau	Miocene	Barstovian	2.262	16.149	10.737
JODA 1316	Oregon	Columbia Plateau	Miocene	Barstovian	2.575	16.452	10.253
JODA 1316	Oregon	Columbia Plateau	Miocene	Barstovian	2.263	15.504	10.306
JODA 1316	Oregon	Columbia Plateau	Miocene	Barstovian	2.419	15.807	10.163
JODA 1316	Oregon	Columbia Plateau	Miocene	Barstovian	1.716	13.406	10.234
JODA 1318	Oregon	Columbia Plateau	Miocene	Barstovian	2.463	14.888	9.486
JODA 1318	Oregon	Columbia Plateau	Miocene	Barstovian	2.418	15.994	10.286
JODA 1318	Oregon	Columbia Plateau	Miocene	Barstovian	2.206	15.565	10.480
JODA 1318	Oregon	Columbia Plateau	Miocene	Barstovian	2.23	15.632	10.468
JODA 1318	Oregon	Columbia Plateau	Miocene	Barstovian	1.505	12.838	10.465
JODA 1332	Oregon	Columbia Plateau	Miocene	Barstovian	0.965	7.41	7.543
JODA 1332	Oregon	Columbia Plateau	Miocene	Barstovian	0.94	7.367	7.598
JODA 1332	Oregon	Columbia Plateau	Miocene	Barstovian	0.92	9.343	9.741
JODA 1332	Oregon	Columbia Plateau	Miocene	Barstovian	0.939	8.827	9.109
JODA 1332	Oregon	Columbia Plateau	Miocene	Barstovian	0.391	5.176	8.278
JODA 1333	Oregon	Columbia Plateau	Miocene	Hemphillian	4.674	19.134	8.850
JODA 1333	Oregon	Columbia Plateau	Miocene	Hemphillian	4.908	20.646	9.319
JODA 1333	Oregon	Columbia Plateau	Miocene	Hemphillian	4.658	21.212	9.828
JODA 1333	Oregon	Columbia Plateau	Miocene	Hemphillian	4.534	19.822	9.309
JODA 1333	Oregon	Columbia Plateau	Miocene	Hemphillian	4.232	20.688	10.056
JODA 1333	Oregon	Columbia Plateau	Miocene	Hemphillian	2.843	17.237	10.223
JODA 1979	Oregon	Columbia Plateau	Miocene	Barstovian	2.538	17.451	10.954
JODA 1980	Oregon	Columbia Plateau	Miocene	Barstovian	2.337	15.78	10.322
JODA 1981	Oregon	Columbia Plateau	Miocene	Barstovian	2.336	15.001	9.815
JODA 1982	Oregon	Columbia Plateau	Miocene	Barstovian	2.425	16.656	10.696

JODA 1987	Oregon	Columbia Plateau	Miocene	Barstovian	2.292	16.437	10.857
JODA 1988	Oregon	Columbia Plateau	Miocene	Barstovian	2.689	20.008	12.201
JODA 1990	Oregon	Columbia Plateau	Miocene	Barstovian	2.689	20.008	12.201
JODA 1997	Oregon	Columbia Plateau	Miocene	Barstovian	2.072	13.926	9.675
JODA 1998	Oregon	Columbia Plateau	Miocene	Barstovian	2.802	16.977	10.142
JODA 2001	Oregon	Columbia Plateau	Miocene	Hemphillian	3.19	19.583	10.964
JODA 2066	Oregon	Columbia Plateau	Miocene	Hemphillian	3.776	19.548	10.060
JODA 2069	Oregon	Columbia Plateau	Miocene	Hemphillian	5.142	20.243	8.927
JODA 2072	Oregon	Columbia Plateau	Miocene	Hemphillian	3.937	17.621	8.881
JODA 2402	Oregon	Columbia Plateau	Miocene	Barstovian	1.922	13.412	9.674
JODA 2405	Oregon	Columbia Plateau	Miocene	Barstovian	2	12.789	9.043
JODA 2406	Oregon	Columbia Plateau	Miocene	Barstovian	1.761	13.744	10.357
JODA 2407	Oregon	Columbia Plateau	Miocene	Barstovian	1.865	13.112	9.601
JODA 2408	Oregon	Columbia Plateau	Miocene	Barstovian	1.79	11.697	8.743
JODA 2409	Oregon	Columbia Plateau	Miocene	Barstovian	2.03	10.406	7.304
JODA 2428	Oregon	Columbia Plateau	Miocene	Barstovian	1.291	9.832	8.653
JODA 2435	Oregon	Columbia Plateau	Miocene	Barstovian	2.209	10.862	7.308
JODA 2435	Oregon	Columbia Plateau	Miocene	Barstovian	2.666	13.48	8.256
JODA 2435	Oregon	Columbia Plateau	Miocene	Barstovian	2.727	14.193	8.595
JODA 2435	Oregon	Columbia Plateau	Miocene	Barstovian	2.745	12.958	7.821
JODA 2435	Oregon	Columbia Plateau	Miocene	Barstovian	2.677	14.393	8.797
JODA 2435	Oregon	Columbia Plateau	Miocene	Barstovian	2.365	13.778	8.959
JODA 2446	Oregon	Columbia Plateau	Miocene	Barstovian	2.846	19.043	11.288
JODA 2564	Oregon	Columbia Plateau	Miocene	Hemphillian	3.912	26.943	13.622
JODA 293	Oregon	Columbia Plateau	Miocene	Barstovian	2.373	17.1	11.101

JODA 294	Oregon	Columbia Plateau	Miocene	Barstovian	2.536	16.971	10.657
JODA 561	Oregon	Columbia Plateau	Miocene	Hemphillian	3.793	20.189	10.366
MVZ 117884			Recent	Recent	6.291	24.088	9.604
MVZ 117884			Recent	Recent	6.295	23.219	9.254
MVZ 117884			Recent	Recent	6.455	22.964	9.039
MVZ 117884			Recent	Recent	5.423	19.163	8.229
MVZ 117884			Recent	Recent	4.9	18.833	8.508
MVZ 117884			Recent	Recent	3.854	17.201	8.762
MVZ 117885			Recent	Recent	5.643	19.015	8.005
MVZ 117885			Recent	Recent	5.594	19.55	8.266
MVZ 117885			Recent	Recent	5.09	19.4	8.599
MVZ 117885			Recent	Recent	4.301	16.554	7.982
MVZ 117885			Recent	Recent	4.262	16.617	8.049
MVZ 117885			Recent	Recent	3.596	15.598	8.225
MVZ 117887			Recent	Recent	5.685	21.42	8.984
MVZ 117887			Recent	Recent	5.307	20.327	8.824
MVZ 117887			Recent	Recent	5.375	21.128	9.113
MVZ 117887			Recent	Recent	4.307	17.864	8.608
MVZ 117887			Recent	Recent	3.859	18.425	9.379
MVZ 117887			Recent	Recent	3.316	16.325	8.965
MVZ 117888			Recent	Recent	5.636	21.309	8.976
MVZ 117888			Recent	Recent	5.596	20.438	8.640
MVZ 117888			Recent	Recent	5.523	20.081	8.545
MVZ 117888			Recent	Recent	5.397	19.094	8.219
MVZ 117888			Recent	Recent	4.818	18.611	8.479

MVZ 117888			Recent	Recent	3.569	16.92	8.956
MVZ 154358			Recent	Recent	4.735	16.469	7.568
MVZ 154358			Recent	Recent	5.159	17.936	7.897
MVZ 154358			Recent	Recent	5.287	18.543	8.064
MVZ 154358			Recent	Recent	4.483	16.168	7.636
MVZ 154358			Recent	Recent	4.373	16.386	7.836
MVZ 154358			Recent	Recent	4.059	16.384	8.132
MVZ 55150			Recent	Recent	7.841	22.652	8.089
MVZ 55150			Recent	Recent	7.595	23.764	8.623
MVZ 55150			Recent	Recent	7.52	24.842	9.059
MVZ 55150			Recent	Recent	6.464	20.978	8.251
MVZ 55150			Recent	Recent	6.813	21.928	8.401
MVZ 55150			Recent	Recent	6.016	20.629	8.411
SDSM 12195	South Dakota	Great Plains	Pleistocene	Irv/Rancho	9.914	34.932	11.094
SDSM 22027	Washington	Columbia Plateau	Pliocene	Blancan	5.788	24.504	10.185
SDSM 22032	Washington	Columbia Plateau	Pliocene	Blancan	6.862	26.805	10.233
SDSM 505	Nebraska	Great Plains	Miocene	Barstovian	2.699	12.496	7.606
SDSM 505	Nebraska	Great Plains	Miocene	Barstovian	3.191	14.976	8.384
SDSM 505	Nebraska	Great Plains	Miocene	Barstovian	3.244	15.285	8.486
SDSM 505	Nebraska	Great Plains	Miocene	Barstovian	2.824	6.665	3.966
SDSM 505	Nebraska	Great Plains	Miocene	Barstovian	2.877	15.653	9.228
SDSM 505	Nebraska	Great Plains	Miocene	Barstovian	3.023	15.418	8.868
SDSM 5057	Nebraska	Great Plains	Miocene	Barstovian	2.939	14.295	8.338
SDSM 5057	Nebraska	Great Plains	Miocene	Barstovian	3.022	15.582	8.963
SDSM 53217	South Dakota	Great Plains	Miocene	Clarendonian	2.276	15.258	10.114

