INTRODUCTION

In his anniversary address to the Geological Society of London (1962), Thomas Henry Huxley proposed the term "homoeastasia" (from the Greek "homoios" same and "aetos" animal) for the similarity or order of occurrence of fossils in two or more stratified sequences. Huxley proposed the term to avoid the implication that homoeastasia sequences were necessarily synchronous.

The time significance of homoeastasia sequences has been much discussed by biostatigraphers (e.g., Harper, 1980; O'Dowd, 1976; Scott, 1965; Bell, 1959). Rarely, however, has it been possible to test the synchronism of homoeastasia sequences.

To test this hypothesis of synchrony, one must have a high-resolution form of time control, independent of the biostatigraphy. Some high-resolution events that have been used include: 1) palaeomagnetic reversals in deep-sea cores (e.g., Hays et al., 1966); 2) isotopic events in deep-sea cores (e.g., Hays et al., 1980; Hays and Shackleton, 1976); 3) seismic events (e.g., Kauffman, 1970); and 4) radiometric dates (Kauffman, 1970; Churkin et al., 1977). In the microfossil and macrofossil assemblages examined, the sequences have generally proved to be synchronous within the resolution of the technique. To my knowledge, however, no attempt has been made rigorously to test the synchrony of vertebrate biostatigraphic events.

Palaeomagnetic reversals, which are worldwide and geologically instantaneous, could be used as time planes with which one could test mammalian biostatigraphy. The ideal way to make this test would be to develop a biostatigraphy and macrofossil stratigraphy for an area that is abundantly fossiliferous, with numerous continuous, thick, well-exposed sections over a wide geographic area. The Oligocene White River Group of the High Plains (Text-fig. 1) meets those criteria better than almost any other part of the vertebrate record. Indeed, the white River Badlands remain among the most fossiliferous vertebrate-loving beds known. It is also necessary to have precise stratigraphic control on nearly every section. Fortunately, thanks to the diligent attention paid to stratigraphy by the workers of the Frick Laboratory, the Frick white River collections in the American Museum of Natural History have the necessary level of stratigraphic resolution. They have actually zoned to local stratigraphic markers (frequently ash beds), and the stratigraphic data on each brick specimen is often reliable to the nearest five feet or less.


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BIOSTRATIGRAPHY

The most abundantly fossiliferous interval in the White River Oolite Group, the late Chadronian-Orellan-early Whitman, was chosen for analysis. Our paleomagnetic studies (Prothero et al., in press) show that this interval spans over two million years, from about 30.0 to 32.5 Ma (millions of years before present). Several groups of land mammals which lived then are represented by abundant track specimens in the American Museum collections. These Oolitic beds are unusual for vertebrate-bearing deposits in that they are abundantly fossiliferous throughout most of the section, with relatively few barren intervals. Thus, conditions appear ideal for developing a full biostratigraphic zonation from local range zone data.

The most abundant, rapidly changing, and thus most useful groups are the following:

1. Titanotheres: The last appearance of Titanotheres (family Brontotheriidae) has traditionally been one of the criteria for the Chadronian-Orellan boundary (Wood et al., 1934; Emsy et al., in press). Since Titanotheres are the largest mammals present in the White River Group, even fragmentary remains are readily spotted in surface collection and easily identified.

2. Crocodylians: Crocodyliforms are so abundant in the Orellan that their rocks were once known as the "Orellan beds." The larger crocodyliform, "Orellan crocodyliform," occurs throughout the Orellan. In the late Orellan, it acquires an inflated auditory bulla. The smaller crocodyliform, "Orellan crocodyliform," decreases in size through the Orellan that correlation can be made on basis of size.

3. Other artiodactyls: The small deerlike ruminant "Eocerus" is known only from the Orellan. A slightly larger deerlike ruminant, "Cricetida," occurs through the Orellan. The chief character distinguishing these two species is a change in the form of the third lower premolar (Emsy, 1970). The ceratopsian "Ceratopsia" has at least three distinct species in this interval.

4. Rats: Several species of rat-like mammals occur in great abundance in the Orellan. Palaeochoerus McKennai is the most abundant in the early Orellan. A smaller form, "Palaeochoerus Barcrofti," first appears in the late Orellan. The last appearance of the Chadronian rat-like mammal, "Palaeochoerus," is also present here, as is fairly rare (Gowdy, 1937; Wood, 1940; Deaton, 1958).

5. Rodents: The most abundant and rapidly changing rodents is "Eomys." Using the species definitions of Wood (1980), the last, latest Chadronian form "Eomys sp." is also useful. A larger rodent, "Palaecisteus woodwardii" or "Eomys," is also present but fairly rare.

