Biostratigraphy and magnetostratigraphy, late Pliocene rocks, 111 Ranch, Arizona

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ABSTRACT

Fossiliferous strata exposed along the northwestern flank of Dry Mountain on the 111 Ranch, 27 km southeast of Safford, Graham County, Arizona, were dated by means of isotopic methods and the magnetic-reversal time scale. A 100-m fossiliferous interval contains the later part of the Gauss Chron and the early part (pre-Olduvai) of the Matuyama Chron. Zircon fission-track ages on an ash bed just below the Gauss-Matuyama boundary support this identification. Owing to these age constraints, the fossil mammals at the 111 Ranch locality are all constrained within the later part of the Blancan Mammal Age rather than the latest Blancan and early Irvingtonian, as previously stated in the literature. They are, therefore, synchronous with certain localities (Wolf Ranch and California Inst. Technology) in the Saint David Formation of the San Pedro Valley 130 km to the southwest of Dry Mountain. The horse *Nannippus* persisted in the 111 Ranch locality at least until the end of the Gauss Chron, in confirmation of data from the San Pedro Valley. A diverse group of equine and asinine equids is evident in the 111 Ranch fauna, which argues for an early divergence of these major branches of horse phylogeny. The 111 Ranch fauna records the first appearance of three neotropical immigrants in the southwest, including the sloth *Glossotherium*, the glyptodont *Glyptotherium*, and the capybara *Neochoerus*. A palearctic immigrant, the vole *Synaptomys*, is also present.

INTRODUCTION

In a series of papers, three of the authors (Johnson and others, 1975; Lindsay and others, 1976; Opdyke and others, 1977) were concerned with the determination of mammalian range zones of regional applicability and their calibration against radioisotope data and the pa-

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*Deceased.

leomagnetic time scale. Through these means, we tested correlations of late Cenozoic faunas of western North America independent of the faunas themselves (Lindsay and others, 1976). The present study further explores these problems in an area in Arizona near the New Mexico border, 130 km northeast of that previously studied in the San Pedro Valley. Outcrops on the old 111 Ranch, 27 km southeast of Safford, Graham County, Arizona, have long been studied by the University of Arizona and the Frick Laboratory of the American Museum of Natural History. The work of these institutions is combined and summarized here as a contribution toward the biostratigraphy of a critical part of the geological column that elsewhere in the Southwest is not so completely represented. This study gives us the opportunity to test our knowledge of the range zones of biochronologically important mammalian taxa and to better define the chronology of some important biogeographic changes (especially the introduction of exotic neotropical taxa).

Previous investigations (Lance, 1958, 1960; Wood, 1960, 1962) had indicated that the fossiliferous strata of the 111 Ranch locality contained representatives of superposed Blancan and Irvingtonian faunas and hence might be of importance in defining and calibrating these mammal ages. Our preliminary investigations indicated that this may not be the case (Lindsay and others, 1980, their Fig. 1) and in this report we elaborate further on the problem.

GEOLOGIC SETTING

The late Cenozoic sediments that flank Dry Mountain, a salient of the northern Whitlock Mountains, 27 km southeast of Safford, Graham County, Arizona, were first described by Knechtel (1938), in the course of a study of the ground-water resources of a portion of the Gila River and its tributary, San Simon Creek. These deposits received little attention until the late 1950s and early 1960s, when they were studied in some detail by Seff (1960) during the Univer-

sity of Arizona's paleontological work at the 11 Ranch site. At the same time, Harbour (1966 considered these deposits in a broader treatmer of the Cenozoic sediments of the upper Saffor Basin. Ted Galusha began stratigraphic studie at Dry Mountain in 1939, and these were inter sified in 1977–1978 (with Marian Galusha yielding the basis for the present summary of th lithostratigraphy and biostratigraphy. The area included on a recent geologic map of the Whit lock Mountains by Richter and others (1981).

About 100 m of the upper part of the basi fill is exposed on the flanks of Dry Mountain i sec. 26–29, 31–35, T. 8 S. and sec. 4, T. 9 S., F 28 E. (Dry Mountain and Artesia NE, 1:24,00(quadrangles) (Figs. 1 and 2). These rock include a complex of fluviatile, paludal, an lacustrine facies referred to as the 111 Ranc beds by Seff (1960). These sediments lap di rectly onto the Miocene volcanics that compos the core of Dry Mountain. Only a thin talus c volcanic debris separates the Miocene volcanic and the alluvial basin-fill deposits. The basin fi dips radially away from the mountain mass a very low angles (2° to 3°), increasing only ove buried basement salients that are now unroofe as inliers of volcanics surrounded by the basi fill. A few compaction faults occur near thes inliers, but the basin fill is not otherwise cut b faults. Sedimentary facies are to some exten controlled by the presence of the buried base ment ridges, in that lacustrine limestone, mar and diatomite dominate the exposures on th eastern and western sides of Dry Mountair where the salients shielded these local sites o deposition from clastic sediments introduce from northern sources. The most widesprea lithology in the 111 Ranch beds is silt sandstones that interdigitate with all other facie The top of a widely traceable marl and lime stone unit cropping out at about 3,400-1 elevation is mapped in Figure 1 and seems t mark a significant hiatus in the sedimentary se quence and an important biostratigraphi change. Above this unit, clastic sediments con taining several ash beds dominate the sequence
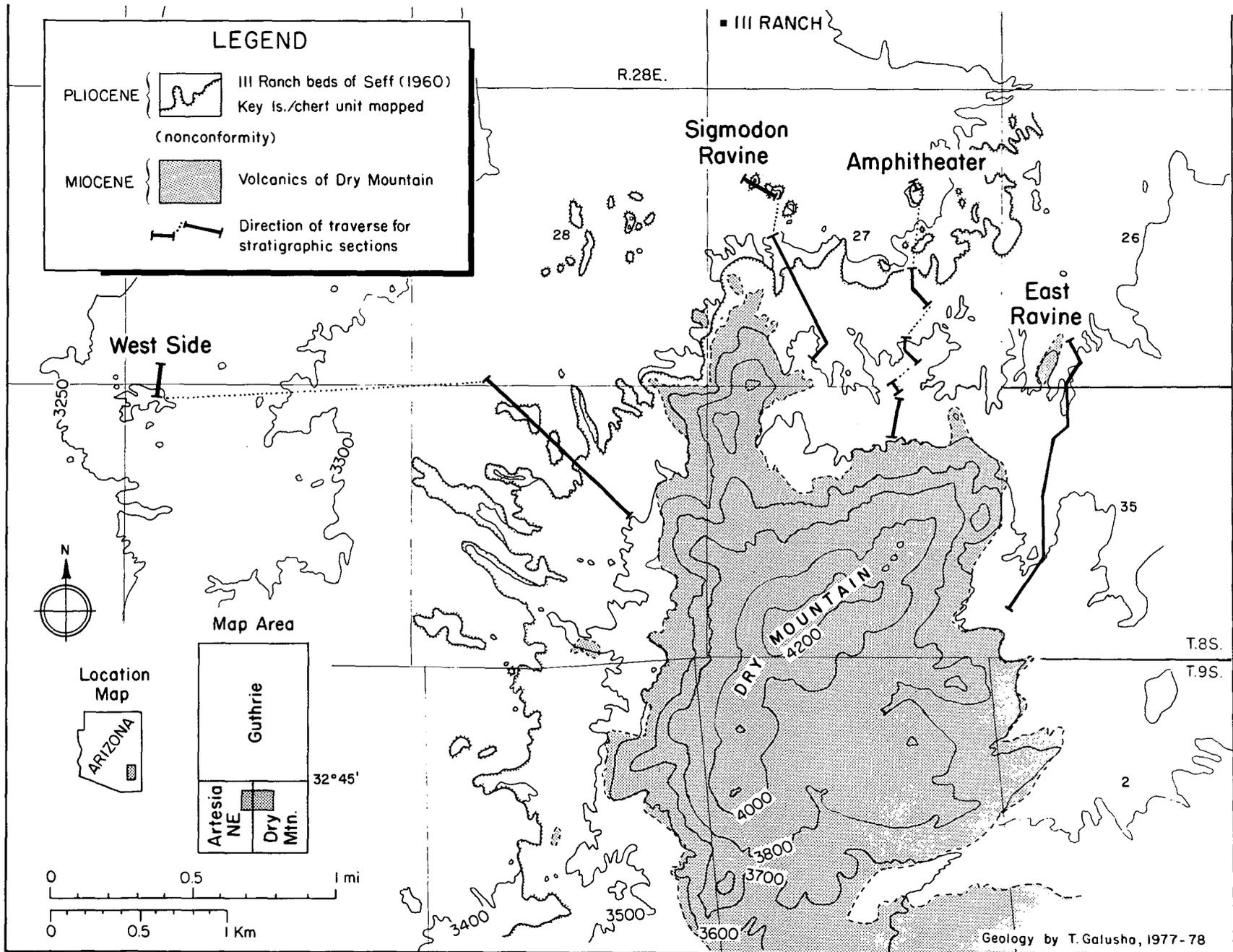
LEGEND