SDSM 53217 F1	South Dakota	Great Plains	Miocene	Clarendonian	2.343	15.36	10.035
SDSM 53217-12	South Dakota	Great Plains	Miocene	Clarendonian	4.44	22.671	10.759
SDSM 53217-17	South Dakota	Great Plains	Miocene	Clarendonian	5.392	24.991	10.762
SDSM 53217-3	South Dakota	Great Plains	Miocene	Clarendonian	5.465	28.41	12.153
SDSM 53217-30	South Dakota	Great Plains	Miocene	Clarendonian	5.356	24.968	10.789
SDSM 53217-31	South Dakota	Great Plains	Miocene	Clarendonian	4.03	23.094	11.504
SDSM 53217-34	South Dakota	Great Plains	Miocene	Clarendonian	4.147	25.026	12.289
SDSM 53217-40	South Dakota	Great Plains	Miocene	Clarendonian	4.896	24.847	11.229
SDSM 53217-5	South Dakota	Great Plains	Miocene	Clarendonian	3.349	16.655	9.101
SDSM 53217-9	South Dakota	Great Plains	Miocene	Clarendonian	4.804	23.828	10.871
SDSM 53217-D	South Dakota	Great Plains	Miocene	Clarendonian	4.402	25.061	11.945
SDSM 53217-E	South Dakota	Great Plains	Miocene	Clarendonian	5.193	23.909	10.492
SDSM 53218 E	South Dakota	Great Plains	Miocene	Clarendonian	6.226	25.564	10.245
SDSM 53218 K	South Dakota	Great Plains	Miocene	Clarendonian	2.213	11.197	7.527
SDSM 53219	South Dakota	Great Plains	Miocene	Clarendonian	2.269	15.472	10.271
SDSM 53219 AG	South Dakota	Great Plains	Miocene	Clarendonian	2.508	16.465	10.397
SDSM 53219 AR	South Dakota	Great Plains	Miocene	Clarendonian	2.768	17.726	10.654
SDSM 53219 CJ	South Dakota	Great Plains	Miocene	Clarendonian	2.564	15.743	9.832
SDSM 53219 CZ	South Dakota	Great Plains	Miocene	Clarendonian	4.24	23.264	11.298
SDSM 53219 DS	South Dakota	Great Plains	Miocene	Clarendonian	2.124	15.917	10.922
SDSM 53219 X	South Dakota	Great Plains	Miocene	Clarendonian	2.269	16.83	11.173
SDSM 53219 Y	South Dakota	Great Plains	Miocene	Clarendonian	2.658	16.033	9.834
SDSM 53220	South Dakota	Great Plains	Miocene	Clarendonian	3.476	15.685	8.413
SDSM 53220 A	South Dakota	Great Plains	Miocene	Clarendonian	4.003	18.53	9.262
SDSM 53220 C	South Dakota	Great Plains	Miocene	Clarendonian	5.503	25.765	10.983

SDSM 53220-01	South Dakota	Great Plains	Miocene	Clarendonian	3.56	18.638	9.878
SDSM 5622	Nebraska	Great Plains	Miocene	Barstovian	2.967	17.13	9.945
SDSM 5622	Nebraska	Great Plains	Miocene	Barstovian	4.044	19.354	9.624
SDSM 577 Q	South Dakota	Great Plains	Miocene	Clarendonian	2.57	16.329	10.186
SDSM 577P-03	South Dakota	Great Plains	Miocene	Clarendonian	2.165	13.712	9.319
SDSM 62281	South Dakota	Great Plains	Miocene	Clarendonian	2.519	15.003	9.453
SDSM 62281	South Dakota	Great Plains	Miocene	Clarendonian	2.125	11.108	7.620
SDSM 62281	South Dakota	Great Plains	Miocene	Clarendonian	2.461	15.204	9.692
SDSM 62290	South Dakota	Great Plains	Pleistocene	Irv/Rancho	8.639	33.401	11.364
SDSM 65125	Nebraska	Great Plains	Miocene	Barstovian	3.697	18.294	9.514
SDSM 65125	Nebraska	Great Plains	Miocene	Barstovian	3.052	18.611	10.653
SDSM 7861	South Dakota	Great Plains	Miocene	Clarendonian	2.747	14.836	8.951
SDSM 7861	South Dakota	Great Plains	Miocene	Clarendonian	2.602	15.268	9.465
SDSM 7861	South Dakota	Great Plains	Miocene	Clarendonian	2.311	13.855	9.114
SDSM 7861	South Dakota	Great Plains	Miocene	Clarendonian	2.201	13.748	9.267
UCMP 124927	California	California	Miocene	Hemphillian	5.674	18.883	7.927
UCMP 124927	California	California	Miocene	Hemphillian	5.84	19.645	8.129
UCMP 124927	California	California	Miocene	Hemphillian	5.63	19.837	8.360
UCMP 124927	California	California	Miocene	Hemphillian	5.642	20.009	8.424
UCMP 124927	California	California	Miocene	Hemphillian	5.785	20.807	8.651
UCMP 124927	California	California	Miocene	Hemphillian	4.393	18.575	8.862
UCMP 21422	California	Great Basin	Miocene	Barstovian	1.522	9.435	7.648
UCMP 21422	California	Great Basin	Miocene	Barstovian	1.503	8.133	6.634
UCMP 21422	California	Great Basin	Miocene	Barstovian	1.479	7.921	6.513
UCMP 21422	California	Great Basin	Miocene	Barstovian	1.258	8.126	7.245

UCMP 23088	Oregon	Columbia Plateau	Miocene	Barstovian	2.72	14.885	9.025
UCMP 23088	Oregon	Columbia Plateau	Miocene	Barstovian	3.297	16.699	9.197
UCMP 23088	Oregon	Columbia Plateau	Miocene	Barstovian	3.036	16.332	9.373
UCMP 23088	Oregon	Columbia Plateau	Miocene	Barstovian	2.829	16.115	9.581
UCMP 23088	Oregon	Columbia Plateau	Miocene	Barstovian	2.608	15.395	9.533
UCMP 23088	Oregon	Columbia Plateau	Miocene	Barstovian	1.25	6.088	5.445
UCMP 27126	Nevada	Great Basin	Miocene	Hemphillian	3.999	18.828	9.415
UCMP 27126	Nevada	Great Basin	Miocene	Hemphillian	4.475	20.473	9.678
UCMP 27126	Nevada	Great Basin	Miocene	Hemphillian	4.176	21.579	10.560
UCMP 27126	Nevada	Great Basin	Miocene	Hemphillian	4.392	20.166	9.623
UCMP 27126	Nevada	Great Basin	Miocene	Hemphillian	3.701	19.425	10.097
UCMP 27126	Nevada	Great Basin	Miocene	Hemphillian	2.875	17.024	10.040
UCMP 30200	Texas	Great Plains	Miocene	Hemphillian	6.364	14.528	5.759
UCMP 30200	Texas	Great Plains	Miocene	Hemphillian	7.384	21.108	7.768
UCMP 30200	Texas	Great Plains	Miocene	Hemphillian	7.274	21.113	7.828
UCMP 30200	Texas	Great Plains	Miocene	Hemphillian	5.466	19.965	8.540
UCMP 30200	Texas	Great Plains	Miocene	Hemphillian	5.955	21.416	8.776
UCMP 30200	Texas	Great Plains	Miocene	Hemphillian	6.075	21.705	8.806
UCMP 30225	Texas	Great Plains	Miocene	Hemphillian	3.398	14.722	7.986
UCMP 30225	Texas	Great Plains	Miocene	Hemphillian	3.653	16.034	8.389
UCMP 30225	Texas	Great Plains	Miocene	Hemphillian	3.747	16.514	8.531
UCMP 30225	Texas	Great Plains	Miocene	Hemphillian	3.311	15.199	8.353
UCMP 30225	Texas	Great Plains	Miocene	Hemphillian	3.091	15.504	8.818
UCMP 30225	Texas	Great Plains	Miocene	Hemphillian	2.919	16.35	9.570
UCMP 30813	Texas	Great Plains	Miocene	Hemphillian	5.277	18.648	8.118