6. Other taxa: The first appearance of the incognitum "Palaecisteus" occurs in the earliest Orellan. The creodonts "Hyomys" and "Hyomys" are common and become extinct in the Orellan (Mallott, 1977). The rare carnivore Palaeolycroxyx appachsylos occurs at a similar level where it is known. The opposite range for these taxa are shown in Text-fig. 1, plotted against their position in the numerical polarity timescale. The sequence of biostratigraphic datum is listed in Table 1.
TEXT-Fig. 3.--Polarity interpretations for 17 late Chadronian-Dreison-Whitehorn-Arikareean sections in Wyoming, Nebraska, the Dakotas, and Colorado. Section locations are shown in Text-Fig. 1. Solid bars indicate normal polarity; open bars are of reversed polarity. Correlations based on biostratigraphic studies discussed in text. Data is in contact between the Chadron and Brule Formations, or its equivalents. Double line indicates formation boundaries. Abbreviations are as follows: C.-- Chadron Formation; G.--Ewing Formation, Arikaree Group; D.-- Dreison Member, Brule Formation; P.-- Poleslide Member, Brule Formation; FAL-- Purplish Yellow Layer, a marker ash; BFA-- Rockyford Ash; S.-- Scenic Member, Brule Formation; SH-- Shaw Formation, Arikaree Group; W.-- Whitney Member, Brule Formation; UPW-- Upper Purplish White layer, Toadstool Park, Nebraska.

than 4000 feet (1200 m) of section. Samples were cut down with a tungsten-carbide band saw blade and measured in an off-progenitor magnetometer at Woods Hole Oceanographic Institution and Lamont-Doherty Geological Observatory. Both thermal and alternating field demagnetization were necessary to obtain a reasonable polarity interpretation on over 90% of the sites. Further details of the palaeomagnetic analysis are presented elsewhere (Prothero et al., in press). The primary result of the analysis was that a consistent pattern of magnetic reversal was obtained: a latest Chadronian normal interval we correlate with anomaly 12; an early Brulean normal interval we correlate with anomaly 11; a mid-Whitehornian normal interval we correlate with anomaly 30. The date of the Arikareean Land Mammal "Age" seem to correspond to the base of anomaly 9.
tions is the magnetic polarity signal. The most conti-
tinuously fossiliferous sequences are those at Lux-
us and Douglas. In these two sections, the succession of
bioturbatographic datums is nearly identical, and all
datums fall in the same polarity intervals except one.
The exception is the first appearance of eumyid cir-
tellid rodents (Datum 10), which occurs below anomaly
11 in Douglas but within it at Luxus. This discrepancy
is probably an artifact of collection, since eumyids
are very small and tend to be scarce from these two
localities.

In the Big Badlands section, all of the events that
occurred around anomaly 11 in Wyoming are clustered
at the base of anomaly 11. This clearly seems to
indicate that a large hiatus is present at the base of
anomaly 11 (the base of the Lower Niobrara Zone in
the Big Badlands), resulting in truncated ranges.
Larger Cretaceous and Cenozoic datums are present in
the Big Badlands sections that do not show up in the
Wyoming sections, which apparently do not range into
that interval.

The North Dakota collections are much smaller than
those from the other areas, and most of the interval
is barren. Thus, the sequence appears scrambled by
alteration with the Wyoming and South Dakota sec-
tions, and many ranges appear shorter here than else-
where. In addition, some taxa that are abundant in
other areas are surprisingly absent in North Dakota
(e.g. Hormathomys neglectus), possibly indicating
some ecologic or geographic differences between North
Dakota and the areas to the south. Given these limi-
tations, only four datums in North Dakota occur in the
wrong polarity zone. These are the first appear-
ances of Hoplophorus urticae, Winklerhorvathia dissimulata,
Paleomys sp., and eumyid crenellids (Datums 3, 5, 9,
and 10 respectively). All of these taxa are
extremely rare in the lower levels in North Dakota,
so these anomalous ranges are probably truncated due
to lack of sampling. Datums 10 in the most abundant taxa,
and those representing evolutionary first occurrences,
are consistent with the pattern seen in other areas.

Thus, the overall bioturbatographic zonation in the
medial Oligocene is only contradicted by the mag-
netostratigraphy in a few instances. These exceptions
Dear Colleague:

Since the deadline for this manuscript, the biostratigraphic zonation has been considerably refined. Attached are some figures which show the increased resolution of biostratigraphic datums around polarity transitions, and strengthen the conclusions of this paper.

BASE OF CHRON C11N (Anomaly 11)

Just before Anomaly 11: LAD Brontotheriidae, LAD Poebrotherium eximium, transition from Leptomeryx speciosus to L. evansi.

Just above base of Anomaly 11: transition from Miniochoerus douglasensis to M. gracilis, FAD of Eumys elegans, FAD of Eumys obliquidens.

TOP OF CHRON C11N (Anomaly 11)

Just below top of Anomaly 11: LAD Eumys obliquidens.

Just above top of Anomaly 11: transition from Ischyromys typus to I. pilosus, transition from Miniochoerus gracilis to M. nicholai, FAD Wilsoneumys plantidens, FAD Eumys carvidens.

Occurrence variable (probably due to poor sampling): LAD Hyasodon cruciatus, FAD Palaeolagus burkei.

Biostratigraphic ranges plotted against the magnetic polarity timescale for the remaining taxa of the study are shown in Fig. 171.
Hyænodon crucians
Ischyromys typus
Miniochaeru$\text{g}$ gracilis

Ischyromys typus
Palæologu$\text{s}$ burkei
Miniochaeru$\text{g}$ gracilis
Eumys parvidens