PLIOCENE
- 111 Ranch beds of Seff (1960)
- Key ls./chert unit mapped
- (nonconformity)

MIOCENE
- Volcanics of Dry Mountain

- Direction of traverse for stratigraphic sections

- III RANCH

R.28E.

Sigmodon Ravine

Amphitheater

East Ravine

West Side

N

Map Area

Location Map

ARIZONA

Guthrie

Artesia NE

Dry Mtn.

32°45'

0   0.5   1 mi
0   0.5   1 Km

28   27   26

35

DRY MOUNTAIN

4200

4000

3800

3700

3600

3500

3400

3250

3300

3500

T.8S.
T.9S.

2

Geology by T. Galusha, 1977-78

Figure 1. Geological map of a part of the 111 Ranch and Dry Mountain area, Graham County, Arizona, showing location of the traverses along which the stratigraphic columns of Figure 2 were measured.
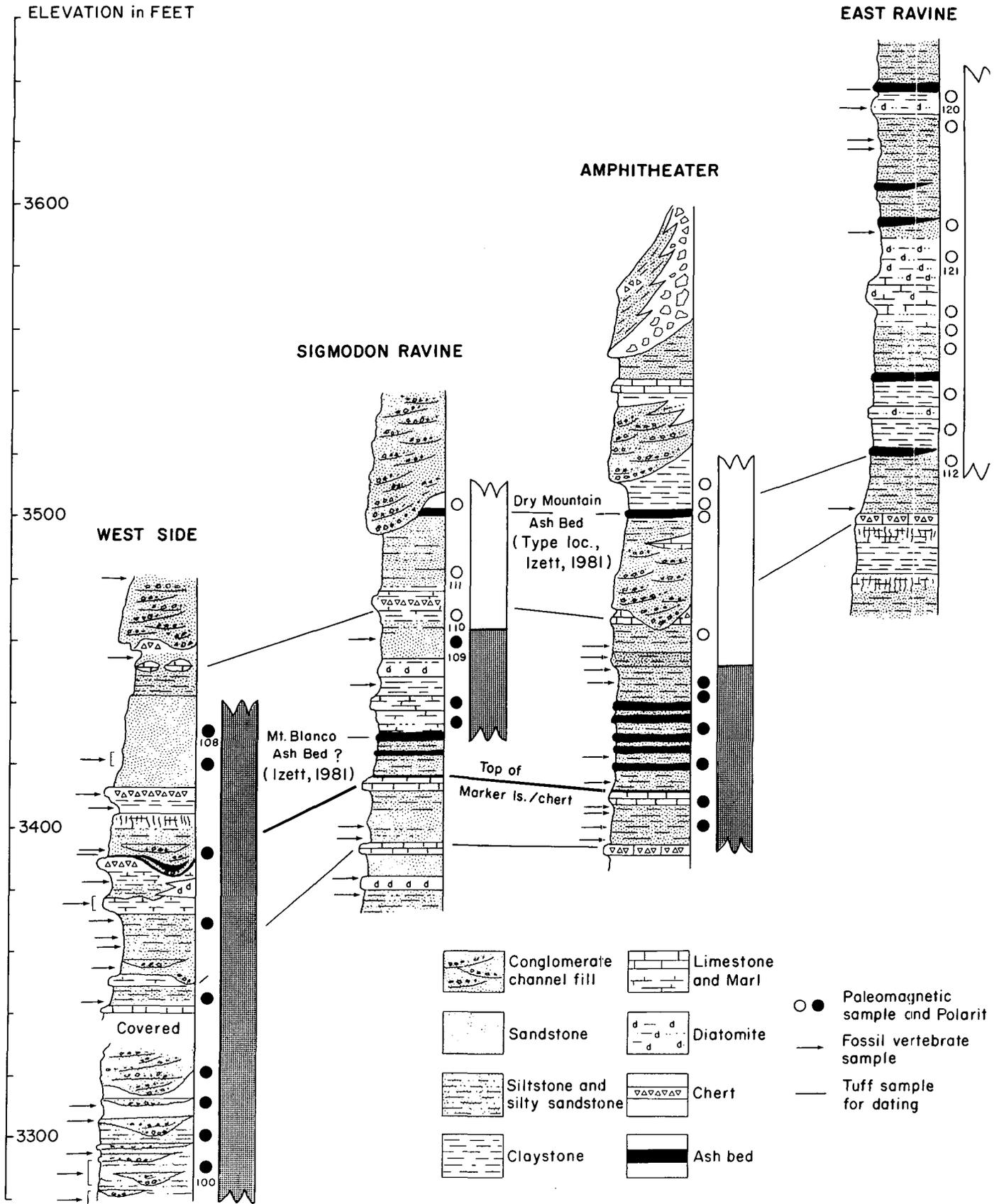
Figure 2. Stratigraphic columns used to orient magnetostratigraphic and biostratigraphic profiles, 111 Ranch and Dry Mountain area, Graham County, Arizona. Lithology shown by symbols; lithological correlations effected by tracing key limestone and ash beds (marker chert/limestone unit mapped in Fig. 1 indicated). Sample number, position, polarity (normal black circles, reversed open circles) of samples collected for magnetostratigraphy indicated and interpreted magnetostratigraphy shown in columns to right of diagrammatic lithostratigraphy.