UCMP 30813	Texas	Great Plains	Miocene	Hemphillian	5.114	19.322	8.544
UCMP 30813	Texas	Great Plains	Miocene	Hemphillian	5.376	19.499	8.410
UCMP 30813	Texas	Great Plains	Miocene	Hemphillian	4.691	16.918	7.811
UCMP 30813	Texas	Great Plains	Miocene	Hemphillian	4.769	18.184	8.327
UCMP 30813	Texas	Great Plains	Miocene	Hemphillian	3.967	16.435	8.252
UCMP 31256	Texas	Great Plains	Miocene	Clarendonian	3.497	13.939	7.454
UCMP 31256	Texas	Great Plains	Miocene	Clarendonian	4.028	16.736	8.339
UCMP 31256	Texas	Great Plains	Miocene	Clarendonian	4.433	17.531	8.326
UCMP 31256	Texas	Great Plains	Miocene	Clarendonian	3.534	15.626	8.312
UCMP 31256	Texas	Great Plains	Miocene	Clarendonian	4.23	17.247	8.386
UCMP 31256	Texas	Great Plains	Miocene	Clarendonian	3.825	17.206	8.798
UCMP 31875	California	California	Miocene	Hemphillian	5.987	18.632	7.615
UCMP 31875	California	California	Miocene	Hemphillian	5.813	20.004	8.297
UCMP 31875	California	California	Miocene	Hemphillian	5.647	19.545	8.225
UCMP 31875	California	California	Miocene	Hemphillian	4.576	17.931	8.382
UCMP 31875	California	California	Miocene	Hemphillian	4.688	14.688	6.784
UCMP 31875	California	California	Miocene	Hemphillian	4.334	18.705	8.985
UCMP 32306	South Dakota	Great Plains	Miocene	Clarendonian	4.41	18.003	8.573
UCMP 32306	South Dakota	Great Plains	Miocene	Clarendonian	4.923	19.868	8.954
UCMP 32306	South Dakota	Great Plains	Miocene	Clarendonian	4.893	21.376	9.664
UCMP 32306	South Dakota	Great Plains	Miocene	Clarendonian	4.11	17.154	8.461
UCMP 32306	South Dakota	Great Plains	Miocene	Clarendonian	4.506	19.244	9.066
UCMP 32306	South Dakota	Great Plains	Miocene	Clarendonian	2.925	17.789	10.401
UCMP 32503	Nebraska	Great Plains	Miocene	Clarendonian	2.9	14.972	8.792
UCMP 32503	Nebraska	Great Plains	Miocene	Clarendonian	2.855	14.897	8.816

UCMP 32503	Nebraska	Great Plains	Miocene	Clarendonian	2.94	15.468	9.021
UCMP 32503	Nebraska	Great Plains	Miocene	Clarendonian	2.337	13.184	8.624
UCMP 32503	Nebraska	Great Plains	Miocene	Clarendonian	2.95	17.147	9.983
UCMP 32503	Nebraska	Great Plains	Miocene	Clarendonian	3.044	14.716	8.435
UCMP 32504	Nebraska	Great Plains	Miocene	Clarendonian	2.691	14.3	8.717
UCMP 32504	Nebraska	Great Plains	Miocene	Clarendonian	3.005	16.399	9.460
UCMP 32504	Nebraska	Great Plains	Miocene	Clarendonian	2.831	16.388	9.740
UCMP 32504	Nebraska	Great Plains	Miocene	Clarendonian	2.432	15.154	9.717
UCMP 32504	Nebraska	Great Plains	Miocene	Clarendonian	2.68	15.372	9.390
UCMP 32504	Nebraska	Great Plains	Miocene	Clarendonian	1.73	11.071	8.417
UCMP 32773	Texas	Great Plains	Miocene	Clarendonian	1.179	8.685	7.999
UCMP 32773	Texas	Great Plains	Miocene	Clarendonian	1.505	9.169	7.474
UCMP 32773	Texas	Great Plains	Miocene	Clarendonian	1.68	9.572	7.385
UCMP 32773	Texas	Great Plains	Miocene	Clarendonian	1.464	8.664	7.161
UCMP 32773	Texas	Great Plains	Miocene	Clarendonian	1.33	9.539	8.271
UCMP 32773	Texas	Great Plains	Miocene	Clarendonian	1.184	8.518	7.828
UCMP 32814	Oklahoma	Great Plains	Miocene	Clarendonian	3.309	10.734	5.901
UCMP 32814	Oklahoma	Great Plains	Miocene	Clarendonian	4.317	11.948	5.750
UCMP 32814	Oklahoma	Great Plains	Miocene	Clarendonian	4.218	12.506	6.089
UCMP 32814	Oklahoma	Great Plains	Miocene	Clarendonian	3.811	11.695	5.991
UCMP 32814	Oklahoma	Great Plains	Miocene	Clarendonian	3.588	12.259	6.472
UCMP 32814	Oklahoma	Great Plains	Miocene	Clarendonian	2.163	7.74	5.263
UCMP 33481	Texas	Great Plains	Miocene	Clarendonian	5.213	16.8	7.358
UCMP 33481	Texas	Great Plains	Miocene	Clarendonian	5.462	17.666	7.559
UCMP 33481	Texas	Great Plains	Miocene	Clarendonian	5.294	18.05	7.845

UCMP 33481	Texas	Great Plains	Miocene	Clarendonian	4.902	17.982	8.122
UCMP 33481	Texas	Great Plains	Miocene	Clarendonian	4.887	17.945	8.117
UCMP 33481	Texas	Great Plains	Miocene	Clarendonian	3.973	16.327	8.191
UCMP 34032	Idaho	Columbia Plateau	Pliocene	Blancan	8.035	25.654	9.050
UCMP 34032	Idaho	Columbia Plateau	Pliocene	Blancan	9.273	29.776	9.778
UCMP 34032	Idaho	Columbia Plateau	Pliocene	Blancan	7.787	27.985	10.029
UCMP 34032	Idaho	Columbia Plateau	Pliocene	Blancan	8.075	26.64	9.375
UCMP 34032	Idaho	Columbia Plateau	Pliocene	Blancan	7.912	28.047	9.971
UCMP 34032	Idaho	Columbia Plateau	Pliocene	Blancan	4.446	14.428	6.843
UCMP 34511	California	California	Miocene	Clarendonian	4.633	18.518	8.603
UCMP 34511	California	California	Miocene	Clarendonian	4.411	18.855	8.978
UCMP 34511	California	California	Miocene	Clarendonian	3.629	16.265	8.538
UCMP 34511	California	California	Miocene	Clarendonian	4.251	18.28	8.866
UCMP 34511	California	California	Miocene	Clarendonian	4.14	18.693	9.187
UCMP 50750	California	California	Miocene	Barstovian	3.456	15.398	8.283
UCMP 50750	California	California	Miocene	Barstovian	3.816	16.727	8.563
UCMP 50750	California	California	Miocene	Barstovian	3.832	16.766	8.565
UCMP 50750	California	California	Miocene	Barstovian	3.549	16.497	8.757
UCMP 50750	California	California	Miocene	Barstovian	3.685	16.929	8.819
UCMP 50750	California	California	Miocene	Barstovian	2.77	14.313	8.600
UCMP 50950	California	California	Miocene	Barstovian	3.148	13.598	7.664
UCMP 50950	California	California	Miocene	Barstovian	3.795	14.066	7.220
UCMP 50950	California	California	Miocene	Barstovian	3.904	16.113	8.155
UCMP 50950	California	California	Miocene	Barstovian	3.751	15.973	8.247
UCMP 50950	California	California	Miocene	Barstovian	3.796	17.389	8.925

UCMP 50950	California	California	Miocene	Barstovian	3.271	13.834	7.649
UCMP 51000	California	California	Miocene	Barstovian	3.536	15.716	8.358
UCMP 51000	California	California	Miocene	Barstovian	4.195	17.132	8.365
UCMP 51000	California	California	Miocene	Barstovian	3.74	17.186	8.887
UCMP 51000	California	California	Miocene	Barstovian	3.757	17.542	9.050
UCMP 51000	California	California	Miocene	Barstovian	3.657	17.112	8.948
UCMP 51000	California	California	Miocene	Barstovian	2.35	12.234	7.981
UCMP 56278	California	California	Miocene	Clarendonian	4.51	15.379	7.242
UCMP 56278	California	California	Miocene	Clarendonian	5.391	17.642	7.598
UCMP 56278	California	California	Miocene	Clarendonian	5.569	18.753	7.947
UCMP 56278	California	California	Miocene	Clarendonian	5.691	19.436	8.147
UCMP 56278	California	California	Miocene	Clarendonian	6.044	20.692	8.417
UCMP 56278	California	California	Miocene	Clarendonian	5.754	22.146	9.232
UCMP 64609	Chihuahua	Gulf Coast	Miocene	Hemphillian	3.335	17.131	9.381
UCMP 64609	Chihuahua	Gulf Coast	Miocene	Hemphillian	3.728	19.838	10.274
UCMP 64609	Chihuahua	Gulf Coast	Miocene	Hemphillian	3.633	18.174	9.535
UCMP 64609	Chihuahua	Gulf Coast	Miocene	Hemphillian	3.155	18.025	10.148
UCMP 64609	Chihuahua	Gulf Coast	Miocene	Hemphillian	3.024	16.323	9.387
UCMP 64609	Chihuahua	Gulf Coast	Miocene	Hemphillian	2.365	15.862	10.314
UCMP 69575	California	Great Basin	Miocene	Clarendonian	2.627	14.236	8.783
UCMP 69575	California	Great Basin	Miocene	Clarendonian	3.272	19.468	10.763
UCMP 69575	California	Great Basin	Miocene	Clarendonian	3.362	19.839	10.820
UCMP 69575	California	Great Basin	Miocene	Clarendonian	2.872	17.222	10.162
UCMP 69575	California	Great Basin	Miocene	Clarendonian	2.871	17.385	10.260
UCMP 69575	California	Great Basin	Miocene	Clarendonian	2.056	12.905	9.000

UCMP 97903	Nebraska	Great Plains	Miocene	Barstovian	3.805	13.47	6.905
UCMP 97903	Nebraska	Great Plains	Miocene	Barstovian	4.114	16.076	7.926
UCMP 97903	Nebraska	Great Plains	Miocene	Barstovian	3.993	16.789	8.402
UCMP 97903	Nebraska	Great Plains	Miocene	Barstovian	3.436	15.435	8.327
UCMP 97903	Nebraska	Great Plains	Miocene	Barstovian	3.526	16.554	8.816
UCMP 97903	Nebraska	Great Plains	Miocene	Barstovian	2.622	14.406	8.897
UF 32300	Florida	Gulf Coast	Miocene	Clarendonian	2.83	18.072	10.743
UF 32300	Florida	Gulf Coast	Miocene	Clarendonian	3.169	18.239	10.246
UF 32300	Florida	Gulf Coast	Miocene	Clarendonian	3.03	20.911	12.013
UF 32300	Florida	Gulf Coast	Miocene	Clarendonian	2.657	18.581	11.399
UF 32300	Florida	Gulf Coast	Miocene	Clarendonian	2.578	16.927	10.542
UF 32300	Florida	Gulf Coast	Miocene	Clarendonian	2.086	15.56	10.773
UF 57343	Florida	Gulf Coast	Miocene	Hemphillian	0.709	5.472	6.499
UF 57343	Florida	Gulf Coast	Miocene	Hemphillian	0.627	5.207	6.576
UF 57343	Florida	Gulf Coast	Miocene	Hemphillian	0.539	4.804	6.543
UF 57343	Florida	Gulf Coast	Miocene	Hemphillian	0.608	4.925	6.316
UF 58311	Florida	Gulf Coast	Miocene	Hemphillian	1.376	11.884	10.131
UF 58311	Florida	Gulf Coast	Miocene	Hemphillian	1.23	11.149	10.053
UF 58311	Florida	Gulf Coast	Miocene	Hemphillian	1.07	10.257	9.916
UF 58311	Florida	Gulf Coast	Miocene	Hemphillian	1.035	9.762	9.596
UNSM 113025	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.253	24.634	10.748
UNSM 113026	Nebraska	Great Plains	Pleistocene	Irv/Rancho	7.149	32.2208	12.051
UNSM 113091	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.778	28.878	11.092
UNSM 118794	Nebraska	Great Plains	Pleistocene	Irv/Rancho	8.817	30.627	10.314
UNSM 118794	Nebraska	Great Plains	Pleistocene	Irv/Rancho	9.832	33.214	10.593

UNSM 118794	Nebraska	Great Plains	Pleistocene	Irv/Rancho	10.343	30.605	9.516
UNSM 118794	Nebraska	Great Plains	Pleistocene	Irv/Rancho	7.646	27.591	9.978
UNSM 118794	Nebraska	Great Plains	Pleistocene	Irv/Rancho	7.857	26.89	9.593
UNSM 123506	Nebraska	Great Plains	Pleistocene	Irv/Rancho	4.857	22.864	10.375
UNSM 123506	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.159	23.19	10.210
UNSM 123506	Nebraska	Great Plains	Pleistocene	Irv/Rancho	4.225	20.43	9.939
UNSM 123613	New Mexico	Great Basin	Pleistocene	Irv/Rancho	4.652	21.366	9.906
UNSM 123657	Kentucky	Eastern US	Pleistocene	Irv/Rancho	5.215	26.164	11.457
UNSM 123658	Kentucky	Eastern US	Pleistocene	Irv/Rancho	5.533	31.701	13.477
UNSM 125528	Nebraska	Great Plains	Miocene	Barstovian	2.387	15.074	9.757
UNSM 125529	Nebraska	Great Plains	Miocene	Barstovian	3.322	15.088	8.278
UNSM 125530	Nebraska	Great Plains	Miocene	Barstovian	3.388	19.773	10.742
UNSM 125531	Nebraska	Great Plains	Miocene	Barstovian	3.495	16.593	8.876
UNSM 125532	Nebraska	Great Plains	Miocene	Barstovian	5.719	15.084	6.307
UNSM 125533	Nebraska	Great Plains	Miocene	Barstovian	3.88	21.256	10.791
UNSM 125534	Nebraska	Great Plains	Miocene	Barstovian	2.126	13.499	9.258
UNSM 129108	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.769	27.855	11.597
UNSM 133050	New Mexico	Great Basin	Pleistocene	Irv/Rancho	4.779	19.32	8.838
UNSM 133051	New Mexico	Great Basin	Pleistocene	Irv/Rancho	5.321	23.11	10.019
UNSM 133052	Kentucky	Eastern US	Pleistocene	Irv/Rancho	5.614	28.597	12.069
UNSM 133053	Kentucky	Eastern US	Pleistocene	Irv/Rancho	7.211	31.546	11.748
UNSM 133054	Kentucky	Eastern US	Pleistocene	Irv/Rancho	6.462	32.273	12.696
UNSM 133055	Kentucky	Eastern US	Pleistocene	Irv/Rancho	6.65	30.48	11.820
UNSM 133056	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.469	26.247	11.223
UNSM 133057	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.044	26.549	10.799

UNSM 133058	Nebraska	Great Plains	Pleistocene	Irv/Rancho	4.927	24.395	10.990
UNSM 133059	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.027	27.261	11.104
UNSM 133059	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.491	26.605	11.354
UNSM 133059	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.889	28.128	11.591
UNSM 133060	Nebraska	Great Plains	Pliocene	Blancan	6.399	28.45	11.247
UNSM 133061	Nebraska	Great Plains	Pliocene	Blancan	7.212	26.901	10.017
UNSM 133061	Nebraska	Great Plains	Pliocene	Blancan	6.897	26.204	9.978
UNSM 133061	Nebraska	Great Plains	Pliocene	Blancan	5.787	22.399	9.311
UNSM 133061	Nebraska	Great Plains	Pliocene	Blancan	5.645	25.108	10.568
UNSM 133061	Nebraska	Great Plains	Pliocene	Blancan	4.17	19.709	9.652
UNSM 133063	Nebraska	Great Plains	Pliocene	Blancan	10.43	28.693	8.885
UNSM 133063	Nebraska	Great Plains	Pliocene	Blancan	11.529	32.158	9.471
UNSM 133063	Nebraska	Great Plains	Pliocene	Blancan	9.804	31.031	9.910
UNSM 133063	Nebraska	Great Plains	Pliocene	Blancan	7.411	24.451	8.982
UNSM 133063	Nebraska	Great Plains	Pliocene	Blancan	8.276	26.452	9.195
UNSM 133063	Nebraska	Great Plains	Pliocene	Blancan	6.113	23.021	9.311
UNSM 1349	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.601	22.292	8.676
UNSM 1349	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.298	24.724	9.852
UNSM 1349	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.236	26.128	10.463
UNSM 1349	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.803	22.956	9.529
UNSM 1349	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.788	23.472	9.756
UNSM 1349	Nebraska	Great Plains	Pleistocene	Irv/Rancho	4.921	23.081	10.405
UNSM 1350	Idaho	Columbia Plateau	Pliocene	Blancan	8.757	25.928	8.762
UNSM 1350	Idaho	Columbia Plateau	Pliocene	Blancan	9.131	27.5	9.101
UNSM 1350	Idaho	Columbia Plateau	Pliocene	Blancan	8.907	28.051	9.399