nd gravel-filled, narrow, deep paleochannels reak the finer-grained sequence more fre- uently. Channel axes and internal structures idicate transport from the northeast and north round the western flank of Dry Mountain. Ilasts in these channel fills are dominated by olcanics derived from the surrounding Safford Iasin. Exotic lithologies (porphyry, quartz mon- onite, metamorphics, and copper ores) are iresent, however, that have sources beyond the iasin to the northeast, implying intercommuni- ation of basin fills within the upper Gila River Irainage of Pliocene time.

Sedimentation of the basin fill was terminated iy a shift in sedimentary regime, which pro- luced a conformable unit of coarse alluvial-fan naterial. Subsequent geological events are re- ated to the establishment and entrenchment of he modern Gila drainage, including its impor- ant tributary San Simon Creek, at present dis- ecting the valley west of Dry Mountain.

MAGNETOSTRATIGRAPHY

Sites were sampled from the 111 Ranch locali- ies over three field seasons, initially in 1971, igain in 1974, and finally in 1979. At each site, hree oriented samples were taken, using the echniques described by Johnson and others 1975). Care was taken to avoid weathered samples and sampling was in general confined to arroyos where lightning incidence was likely to be smaller. The samples were oriented in the field, using a Brunton compass, and were fash- ioned into cubes 2.5 cm on a side. The samples were then measured on a commercially availa- ble spinner magnetometer of the type described by Molyneaux (1971).

Pilot samples were subjected to partial de- magnetization in alternating fields. In most cases, the characteristic direction of magnetiza- tion was isolated in AF fields of 200 Oe. At certain of the sites, however, AF demagnetiza- tion did not prove effective. In other studies (Khan and Opdyke, 1981) of late Cenozoic ter- restrial sediments, we noted that low blocking temperature components with high coercivities are present in sediments, presumably due to the presence of geothite; therefore, thermal demag- netization curves were done on samples from selected sites. We found in most of these that 90% of the NRM was removed at temperatures as low as 200 °C (Fig. 3). All sites therefore were subjected to blanket thermal demagnetiza- tion at 300 °C. This partial thermal demagneti- zation markedly improved the quality of the data, leading to an excellent internally consistent magnetostratigraphy. Figure 4 gives the latitude of the VGP of all class I sites, using the conven- tion of Opdyke and others (1977). Although the bulk of these sediments are white to drab in color, a comparison of AF and thermal demag-

netization techniques demonstrates that, in this case, thermal demagnetization was the more ef- fective technique in removing secondary com- ponents of magnetization.

Figure 4 gives a comparison of the magnetic stratigraphy after AF demagnetization at 200 Oe and thermal demagnetization after 300 °C. It can be seen that four sites with reversed polarity possess random directions of magnetization (criteria of Watson, 1956) after AF demagneti- zation. A dramatic change occurs after thermal demagnetization. One site, no. 111, changed po- larity after thermal treatment and the next site in sequence yielded a VGP at much higher latitude. Three of the sites became statistically significant, and one site, 118, shifted to random behavior with thermal treatment. Another site, 121, re- mained random after both types of partial de- magnetization. After thermal treatment, the polarities of all of the sites are clear, even those that are not statistically significant. This study illustrates the problems that may be encountered in magnetostratigraphic studies when AF de- magnetization alone is used. Normal magnetized zones should always be subjected to thermal demagnetization to test for the presence of low- temperature, high-coercivity components pre- sumably due to goethite.

Through 40 m of section along the traverse in the East Ravine, 10 sites were sampled, and all of these are reversely magnetized (Fig. 2). The West Side traverse was sampled through an in- terval of 45 m (150 ft) and all sites were nor-

mally magnetized (Fig. 2). The Sigmodon Ravine and Amphitheater traverses record the actual change of polarity from normal to re- versed going up-section. The polarity transition is most precisely fixed in the Sigmodon Ravine section, where it occurs between sites 109 and 110, which are separated stratigraphically by 2.5 m.