UNSM 1350	Idaho	Columbia Plateau	Pliocene	Blancan	8.368	23.431	8.100
UNSM 1350	Idaho	Columbia Plateau	Pliocene	Blancan	9.177	28.251	9.326
UNSM 1350	Idaho	Columbia Plateau	Pliocene	Blancan	8.515	29.09	9.969
UNSM 1352	Nebraska	Great Plains	Miocene	Barstovian	3.65	17.947	9.394
UNSM 238941	Nebraska	Great Plains	Miocene	Clarendonian	3.835	21.407	10.931
UNSM 2626	Nebraska	Great Plains	Miocene	Hemphillian	4.229	23.703	11.526
UNSM 2634	Nebraska	Great Plains	Miocene	Hemphillian	3.382	16.582	9.017
UNSM 2672	Nebraska	Great Plains	Miocene	Barstovian	4.58	21.52	10.056
UNSM 27799	Nebraska	Great Plains	Miocene	Hemphillian	3.603	16.143	8.505
UNSM 27845	Nebraska	Great Plains	Miocene	Clarendonian	1.924	11.724	8.452
UNSM 27845	Nebraska	Great Plains	Miocene	Clarendonian	2.335	14.066	9.205
UNSM 27845	Nebraska	Great Plains	Miocene	Clarendonian	2.44	14.217	9.102
UNSM 27845	Nebraska	Great Plains	Miocene	Clarendonian	2.104	12.687	8.747
UNSM 27845	Nebraska	Great Plains	Miocene	Clarendonian	2.289	14.046	9.284
UNSM 27845	Nebraska	Great Plains	Miocene	Clarendonian	2.173	13.864	9.405
UNSM 27860	Nebraska	Great Plains	Miocene	Clarendonian	3.846	17.352	8.848
UNSM 27860	Nebraska	Great Plains	Miocene	Clarendonian	4.338	21.65	10.395
UNSM 27860	Nebraska	Great Plains	Miocene	Clarendonian	4.203	21.84	10.653
UNSM 27860	Nebraska	Great Plains	Miocene	Clarendonian	3.923	18.596	9.389
UNSM 27860	Nebraska	Great Plains	Miocene	Clarendonian	3.829	18.925	9.671
UNSM 27860	Nebraska	Great Plains	Miocene	Clarendonian	2.394	13.567	8.768
UNSM 27861	Nebraska	Great Plains	Miocene	Clarendonian	3.459	16.751	9.007
UNSM 27861	Nebraska	Great Plains	Miocene	Clarendonian	3.585	18.189	9.606
UNSM 27861	Nebraska	Great Plains	Miocene	Clarendonian	3.913	19.402	9.808
UNSM 27861	Nebraska	Great Plains	Miocene	Clarendonian	3.462	18.251	9.809

UNSM 27861	Nebraska	Great Plains	Miocene	Clarendonian	3.505	18.281	9.765
UNSM 27861	Nebraska	Great Plains	Miocene	Clarendonian	3.076	17.456	9.953
UNSM 27864	Nebraska	Great Plains	Miocene	Clarendonian	3.865	15.14	7.701
UNSM 27864	Nebraska	Great Plains	Miocene	Clarendonian	4.55	17.845	8.366
UNSM 27864	Nebraska	Great Plains	Miocene	Clarendonian	4.805	19.686	8.981
UNSM 27864	Nebraska	Great Plains	Miocene	Clarendonian	4.552	18.391	8.620
UNSM 27864	Nebraska	Great Plains	Miocene	Clarendonian	4.296	18.272	8.816
UNSM 27864	Nebraska	Great Plains	Miocene	Clarendonian	2.568	13.973	8.720
UNSM 27865	Nebraska	Great Plains	Miocene	Clarendonian	3.342	16.805	9.193
UNSM 27865	Nebraska	Great Plains	Miocene	Clarendonian	3.897	18.678	9.462
UNSM 27865	Nebraska	Great Plains	Miocene	Clarendonian	4.321	18.647	8.971
UNSM 27865	Nebraska	Great Plains	Miocene	Clarendonian	3.372	16.576	9.027
UNSM 27865	Nebraska	Great Plains	Miocene	Clarendonian	3.457	16.279	8.755
UNSM 27875	Nebraska	Great Plains	Miocene	Clarendonian	1.665	9.971	7.727
UNSM 27875	Nebraska	Great Plains	Miocene	Clarendonian	1.868	10.853	7.941
UNSM 27875	Nebraska	Great Plains	Miocene	Clarendonian	2.049	11.074	7.736
UNSM 27875	Nebraska	Great Plains	Miocene	Clarendonian	1.921	11.269	8.131
UNSM 27875	Nebraska	Great Plains	Miocene	Clarendonian	1.878	11.44	8.348
UNSM 27875	Nebraska	Great Plains	Miocene	Clarendonian	2.035	13.396	9.391
UNSM 2997	Nebraska	Great Plains	Miocene	Hemphillian	3.003	18.998	10.963
UNSM 33162	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.185	30.42	12.232
UNSM 33508	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.591	29.448	11.470
UNSM 33508	Nebraska	Great Plains	Pleistocene	Irv/Rancho	7.375	28.127	10.357
UNSM 33527	Nebraska	Great Plains	Pleistocene	Irv/Rancho	3.355	18.463	10.080
UNSM 41996	Nebraska	Great Plains	Pliocene	Blancan	6.777	23.541	9.043

UNSM 41996	Nebraska	Great Plains	Pliocene	Blancan	6.576	23.781	9.274
UNSM 41996	Nebraska	Great Plains	Pliocene	Blancan	5.628	20.014	8.436
UNSM 41996	Nebraska	Great Plains	Pliocene	Blancan	5.871	21.822	9.006
UNSM 41996	Nebraska	Great Plains	Pliocene	Blancan	4.909	21.419	9.667
UNSM 42087	Nebraska	Great Plains	Pliocene	Blancan	5.815	13.458	5.581
UNSM 42087	Nebraska	Great Plains	Pliocene	Blancan	6.436	24.612	9.702
UNSM 42087	Nebraska	Great Plains	Pliocene	Blancan	7.232	27.174	10.105
UNSM 42087	Nebraska	Great Plains	Pliocene	Blancan	5.838	22.792	9.433
UNSM 42087	Nebraska	Great Plains	Pliocene	Blancan	6.412	24.378	9.627
UNSM 42087	Nebraska	Great Plains	Pliocene	Blancan	4.524	19.572	9.202
UNSM 42346	Nebraska	Great Plains	Pliocene	Blancan	6.989	27.479	10.394
UNSM 42346	Nebraska	Great Plains	Pliocene	Blancan	7.622	31.441	11.388
UNSM 42346	Nebraska	Great Plains	Pliocene	Blancan	7.598	31.603	11.465
UNSM 42346	Nebraska	Great Plains	Pliocene	Blancan	6.735	25.865	9.967
UNSM 42346	Nebraska	Great Plains	Pliocene	Blancan	6.681	28.415	10.993
UNSM 42346	Nebraska	Great Plains	Pliocene	Blancan	4.711	20.108	9.264
UNSM 42351	Nebraska	Great Plains	Pliocene	Blancan	5.135	20.359	8.984
UNSM 42351	Nebraska	Great Plains	Pliocene	Blancan	6.018	23.682	9.654
UNSM 42351	Nebraska	Great Plains	Pliocene	Blancan	6.869	25.269	9.641
UNSM 42351	Nebraska	Great Plains	Pliocene	Blancan	5.1418	21.688	9.564
UNSM 42351	Nebraska	Great Plains	Pliocene	Blancan	5.667	27.741	11.653
UNSM 42351	Nebraska	Great Plains	Pliocene	Blancan	4.822	20.675	9.415
UNSM 42431	Nebraska	Great Plains	Miocene	Barstovian	2.037	13.86	9.711
UNSM 42433	Nebraska	Great Plains	Miocene	Clarendonian	4.58	17.916	8.372
UNSM 42440	Nebraska	Great Plains	Miocene	Barstovian	2.973	21.45	12.440