VOLCANIC ASH BEDS

A number of beds of air-fall, water-reworked, vitric tuff are situated above the local discon- formity on the marker cherty limestone at about 30 m on the composite section (Fig. 4). A few of these were thick enough and fresh enough to sample for fission-track dating. Pyrogenic zir- con, however, could be obtained from only one of the ashes collected (120 ft above the base of the composite section), and this was dated at 2.32 ± 0.15 m.y. (J. Dickson, U.S. Geological Survey, Denver, in Izett, 1981, Table 5, sample 78W211). Chemical similarities led Izett (1981, p. 10218) to tentatively correlate the 2.32-m.y. ash bed at 111 Ranch with the ash bed in the upper part of the Blanco Formation of Texas. Izett (1981) also designated another ash bed 15 m higher in the section as the "Dry Mountain Ash Bed" (Fig. 5). Both of the ash beds at 111 Ranch are dacitic and show similarities in chem- ical composition that suggest a common source area. Because of their similar chemistry (Izett, 1981), the Mount Blanco Ash Bed in Texas and
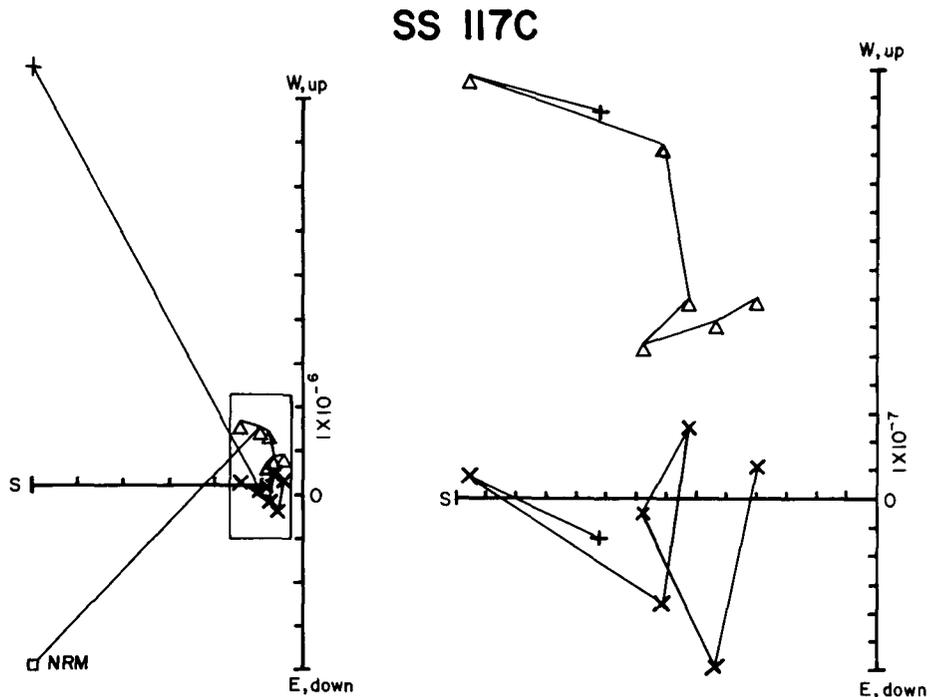

Figure 3. Zijderveld plots showing the response of a reversely magnetized sample to thermal demagnetization. The right-hand side of the figure shows an enlargement of the area on left included in the box. Declination is given by crosses, inclination by open triangles. The right- hand plot begins at 200 °C; highest temperature treatment is 600 °C.
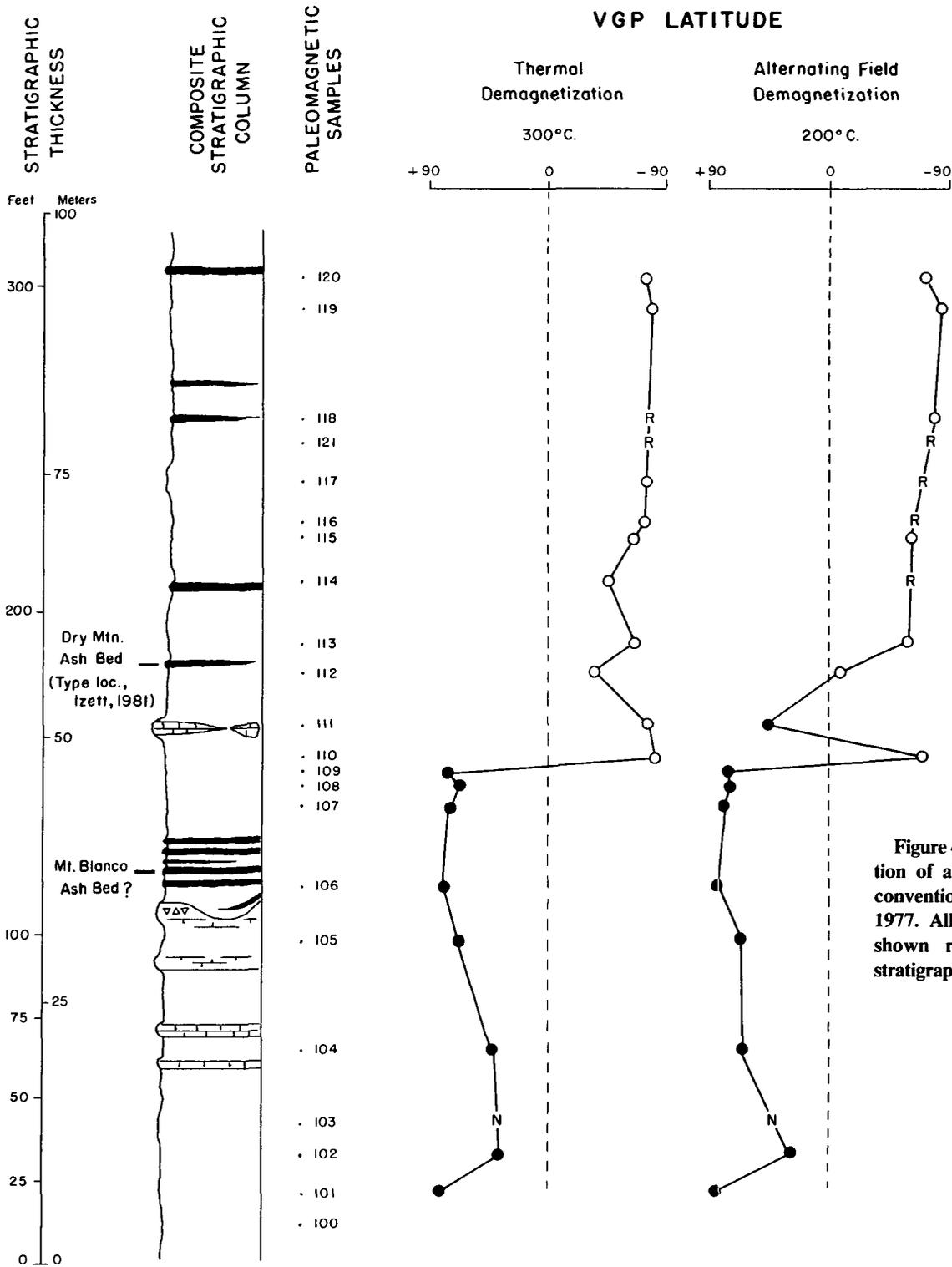
VGP LATITUDE

Figure 4. Directions of magnetization of all class I sites, using the convention of Opdyke and others, 1977. All data are combined and shown relative to a composite stratigraphic column.

the various ashes at 111 Ranch may be members of a family of dacitic ashes, sharing a common source and spanning an interval of some 10^4 yr.