UNSM 42442	Nebraska	Great Plains	Miocene	Barstovian	3.009	16.012	9.231
UNSM 42447	Nebraska	Great Plains	Miocene	Barstovian	3.003	16.655	9.611
UNSM 42452	Nebraska	Great Plains	Miocene	Barstovian	3.895	20.915	10.598
UNSM 42453	Nebraska	Great Plains	Miocene	Clarendonian	5.217	22.147	9.696
UNSM 42454	Nebraska	Great Plains	Miocene	Clarendonian	5.779	19.094	7.943
UNSM 42456	Nebraska	Great Plains	Miocene	Barstovian	3.04	14.136	8.108
UNSM 42468	Nebraska	Great Plains	Miocene	Clarendonian	2.795	15.288	9.144
UNSM 4289	Nebraska	Great Plains	Miocene	Hemphillian	3.424	21.022	11.361
UNSM 46810	Nebraska	Great Plains	Pliocene	Blancan	5.217	24.719	10.822
UNSM 49318	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.638	27.494	11.579
UNSM 49417	Nebraska	Great Plains	Pleistocene	Irv/Rancho	2.842	17.266	10.242
UNSM 52296	Nebraska	Great Plains	Miocene	Clarendonian	2.332	14.908	9.762
UNSM 52296	Nebraska	Great Plains	Miocene	Clarendonian	3.085	18.261	10.397
UNSM 52296	Nebraska	Great Plains	Miocene	Clarendonian	3.006	19.09	11.011
UNSM 52296	Nebraska	Great Plains	Miocene	Clarendonian	3.04	17.705	10.155
UNSM 52296	Nebraska	Great Plains	Miocene	Clarendonian	2.812	17.524	10.450
UNSM 52296	Nebraska	Great Plains	Miocene	Clarendonian	1.514	11.201	9.103
UNSM 52300	Nebraska	Great Plains	Miocene	Clarendonian	5.167	21.221	9.336
UNSM 52300	Nebraska	Great Plains	Miocene	Clarendonian	6.255	25.137	10.051
UNSM 52300	Nebraska	Great Plains	Miocene	Clarendonian	5.929	23.798	9.773
UNSM 52300	Nebraska	Great Plains	Miocene	Clarendonian	4.575	20.463	9.567
UNSM 52300	Nebraska	Great Plains	Miocene	Clarendonian	4.743	20.255	9.300
UNSM 52300	Nebraska	Great Plains	Miocene	Clarendonian	3.264	15.468	8.562
UNSM 54835	Nebraska	Great Plains	Pliocene	Blancan	6.161	26.391	10.632
UNSM 54837	Nebraska	Great Plains	Pliocene	Blancan	7.329	30.331	11.204

UNSM 54839	Nebraska	Great Plains	Pliocene	Blancan	4.761	26.374	12.087
UNSM 54840	Nebraska	Great Plains	Pliocene	Blancan	7.878	32.553	11.598
UNSM 56653	Nebraska	Great Plains	Miocene	Barstovian	2.645	13.818	8.496
UNSM 59261	Nebraska	Great Plains	Miocene	Hemphillian	2.93	13.946	8.147
UNSM 59443	Nebraska	Great Plains	Miocene	Clarendonian	3.157	19.855	11.175
UNSM 5978	Nebraska	Great Plains	Pleistocene	Irv/Rancho	7.728	27.9	10.036
UNSM 5978	Nebraska	Great Plains	Pleistocene	Irv/Rancho	7.781	30.751	11.024
UNSM 5978	Nebraska	Great Plains	Pleistocene	Irv/Rancho	7.892	30.884	10.994
UNSM 5978	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.064	26.187	10.634
UNSM 5978	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.807	26.597	11.037
UNSM 6023	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.329	21.044	9.116
UNSM 6023	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.508	21.446	9.138
UNSM 6023	Nebraska	Great Plains	Pleistocene	Irv/Rancho	4.823	20.698	9.425
UNSM 6023	Nebraska	Great Plains	Pleistocene	Irv/Rancho	4.616	19.858	9.243
UNSM 6023	Nebraska	Great Plains	Pleistocene	Irv/Rancho	4.015	18.958	9.461
UNSM 6027	Nebraska	Great Plains	Pleistocene	Irv/Rancho	8.711	31.912	10.812
UNSM 6027	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.943	26.152	10.728
UNSM 6027	Nebraska	Great Plains	Pleistocene	Irv/Rancho	6.511	25.838	10.126
UNSM 6027	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.781	25.099	10.439
UNSM 62895	Nebraska	Great Plains	Pliocene	Blancan	5.457	27.43	11.742
UNSM 84000	Nebraska	Great Plains	Miocene	Barstovian	3.032	18.813	10.804
UNSM 8515	Nebraska	Great Plains	Miocene	Barstovian	3.22	16.105	8.975
UNSM 8633	Nebraska	Great Plains	Miocene	Clarendonian	4.631	21.703	10.085
UNSM 90576	Nebraska	Great Plains	Miocene	Barstovian	2.874	14.401	8.495
UNSM 90641	Nebraska	Great Plains	Miocene	Hemphillian	4.556	17.874	8.374

UNSM 94445	Nebraska	Great Plains	Miocene	Hemphillian	5.461	21.227	9.083
UNSM 96997	Nebraska	Great Plains	Miocene	Barstovian	3.351	19.123	10.446
UNSM 96999	Nebraska	Great Plains	Miocene	Barstovian	3.3048	16.548	9.103
UNSM 9798	Nebraska	Great Plains	Miocene	Barstovian	3.308	14.611	8.033
UNSM 9800	Nebraska	Great Plains	Miocene	Barstovian	3.294	17.569	9.680
UNSM 98405	Nebraska	Great Plains	Miocene	Barstovian	4.047	19.148	9.518
UNSM 98406	Nebraska	Great Plains	Miocene	Barstovian	3.912	21.466	10.853
UOMNCH B-4028			Recent	Recent	8.465	27.161	9.335
UOMNCH B-4028			Recent	Recent	9.055	30.412	10.106
UOMNCH B-4028			Recent	Recent	10.14	31.826	9.995
UOMNCH B-4028			Recent	Recent	8.101	27.276	9.583
UOMNCH B-4028			Recent	Recent	7.386	27.331	10.057
UOMNCH B-4028			Recent	Recent	5.458	24.13	10.329
UOMNCH B-8698			Recent	Recent	7.816	25.708	9.196
UOMNCH B-8698			Recent	Recent	8.367	30.399	10.509
UOMNCH B-8698			Recent	Recent	8.798	30.154	10.166
UOMNCH B-8698			Recent	Recent	7.844	24.385	8.707
UOMNCH B-8698			Recent	Recent	6.738	22.629	8.718
UOMNCH B-8698			Recent	Recent	5.56	20.289	8.604
UOMNCH B-8700			Recent	Recent	7.057	24.985	9.405
UOMNCH B-8700			Recent	Recent	7.362	27.931	10.294
UOMNCH B-8700			Recent	Recent	7.184	26.809	10.002
UOMNCH B-8700			Recent	Recent	6.234	23.325	9.342
UOMNCH B-8700			Recent	Recent	6.488	23.265	9.134
UOMNCH B-8700			Recent	Recent	5.781	25.048	10.418

UOMNCH B-9092			Recent	Recent	4.427	19.043	9.051
UOMNCH B-9092			Recent	Recent	5.298	21.686	9.422
UOMNCH B-9092			Recent	Recent	4.834	21.042	9.570
UOMNCH B-9092			Recent	Recent	4.25	19.849	9.628
UOMNCH B-9092			Recent	Recent	4.509	20.263	9.543
UOMNCH B-9092			Recent	Recent	4.667	19.273	8.921
UOMNCH F-21828	Oregon	Columbia Plateau	Pleistocene	Irv/Rancho	6.654	29.935	11.605
USNM 10314	Arizona	Great Basin	Pleistocene	Irv/Rancho	4.689	24.944	11.519
USNM 10482	Nevada	Great Basin	Pleistocene	Irv/Rancho	4.676	21.491	9.938
USNM 10571	Florida	Gulf Coast	Pleistocene	Irv/Rancho	4.755	24.37	11.176
USNM 10622	Florida	Gulf Coast	Pleistocene	Irv/Rancho	6.013	30.443	12.415
USNM 11160	Yukon	Polar	Pleistocene	Irv/Rancho	8.166	31.124	10.892
USNM 11190	Florida	Gulf Coast	Pleistocene	Irv/Rancho	4.803	27.49	12.543
USNM 11192	Florida	Gulf Coast	Pleistocene	Irv/Rancho	4.534	23.657	11.110
USNM 11200	Florida	Gulf Coast	Pleistocene	Irv/Rancho	5.269	27.303	11.895
USNM 11351	Arizona	Great Basin	Pleistocene	Irv/Rancho	5.808	28.364	11.769
USNM 11372	Texas	Great Plains	Pleistocene	Irv/Rancho	6.901	32.304	12.297
USNM 11374	Texas	Great Plains	Pleistocene	Irv/Rancho	4.64	22.998	10.677
USNM 11412	Florida	Gulf Coast	Pleistocene	Irv/Rancho	4.542	23.409	10.984
USNM 11623	Florida	Gulf Coast	Pleistocene	Irv/Rancho	6.733	32.206	12.412
USNM 11658	Alaska	Polar	Pleistocene	Irv/Rancho	8.588	30.996	10.577
USNM 1172	South Carolina	Eastern US	Pleistocene	Irv/Rancho	6.265	28.325	11.316
USNM 11745	Arizona	Great Basin	Pliocene	Blancan	2.182	16.801	11.374
USNM 11746	Arizona	Great Basin	Pliocene	Blancan	1.968	15.632	11.143
USNM 11819	Georgia	Eastern US	Pleistocene	Irv/Rancho	6.98	30.435	11.520