CORRELATION OF MAGNETIC POLARITY

In our densely sampled section at 111 Ranch, only one magnetic polarity transition was un-covered by a sampling array of 21 paleomagnetic sites. This implies that the section spans a relatively short time interval, because the mean length for magnetic polarity intervals for the Neogene is 120,000 yr (Johnson and McGee, 1983). We show in Table 1 that if our 21 sampling sites represent separate points in time, the 111 Ranch section would nominally span a 0.13-m.y. interval. The normal polarity zone in our section occupies about one-half of the section and presumably one-half of the time. In other words, the normal polarity zone in our 111 Ranch section is most likely to be 65,000 yr long or longer.

Our 111 Ranch section contains the 78W211 ash (Fig. 2), the age of which is 2.32 ± .15 (2) m.y. (Izett, 1981). At the 95% confidence level (2), this translates into an age for the ash bed of

>mewhere between 2.17 m.y. and 2.47 m.y. his time interval (2.17–2.47 m.y.) would fix ie ash bed within the lower part of the Ma- iyama reversed chron (0.72–2.47 m.y.), ac- ording to the Mankinen and Dalrymple (1979) me scale. Although not published formally, ass shards from the 78W211 ash were also ated by the fission-track method. The glass ielded a date of 2.43 ± .38 (1) m.y. (Dickson nd Izett, 1980), which is somewhat older than ie zircon fission-track date of 2.32 ± .15 (2) ι.y., but not significantly so. The time window ιus provided by the isotopic dates, 2.1–2.5 ι.y., makes three correlations possible between ie magnetic zonation of 111 Ranch and the ιagnetic time scale: a correlation of the normal olarity zone with one of the Reunion sub- ιrons (2.02 m.y. and 2.13 m.y.) or with the ppermost Gauss Chron (2.47 m.y.).

As we showed previously, the normal polarity ɔne in the 111 Ranch section is most probably 5,000 yr or longer in duration. In contrast, the .eunion subchrons are only some 10,000 to 0,000 yr in duration. It seems unlikely, there- ɔre, that the normal polarity zone at 111 Ranch one of the Reunion subchrons.

The weight of evidence, both isotopic and sta- stical, thus falls on the side correlating the _ormal polarity zone at 111 Ranch with the Gauss Chron. The magnetic transition in the 111 Ranch section then is correlated with the Gauss- Matuyama boundary at 2.47 m.y. (Mankinen and Dalrymple, 1979). As the 78W211 ash at 111 Ranch is normally magnetized, it cannot be a correlative of the Mount Blanco ash, which is reversely magnetized (Izett, 1981).

A related issue concerns the sedimentation rate manifested at 111 Ranch. If the 9,500 cm of sediment at 111 Ranch (Fig. 5) was deposited over 130,000 yr then the mean sediment ac- cumulation rate has been 73 cm per millennium. This compares with the 5–10 cm/millennium rate observed in the nearby San Pedro Valley (Johnson and others, 1975). To illustrate this further, both the 111 Ranch and San Pedro Val- ley sections are approximately the same thick- ness, yet the San Pedro Valley section crosses ten magnetic reversals, compared to the single rever- sal found at 111 Ranch. The rapid sedimenta- tion rate at 111 Ranch is most likely due to its proximity to its source rocks, the Miocene volcanics.

BIOSTRATIGRAPHY

History of Investigation

The fossil mammal remains found by Knechtel in 1933–1934 at 111 Ranch in sec. 27, T. 28 S., R. 28 E. during his pioneer study of the geology of San Simon Creek were iden-

TABLE 1. ASSESSMENT OF TIME SPANNED BY 111 RANCH SECTION

Given:

N = number of paleomagnetic sites employed	21
R = number of magnetic reversals found	1
$\bar{\tau}$ = mean length for magnetic polarity intervals in the Neogene	1.2×10^5 yr

Derived:

p = R/(N–1) = probability for the sampling program with respect to finding magnetic reversals	.050
$\Delta t/\bar{\tau}N$ = mean sampling interval*	.053
$\Delta t = .053 \bar{\tau}N$ time span sampled	1.3×10^5 yr
$\sigma = [p(1-p)(N-1)]^{1/2}$ sampling fluctuation	±97%

Note: data are based on the probability of finding reversals by sets of discrete samples (Johnson and McGee, 1983).
*Calculated from relationship, $\Delta t/\bar{\tau}N = \ln(1-2p)/(-2)$, from Johnson and McGee (1983). Sampling geometry is no factor when p < 0.1.

tified by C. L. Gazin (*in* Knechtel, 1938, p. 198) as *Hipparion (Nannippus)* sp.; equid, large form; camelid sp., *Platygonus* sp.; and megalonychid sp. If these specimens were all collected from the indicated section, the fauna was recovered from the fossiliferous interval shown on the Sigmodon Ravine and Amphi- theater columns and chiefly in sediments of normal magnetic polarity. Gazin was prescient in his correlation and age determinations, con- sidering the paucity of the evidence and the state of knowledge at the time. He concluded that the assemblage was "probably not greatly separated in time from the Blanco of Texas" and that it was older than the Curtis Ranch fauna of the San Pedro Valley and "younger than or possibly equivalent to the upper Plio- cene recognized near Benson" in the same area.

Galusha began collecting in the 111 Ranch area in late 1937 and early 1938. The results were so encouraging that he returned in late 1938 and early 1939. This work resulted in the discovery of the type specimen of *Capro- meryx arizonensis* described by Skinner (1942). In 1954, Galusha returned to the Dry Mountain area, working south along the west- ern flank of the range into drainages coming westerly from the northern Whitlock Moun- tains. At about the same time, the University of Arizona, under John F. Lance's direction, began to collect fossils and to study the stratig- raphy of the area on the 111 Ranch. Lance (1958) announced the discovery of capybara remains assigned tentatively to the extinct genus *Neochoerus* associated with *"Equus (Equus)"* in deposits stratigraphically above those containing *"Plesippus"* and *Nannippus.* He assigned the lower fauna to the Blancan (late Pliocene, in agreement with Gazin) and the upper to the Irvingtonian (Pleistocene). Later, the localities from which these faunas were obtained were given the names Flat Tire Claim and Tusker Claim, respectively (Lance,

1960). In 1960, the material that had accumu- lated in the University of Arizona collections was used as the basis of a preliminary note and a dissertation by Paul A. Wood (1960, 1962), who modified Lance's locality names to faunal names, "Flat Tire fauna" and "Tusker fauna," and who agreed that they represented the Blancan and Irvingtonian, respectively. The Blancan age for the "Flat Tire fauna" was based solely on the presence of *Nannippus,* whereas the occurrence of *"Lepus," Reithro- dontomys, Neochoerus,* and *Synaptomys vetus* in "Tusker fauna" was held to indicate an early Irvingtonian age equivalent to the Curtis Ranch fauna of the nearby San Pedro Valley. Downey (1962) studied the Leporidae from the "Tusker local fauna" and identified *Hypo- lagus* (including a new species *H. arizonensis*) and *Lepus* ("near *L. californicus"*). He con- cluded that the joint occurrence of these rabbit genera at University of Arizona locality 15–24 (see Fig. 5) indicated a "late Blancan or early Irvingtonian age for the Tusker local fauna." Faunal lists for the Flat Tire and Tusker as- semblages were published by Lindsay and Tessman (1974) and Blancan ages for both were assigned without discussion. A rationale for this change in age of the Tusker fauna lay in the stratigraphic studies in the adjacent San Pedro Valley by Johnson and others (1975). They assembled a detailed biostratigraphy cal- ibrated by radioisotope data and the magnetic polarity time scale. The Tusker rodents most readily equate with faunas that lie near the Gauss-Matuyama boundary between the lev- els of the classic Benson (Post Ranch site) and Curtis Ranch (Glyptotherium and Gidley) sites and are clearly of late Blancan age. Com- parable studies reported in this paper fully corroborate this conclusion.

Present Studies

In Table 2, a revised list of taxa from the 111 Ranch area is given and the biostrati- graphic distribution is indicated relative to the thickness of the composite stratigraphic col- umn shown in Figure 5. Stratigraphic distri- butions of the chronologically more important taxa are graphed in Figure 5, and these distri- butions are discussed in the following para- graphs, with special emphasis on the devel- opment of regionally important biochronolog- ical markers.

The faunal list records a minimum of 41 taxa identified from the ~100 m of sediments searched in the course of the work of all inves- tigators in this area. These taxa are not uni- formly distributed through the rock column but come from sites distributed irregularly, as shown in Figures 2 and 5. Examination of the

TABLE 2. FAUNAL LIST, MAMMALS, 111 RANCH
AREA, ARIZONA

Taxon	Local stratigraphic range (in feet) in terms of the composite column (Fig. 5)	Remarks and/ or references
Edentata		
Xenarthra (sloths, glyptodonts)		
Megalonyx sp.	25–140	"Megalonchy- cidae" (1)
Glossotherium chapadmalense	158	(8)
Glyptotherium texanum	95–295	(2)
Lagomorpha		
Leporidae (rabbits, hares)		
Hypolagus sp.	112–258	(3)
H. arizonensis Downey, 1962	137	Holotype
Sylvilagus sp.	140	"Lepus" (1)
Nekrolagus sp.	140	(8)
Aluralagus sp.	140	(8)
Rodentia		
Sciuromorpha		
Sciuridae (squirrels)		
Spermophilus sp.	112–140	(1)
Geomyidae (gophers)		
Geomys sp.	112–285	(1)
Heteromyidae (pocket mice, kangaroo rats)		
Perognathus sp.	140	(1)
Prodipodomys sp.	140	(1)
Myomorpha		
Cricetidae (mice and voles)		
Reithrodontomys sp.	140	(1)
Calomys (Bensonomys) sp.	140	(1)
Baiomys sp.	140	(1)
Onychomys sp.	140	(1)
Sigmodon medius	75–140	(7)
Neotoma sp.	112–140	(1)
Ondatra idahoensis	140	(4)
Synaptomys vetus	140	(5)
Pliophenacomys sp.	140	(8)
Hystricomorpha (capybaras)		
Hydrochoeridae		
Neochoerus lancei Mones, 1980	110–140	Holotype
Carnivora		
Canidae (foxes, coyotes, jackals)		
Urocyon sp.	90	(8)
Canis cf. irvingtonensis	15–±170	(8)
C. cf. cedazoensis	95	(8)
Borophagus sp.	±110–285	(8)
Mustelidae (weasels)		
Mustela sp.	140	(1)
Procyonidae (cacomistles)		
?Bassariscus	158	(8)
Felidae (cats)		
Felis sp.	140	(1)
?Homotherium	100	(8)
Proboscidea		
Gomphotheriidae (mastodonts)		
Cuvieronius sp.	90–155	(1)
Rhyncotherium sp.	120	(1)
Perissodactyla		
Equidae (horses)		
Nannippus phlegon	0–150	(5)
Equus (Equus) simplicidens	0–258	(8)
E. (Asinus) sp.	5–200	(8)
E. (Asinus) cf. scotti	±120	(8)
Artiodactyla		
Tayassuidae (peccaries)		
Platygonus sp.	5–295	(1)
Camelidae (camels)		
Hemiauchenia sp.	0–92	(8)
Camelops cf. traviswhitei	62–282	(1)
Titanotylopus sp.	140	(6)
Antilocapridae (pronghorns)		
Capromeryx arizonensis Skinner, 1942	110–118	Holotype

References for identification
(1) Lindsay and Tessman (1974).
(2) Gillette and Ray (1981).
(3) Downey (1962).
(4) C. A. Repenning, 1979, personal commun.
(5) Wood (1962).
(6) J. A. Harrison, 1980, personal commun.
(7) Cantwell (1969).
(8) This report.

stratigraphic ranges of the taxa graphed in Figure 5 and recorded in Table 2 shows local restrictions in the stratigraphic distributions of most taxa (the record of small mammals, for example, is limited to the rocks above the local disconformity at ~30 m). We suspect that all of the local range zones are artifacts of the depositional processes and environments that occurred in the 111 Ranch area during the part of Blancan time represented by the exposed deposits. However, despite such local controls on the stratigraphic occurrence of taxa, the results do assume significance when the 111 Ranch distributions are correlated with other such local data derived from nearby sites in the southwest and beyond. Pertinent are the comparable studies in the San Pedro Valley, Arizona (Johnson and others, 1975), Anza Borrego, California (Opdyke and others, 1977), and the preliminary correlations of such data from the southern Great Plains (Lindsay and others, 1976). Biochronological data from the Rio Grande valley in southern New Mexico and adjacent Texas reviewed by Tedford (1981) include important reference sequences.