USNM 11986	Idaho	Columbia Plateau	Pliocene	Blancan	7.926	24.138	8.574
USNM 12146	Alaska	Polar	Pleistocene	Irv/Rancho	7.817	35.388	12.657
USNM 12804	Alaska	Polar	Pleistocene	Irv/Rancho	7.112	31.443	11.790
USNM 12875	Arizona	Great Basin	Pliocene	Blancan	5.492	23.785	10.149
USNM 13682	Minnesota	Great Plains	Pleistocene	Irv/Rancho	7.314	28.413	10.506
USNM 14417	Idaho	Columbia Plateau	Pleistocene	Irv/Rancho	6.978	26.763	10.131
USNM 15219	Florida	Gulf Coast	Pleistocene	Irv/Rancho	4.91	27.014	12.191
USNM 15389	Mexico	Gulf Coast	Pleistocene	Irv/Rancho	6.19	25.455	10.231
USNM 17082	Maryland	Eastern US	Pleistocene	Irv/Rancho	6.385	25.397	10.051
USNM 171045	Alabama	Eastern US	Miocene	Hemphillian	3.956	22.812	11.469
USNM 173623	Alabama	Eastern US	Miocene	Hemphillian	4.127	24.06	11.843
USNM 17922	Virginia	Eastern US	Pleistocene	Irv/Rancho	4.67	23.62	10.930
USNM 18205	Florida	Gulf Coast	Miocene	Hemphillian	6.435	29.224	11.520
USNM 18206	Florida	Gulf Coast	Miocene	Hemphillian	1.374	11.705	9.986
USNM 18207	Florida	Gulf Coast	Miocene	Hemphillian	1.378	10.223	8.709
USNM 18208	Florida	Gulf Coast	Miocene	Hemphillian	1.983	9.304	6.607
USNM 18212	Florida	Gulf Coast	Miocene	Hemphillian	2.931	18.765	10.961
USNM 182197	North Carolina	Eastern US	Miocene	Hemphillian	2.413	15.618	10.054
USNM 18234	Florida	Gulf Coast	Miocene	Hemphillian	1.687	14.003	10.781
USNM 18236	Florida	Gulf Coast	Miocene	Hemphillian	1.82	13.991	10.371
USNM 18243	Florida	Gulf Coast	Miocene	Hemphillian	1.601	14.354	11.344
USNM 18244	Florida	Gulf Coast	Miocene	Hemphillian	1.74	16.787	12.726
USNM 18250	Florida	Gulf Coast	Miocene	Hemphillian	3.314	20.943	11.504
USNM 187652	Florida	Gulf Coast	Pleistocene	Irv/Rancho	4.321	24.762	11.912
USNM 1907	Mississippi	Gulf Coast	Pleistocene	Irv/Rancho	6.005	34.736	14.175

USNM 1932	Texas	Great Plains	Miocene	Hemphillian	6.639	21.733	8.435
USNM 1933	Texas	Great Plains	Miocene	Hemphillian	6.244	17.594	7.041
USNM 20105	Florida	Gulf Coast	Miocene	Hemphillian	2.927	20.361	11.901
USNM 23892	California	California	Miocene	Clarendonian	2.968	19.233	11.164
USNM 23903	Idaho	Columbia Plateau	Pliocene	Blancan	9.704	30.219	9.701
USNM 244299	Nebraska	Great Plains	Miocene	Barstovian	3.958	21.166	10.639
USNM 25142	Montana	Great Plains	Miocene	Barstovian	1.302	9.409	8.246
USNM 25583	Florida	Gulf Coast	Pleistocene	Irv/Rancho	3.943	21.335	10.744
USNM 25683	Mississippi	Gulf Coast	Pleistocene	Irv/Rancho	5.133	24.286	10.719
USNM 2572	New Mexico	Great Basin	Miocene	Barstovian	4.17	21.958	10.753
USNM 2573	New Mexico	Great Basin	Miocene	Barstovian	2.336	16.456	10.767
USNM 262545	Alaska	Polar	Pleistocene	Irv/Rancho	6.947	27.203	10.321
USNM 26324	Georgia	Eastern US	Pleistocene	Irv/Rancho	4.636	24.602	11.426
USNM 299566	Maryland	Eastern US	Miocene	Clarendonian	2.713	19.747	11.989
USNM 3292	Florida	Gulf Coast		Irv/Rancho	3.34	22.075	12.079
USNM 330994	Alabama	Eastern US	Miocene	Hemphillian	3.724	16.33	8.462
USNM 351924	Nebraska	Great Plains	Miocene	Barstovian	6.87	17.952	6.849
USNM 390722	Alabama	Eastern US	Miocene	Hemphillian	3.043	19.763	11.329
USNM 391594	Alabama	Eastern US	Miocene	Hemphillian	3.442	17.956	9.678
USNM 391852	North Carolina	Eastern US	Pliocene	Blancan	2.405	16.402	10.576
USNM 391854	North Carolina	Eastern US	Pliocene	Blancan	1.743	14.294	10.827
USNM 391855	North Carolina	Eastern US	Pliocene	Blancan	2.673	17.695	10.823
USNM 391856	North Carolina	Eastern US	Pliocene	Blancan	1.783	15.32	11.473
USNM 391864	North Carolina	Eastern US	Pliocene	Blancan	1.999	13.835	9.785
USNM 391865	North Carolina	Eastern US	Pliocene	Blancan	1.6	12.426	9.824

USNM 413207	Virginia	Eastern US	Miocene	Hemphillian	2.887	19.11	11.247
USNM 413212	Texas	Great Plains	Miocene	Hemphillian	2.235	14.183	9.487
USNM 413671	Nevada	Great Basin	Miocene	Barstovian	5.867	20.777	8.578
USNM 416338/UF 17570	Florida	Gulf Coast	Miocene	Hemphillian	2.109	14.72	10.136
USNM 420682	Texas	Great Plains	Miocene	Clarendonian	2.474	14.787	9.401
USNM 4999	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.553	27.559	11.695
USNM 520	Tennessee	Eastern US	Pleistocene	Irv/Rancho	4.348	23.763	11.396
USNM 521290	Alabama	Eastern US	Miocene	Hemphillian	4.537	21.855	10.260
USNM 540677	Panama	Gulf Coast	Pleistocene	Irv/Rancho	4.314	19.901	9.582
USNM 5446	Nebraska	Great Plains	Miocene	Clarendonian	1.477	11.107	9.139
USNM 5447	Nebraska	Great Plains	Miocene	Clarendonian	2.169	16.088	10.924
USNM 555	Massachusetts	Eastern US	Pleistocene	Irv/Rancho	7.905	31.311	11.136
USNM 557	Oregon	Columbia Plateau	Pleistocene	Irv/Rancho	9.331	30.913	10.120
USNM 569	Nebraska	Great Plains	Miocene	Barstovian	3.793	18.338	9.416
USNM 573	Nebraska	Great Plains	Miocene	Barstovian	4.779	18.253	8.350
USNM 584	Nebraska	Great Plains	Miocene	Clarendonian	3.652	21.514	11.258
USNM 587	Nebraska	Great Plains	Miocene	Clarendonian	2.704	18.996	11.552
USNM 619	Nebraska	Great Plains	Miocene	Barstovian	3.364	17.823	9.717
USNM 667	Nebraska	Great Plains	Pleistocene	Irv/Rancho	5.469	23.23	9.933
USNM 7084	Louisiana	Gulf Coast	Pleistocene	Irv/Rancho	5.72	29.615	12.383
USNM 726	Louisiana	Gulf Coast	Pleistocene	Irv/Rancho	8.442	31.737	10.923
USNM 7507	Kansas	Great Plains	Miocene	Hemphillian	3.851	18.801	9.581
USNM 7514	Kansas	Great Plains	Miocene	Hemphillian	4.013	26.216	13.087
USNM 7530	Kansas	Great Plains	Miocene	Hemphillian	4.778	22.604	10.341
USNM 7700	Alaska	Polar	Pleistocene	Irv/Rancho	6.281	26.964	10.759