A prominent neotropical element is present in the assemblage from the 111 Ranch area, including sloths, glyptodonts, and capybaras. The sloth Megalonyx is long-ranging in North America (Hemphillian to Rancholabrean; Hirschfeld and Webb, 1968), but the small mylodont sloth Glossotherium chapadmalense and the glyptodont Glyptotherium texanum appear to be near their earliest appearance in the northern hemisphere in this assemblage. Both occur at Mount Blanco, Texas (the type locality for the glyptodont), beneath the Mount Blanco Ash Bed (Izett, 1981; Schultz, 1977, and references therein) in reversely magnetized rocks, presumably the early Matuyama chron (Lindsay and others, 1976). The capybara Neochoerus dichroplax Ahearn and Lance, 1980, described from material from 111 Ranch, occurs only in the latest Gauss Chron in the Dry Mountain area. A presumably similar form, identified as Neochoerus sp., is reported from the early Matuyama in the San Pedro Valley (Cal Tech site; Johnson and others, 1975). These and the Florida occurrences reported by Ahearn and Lance (1980) seem to be the only records of Blancan capybaras. A considerable temporal gap exists between these earliest occurrences of the North American species of Neochoerus and the larger genotypic species N. pinckneyi of the Rancholabrean.

Cantwell (1969) reviewed the large sample of fossil Sigmodon from 111 Ranch and assigned these specimens to Sigmodon minor, which he considered a highly variable and long-ranged species, including Blancan fossils that previously had been assigned to S. medius and S. intermedius plus Irvingtonian fossils that previously had been assigned to S. minor and S. hilli. Harrison (1978) studied a similar sample of Sigmodon from the Wolf Ranc fauna in the San Pedro Valley, ~130 kr southwest of 111 Ranch. Both Cartwell an Harrison noted that the size range of Sig modon from 111 Ranch and Post Ranch ovei laps the size of Sigmodon medius from th Curtis Ranch fauna in the San Pedro Valley The large samples of Sigmodon from 111 Ranch (UA loc. 15-24) and Post Ranch wer collected from strata deposited near the end c the Gauss Chron and are essentially precis temporal equivalents. This set of circum stances argues strongly for a Sigmodon chror ocline, spanning the interval from 3.0 to 2. m.y. B.P., which complicates assignment c Sigmodon species to either S. medius or S minor. Both Cantwell and Harrison had as signed the 111 Ranch and Wolf Ranch Sig modon to S. minor, realizing that such a assignment broadened the taxonomic concep of S. minor. Martin (1970) reviewed the fossi samples of Sigmodon from the San Pedro Val ley of Arizona and from Meade County, Kan sas. Later (Martin, 1979), he reviewed th fossil history of Sigmodon. We agree with an follow Martin's conclusion that S. mediu should be distinguished from S. minor.

Among the other 111 Ranch rodents, th voles (microtines) are of particular interes geochronologically. The muskrat Ondatra idahoensis and vole Pliophenacomys sp. represent taxa in lineages evolving in North America, whereas the bog lemming Synaptomys (Mictomys) vetus represents an immigrant in Blancan deposits of the United States (Repenning, 1980). All three taxa occur together at 111 Ranch, in the Nine Foot Rapids local fauna from the Glenns Ferry Formation of Idaho (Conrad, 1980), and possibly at Cita Canyon, Texas (Schultz, 1977). In these cases, the joint association of microtine taxa occurs in normally magnetized rocks just below the polarity change attributed to the Gauss-Matuyama boundary. The records are the earliest documented occurrences of Synaptomys (Mictomys) and are used to define the base of the Blancan V biochron by Repenning (1980).

A diverse lagomorph fauna occurs at UA loc. 15-24, just below the magnetic polarity change. The identification of Lepus in this fauna (Downey, 1962) has been shown by Lindsay to be erroneous for Sylvilagus. Review of the material identified as Lepus in the upper part of the San Pedro Valley sequence (the Gidley level; Johnson and others, 1975) has also been shown to pertain to Sylvilagus. The occurrence of Sylvilagus at 111 Ranch approximates the lowest occurrence in the Anza Borrego section (Opdyke and others, 1977). The first occurrence of Lepus appears now to postdate the Olduvai Subchron.

Local Stratigraphic Ranges, Selected Taxa III Ranch, SE Arizona
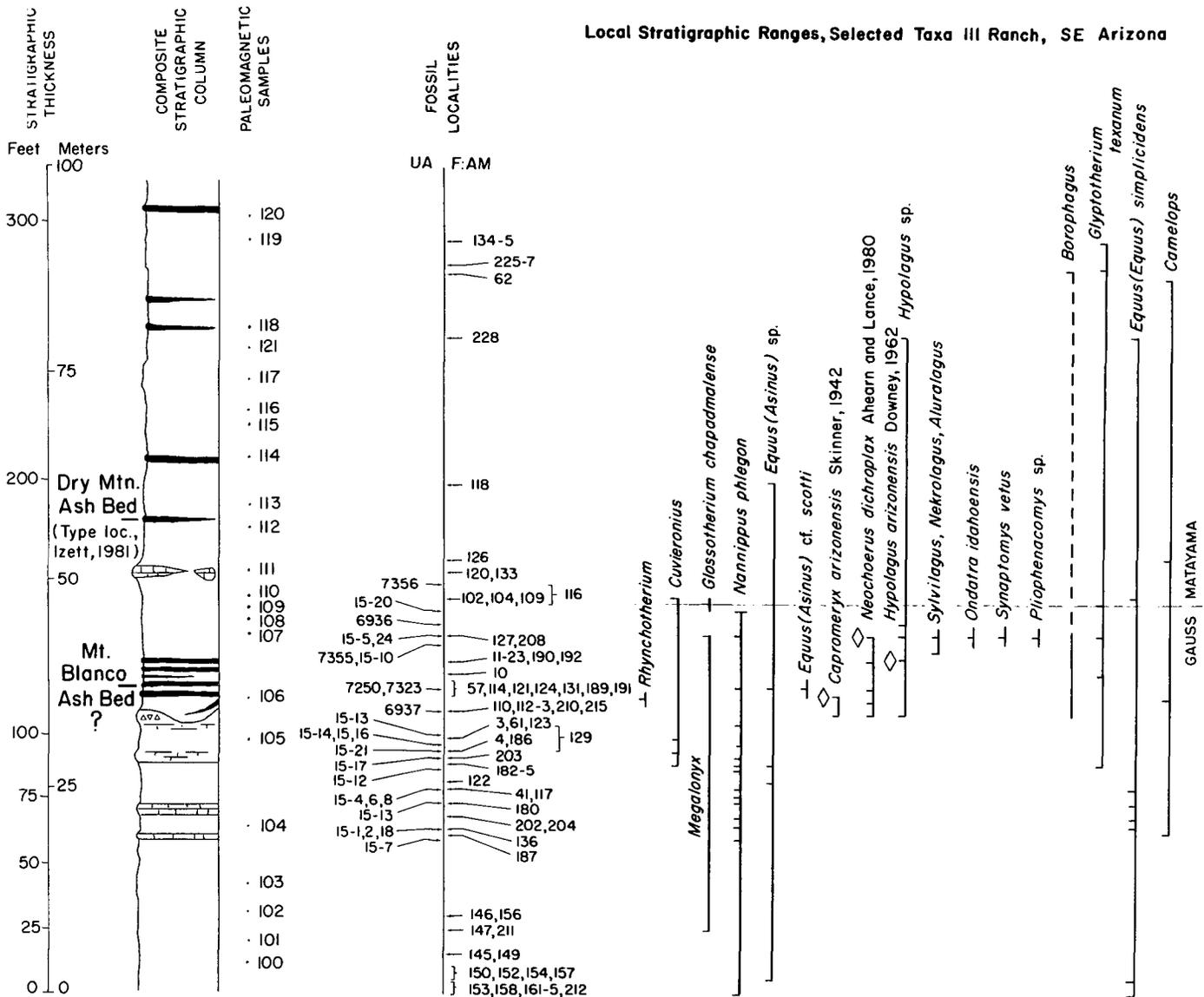
Figure 5. Biostratigraphy of the 111 Ranch beds, Dry Mountain area, Graham County, Arizona. Local range zones of selected taxa shown by heavy vertical bar, individual stratigraphic occurrences by short horizontal line attached to bar, and possible local terminations of range by horizontal line crossing range bar at highest stratigraphic occurrence. Dashed extensions of range bar indicate extension to section where location is not known precisely. Open diamonds indicate stratigraphic position of holotypes of named species. UA, University of Arizona localities; F:AM, Frick Collection, American Museum of Natural History localities.

Carnivores are naturally rare in these deposits, and, although the presence of coyote-like (*Canis* cf. *irvingtonensis*) and jackal-like (*Canis* cf. *cedazoensis*) canids extends the knowledge of these taxa morphologically and temporally, they are of lesser interest biochronologically. The large canid *Borophagus* is recorded imprecisely in the later part of the Gauss chron and extends nearly to the top of the fossiliferous interval, indicating that the section is no younger than 1.8 m.y. B.P.

Proboscidean remains are locally abundant in the cherty limestones at ~30 m on the composite section (Fig. 5) and in the lower part of the disconformably overlying beds of late Gauss age. Both the short-jawed gomphothere

Cuvieronius and the break-jawed *Rhyncotherium* seem to be present.

The equids, traditionally used in biochronology of the Cenozoic rocks, are represented by the tiny hipparion horse, *Nannippus phlegon*, and three distinct species of *Equus*. The occurrence of *Nannippus phlegon* is significant, because at four sites (111 Ranch, San Pedro Valley, Cita Canyon, and Mount Blanco) in the Southwest, this species has its last appearance in latest Gauss or earliest Matuyama time. The Concurrent Range Zone, composed of the top of the *Nannippus* Range Zone and the base of the *Glyptotherium, Neochoerus*, and possibly *Glossotherium* range zones or any of the microtine rodents listed

here, represents a short span of geological time and thus a very useful faunal datum in the Southwest (Tedford, 1981).

The *Equus* species represent different lineages within the genus as defined by Bennett (1980), including a large *Dolichohippus*-like form *E. simplicidens* (*"Plesippus"* of the older literature), a large onager-like *E.* (*Asinus*) cf. *scotti*, and a hemione *E.* (*Asinus*) sp. The two major clades (Bennett, 1980) united within the genus *Equus* thus have representatives in the medial Blancan of the 111 Ranch area and more widely in the Southwest (Tedford, 1981), demonstrating considerable evolution within the living genus of horses before the close of Pliocene time. Representatives of the

subgenus *Asinus* were thus present in North America at the time that *E.* (*Equus*) first reached the old world (Lindsay and others, 1980). Ass-like horses followed the dolichohippine horses in the Eurasian record toward the close of Pliocene time (Azzaroli, 1979).

The 111 Ranch artiodactyls include a typical assemblage of late Blancan forms. Remains of a large *Camelops,* the size of *C. hesternus,* include a fine skull, mandible, and partial skeleton from F:AM site 62 near the top of the fossiliferous deposits. Dental features of this camel resemble those of *C. traviswhitei* from the earliest Rancholabrean of central Mexico (Cedazo local fauna; Mooser and Dalquest, 1975). A similar camel was reported by Schultz (1977) from Cita Canyon in deposits that are correlative with those at 111 Ranch. These records of *Camelops* may be close to the earliest reported for the genus (Kurten and Anderson, 1980).

DISCUSSION

The significance of the 111 Ranch biostratigraphy in local and regional terms within North America lies in the additional and critical data bearing on the determination and calibration of range zones of chronologically useful taxa. The faunas from 111 Ranch contain both large and small mammals, permitting refinement of the San Pedro Valley biostratigraphy in an interval between the classic Benson and Curtis Ranch faunas, typified there mainly by small mammals. The presence of three microtines is particularly important in regional correlation with the Great Plains and the Snake River Plain; the sloths, glyptodonts, and horses allow correlation with large mammal samples from elsewhere in the Southwest. The confirmation of the last appearance of *Nannippus* near the Gauss-Matuyama boundary (2.48 m.y. B.P.) in the Southwest is of importance. *Nannippus phlegon* occurs in reversely magnetized strata of the Blanco Formation of the Texas panhandle, indicating survival there into earliest Matuyama time (Lindsay and others, 1976). The first appearance of the sloth *Glossotherium* and the glyptodont *Glyptotherium* and the last appearance of *Nannippus* mark a concurrent Range Zone useful in the Southwest and of short enough duration (0.5-m.y. interval be-

tween 2.0–2.5 m.y. B.P.) to allow significant correlation.

On an intercontinental scale, the occurrence of the neotropical taxa *Glossotherium, Glyptotherium, Neochoerus,* and, in the San Pedro Valley (Wolf Ranch), of the porcupine *Coendou stirtoni* (Harrison, 1978) at the end of Gauss time heralds the beginning of a larger-scale immigration of neotropical forms into Nearctica. It is interesting to note that biostratigraphic and magnetostratigraphic studies of the Uquia Formation of Argentina, containing the typical fauna of the Uquian Mammal Age, is similarly placed in late Pliocene and early Pleistocene time and records the first major influx of nearctic forms into the southern neotropics (Marshall and others, 1982). In like manner, dispersals of microtines to the new world and horses to the old occur at the time of the Gauss-Matuyama polarity transition, indicating that global avenues for mammalian dispersal became available at that time, as discussed by Repenning (1980) and Lindsay and others (1980).

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