USNM 7868	Nebraska	Great Plains	Pleistocene	Irv/Rancho	9.62	32.958	10.626
USNM 7935	West Virginia	Eastern US	Pleistocene	Irv/Rancho	5.647	27.879	11.732
USNM 8265	Florida	Gulf Coast	Miocene	Hemphillian	4.561	24.063	11.267
USNM 8268	Florida	Gulf Coast	Pleistocene	Irv/Rancho	7.125	30.659	11.486
USNM 8426	Yukon	Polar	Pleistocene	Irv/Rancho	6.783	23.639	9.076
USNM 8642	Oklahoma	Great Plains	Pleistocene	Irv/Rancho	7.816	29.251	10.463
USNM 876	Ohio	Eastern US	Pleistocene	Irv/Rancho	6.996	32.143	12.152
USNM 8813	Massachusetts	Eastern US	Pleistocene	Irv/Rancho	7.27	30.109	11.167
USNM 882	Massachusetts	Eastern US	Pleistocene	Irv/Rancho	5.155	25.301	11.144
USNM 8945	Tennessee	Eastern US	Pleistocene	Irv/Rancho	4.931	23.046	10.378
USNM 9464	Iowa	Great Plains	Pleistocene	Irv/Rancho	8.203	29.532	10.311
UWBM 17938	Nevada	Columbia Plateau	Miocene	Barstovian	2.882	18.289	10.773
UWBM 19200	Alaska	Polar	Pleistocene	Irv/Rancho	11.58	41.886	12.309
UWBM 19201	Alaska	Polar	Pleistocene	Irv/Rancho	13.691	44.684	12.076
UWBM 19202	Alaska	Polar	Pleistocene	Irv/Rancho	8.364	32.009	11.068
UWBM 19203	Alaska	Polar	Pleistocene	Irv/Rancho	11.159	38.905	11.646
UWBM 22278	California	California	Pliocene	Blancan	7.424	23.709	8.702
UWBM 22296	California	California	Pliocene	Blancan	7.71	24.128	8.689
UWBM 22297	California	California	Pliocene	Blancan	6.723	24.19	9.329
UWBM 22298	California	California	Pliocene	Blancan	6.247	23.428	9.373
UWBM 22299	California	California	Pliocene	Blancan	7.31	25.304	9.359
UWBM 22300	California	California	Pliocene	Blancan	7.066	24.902	9.368
UWBM 28027	Texas	Great Plains	Pleistocene	Irv/Rancho	6.529	25.526	9.990
UWBM 28027	Texas	Great Plains	Pleistocene	Irv/Rancho	6.219	26.252	10.527
UWBM 40927	Oregon	Columbia Plateau	Miocene	Barstovian	2.936	15.508	9.051

UWBM 40927	Oregon	Columbia Plateau	Miocene	Barstovian	2.433	14.235	9.126
UWBM 42136	Washington	Columbia Plateau	Pliocene	Blancan	7.239	27.111	10.076
UWBM 42323	Washington	Columbia Plateau	Pliocene	Blancan	6.024	22.834	9.303
UWBM 42331	Washington	Columbia Plateau	Pliocene	Blancan	6.575	24.067	9.386
UWBM 45033	Washington	Columbia Plateau	Pliocene	Blancan	5.405	21.273	9.150
UWBM 45033	Washington	Columbia Plateau	Pliocene	Blancan	6.178	22.001	8.852
UWBM 45033	Washington	Columbia Plateau	Pliocene	Blancan	5.873	23.006	9.493
UWBM 45102	Washington	Columbia Plateau	Pliocene	Blancan	8.604	29.27	9.979
UWBM 48724	Oregon	Columbia Plateau	Miocene	Hemphillian	4.828	25.305	11.517
UWBM 50008	Alaska	Polar	Pleistocene	Irv/Rancho	7.57	27.424	9.967
UWBM 50008	Alaska	Polar	Pleistocene	Irv/Rancho	8.153	28.723	10.059
UWBM 58727	Idaho	Columbia Plateau	Pliocene	Blancan	6.423	20.238	7.985
UWBM 58727	Idaho	Columbia Plateau	Pliocene	Blancan	7.582	24.732	8.982
UWBM 58727	Idaho	Columbia Plateau	Pliocene	Blancan	7.246	24.758	9.197
UWBM 58727	Idaho	Columbia Plateau	Pliocene	Blancan	8.452	25.832	8.885
UWBM 58727	Idaho	Columbia Plateau	Pliocene	Blancan	7.615	26.954	9.768
UWBM 59241	Oregon	Columbia Plateau	Miocene	Hemphillian	2.134	11.866	8.123
UWBM 59241	Oregon	Columbia Plateau	Miocene	Hemphillian	2.407	10.314	6.648
UWBM 59241	Oregon	Columbia Plateau	Miocene	Hemphillian	1.804	11.847	8.820
UWBM 59241	Oregon	Columbia Plateau	Miocene	Hemphillian	2.072	13.339	9.267
UWBM 61573	Oregon	Columbia Plateau	Miocene	Hemphillian	4.927	25.024	11.274
UWBM 71401	Montana	Great Plains	Miocene	Barstovian	2.907	16.794	9.850
UWBM 71401	Montana	Great Plains	Miocene	Barstovian	2.778	14.755	8.853
UWBM 75621	Oregon	Columbia Plateau	Pleistocene	Irv/Rancho	11.445	34.799	10.286
UWBM 80705	Washington	Columbia Plateau	Pliocene	Blancan	7.642	27.365	9.899

UWBM 87138	Alaska	Polar	Pleistocene	Irv/Rancho	8.836	30.716	10.333
UWBM 87138	Alaska	Polar	Pleistocene	Irv/Rancho	7.029	27.93	10.535
UWBM 87138	Alaska	Polar	Pleistocene	Irv/Rancho	7.219	30.635	11.402

APPENDIX B

FRACTAL DIMENSIONALITY RAW DATA TABLE

Specimen #	Subfamily	Tribe	Genus	Species	Tooth Position	*D*	True Area (cm^2)
UOMNCH B-4028	Equinae	Equini	*Equus*	*caballus*	P3	1.396	9.055
UOMNCH B-8698	Equinae	Equini	*Equus*	*caballus*	P3	1.457	8.367
UOMNCH B-8700	Equinae	Equini	*Equus*	*caballus*	P3	1.506	7.362
UOMNCH B-9092	Equinae	Equini	*Equus*	*caballus*	P3	1.39	5.298
MVZ 55150	Equinae	Equini	*Equus*	*grevyi*	P3	1.276	7.595
MVZ 117884	Equinae	Equini	*Equus*	*quagga*	P3	1.264	6.295
MVZ 117885	Equinae	Equini	*Equus*	*quagga*	P3	1.223	5.594
MVZ 117887	Equinae	Equini	*Equus*	*quagga*	P3	1.254	5.307
MVZ 117888	Equinae	Equini	*Equus*	*quagga*	P3	1.252	5.596
MVZ 154358	Equinae	Equini	*Equus*	*asinus*	P3	1.229	5.159
F:AM 71891	Equinae	Hipparionini	*Cormohipparion*	*quinni*	P3	1.445	4.587
F:AM 73940	Equinae	Hipparionini	*Cormohipparion*	*goorisi*	P3	1.415	3.8
UCMP 31256	Equinae	Hipparionini	*Neohipparion*	*eurystyle*	P3	1.298	4.028
UF 32300	Equinae	Hipparionini	*Cormohipparion*	*ingenuus*	P3	1.317	3.169
UNSM 27860	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P3	1.337	4.338
UNSM 27861	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P3	1.309	3.585
UNSM 52296	Equinae	Hipparionini	*Neohipparion*	*affine*	P3	1.314	3.085
UNSM 52300	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P3	1.38	6.255
UNSM 96997	Equinae	Hipparionini	*Cormohipparion*	*occidentale*	P3	1.371	3.351
F:AM 108233	Equinae	Hipparionini	*Cormohipparion*	*sphenodus*	P3	1.427	5.315

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