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Stratigraphic Nomenclature of the Miocene Hemingford Group, Nebraska

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The present paper is an attempt to analyze the rather perplexing and labyrinthine literature dealing with the Miocene stratigraphy and vertebrate paleontology of western Nebraska and nearby areas. Little or no new information is introduced here, but my interpretation of the published data is in some cases at variance with the views of others, and such differences of opinion should be aired. The discussion presented here is not, however, wholly an office exercise. Like many another vertebrate paleontologist, I owe a great debt to the late Dr. Harold J. Cook of Agate, Nebraska, who first introduced me to the complex Miocene stratigraphy of western Nebraska in 1947 and who gave freely of his knowledge on innumerable occasions thereafter, both in the field and in his home. I also owe much to other colleagues for their patient instruction. Dr. C. Bertrand Schultz guided me through part of the type area of Peterson's Upper Harrison beds; Mr. Ted Galusha instructed me in the Hemingfordian and later sediments of Dawes, Sheridan, and Box Butte counties; and Mr. Morris F. Skinner guided me in various parts of Sioux County and elsewhere. My views are, of course, my own, and none of these gentlemen necessarily endorses my conclusions. I have personally studied all the rock units discussed and have visited all but one² of the localities on various occasions. Fossil mammals in the Cook Collection and the Ameri-

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² The type locality of the Sand Canyon Member, southwest of Hay Springs, Nebraska.

can Museum of Natural History have been studied in connection with the work, though they are not primarily the subject of this paper.

I hope that this summary will prove useful, either as a rudimentary guide to publications on the subject or as a stimulant to more precisely documented stratigraphic nomenclature and other data in future publications.

MARSLAND FORMATION

In the Miocene of western Nebraska and nearby states the term Marsland Formation has been applied to various post-Harrison, pre-Sheep Creek sediments by a number of authors, beginning with Schultz (1938), who suggested the name Marsland as a substitute for the name Upper Harrison beds (Peterson, 1906, pp. 22, 23, 26; type section¹ shown in fig. 1; = "The Nebraska Beds, of Scott" of Hatcher, 1902, p. 117). Schultz, in his paper in 1938, made the following statements: ". . . The Harrison formation is restricted to the upper part of the Arikaree group as used by Mr. J. B. Hatcher in 1902. The name Marsland is proposed for the formation (until now incorrectly called 'upper Harrison') which lies above the Harrison and below the Sheep Creek [abstract, p. 441]."

"To the deposits ('upper Harrison beds') which immediately overlie the Arikaree group and which are faunally and lithologically distinct from the typical Arikaree, the writer suggests the name Marsland formation. This formation is best exposed in Nebraska in the region about Marsland along the Niobrara River where it includes some 150 feet of buff and gray, soft sandstones. The Marsland consists, in part, of valley fills, and in places seems to mantle the slopes of certain large valleys. The upper part of the Marsland formation in this region is more gritty and is mostly buff-colored [text, pp. 443, 444]."

Lugn (1938, p. 227; 1939, pp. 1253, 1254, 1264, 1267-1271), Schultz and Falkenbach (1940, p. 291; 1947, p. 188; 1949, p. 83), Wood and his co-authors (January, 1941, p. 25), Schultz and Stout (August, 1941, p. 4; 1961, p. 7), Schultz (1942a, p. 6; 1942b, p. 9), Elias (1942, p. 124), Condra and Reed (1943, p. 11), Cady and Scherer (1946, pp. 26-32), Lugn and Lugn (1956, p. 100), and others have accepted the name Marsland Formation as a replacement name for what had previously been called the Upper Harrison beds.

¹ Type sections were not always rigorously identified as such in the early years of this century, but Peterson's was well defined in terms of both location and geology, was figured (and refigured by others), and was the only section published by Peterson in his definition of the Upper Harrison beds. For its time Peterson's was a very well-documented section and is the only section that can be considered to be the type. See also Peterson (1904, pp. 473-475).

With no reference to Peterson's section, which had long priority, Schultz and Stout (August, 1941, p. 38) referred in a guidebook to the "typical section of the Marsland formation, and Marsland Quarry site (Hemingford Quarry 22)" close to a point 4.4 miles south of Marsland on Nebraska State Highway no. 2; this site is evidently the same as that mentioned later by Schultz (December, 1941), and Schultz and Stout in another guidebook (1961, pp. 7, 8, 49). Cook and Gregory (September, 1941, p. 549) incorrectly interpreted that Schultz (1938) had described the type of the Marsland Formation, whereas actually (1) this rock unit had already been established under an objectively synonymous name and a type section had been described by Peterson in 1906 (see also Hatcher, 1902) and (2) Schultz's only locality reference in 1938 was vague and inadequate (see Ashley *et al.*, 1933, p. 435, art. 8). Cook and Gregory, however, emphasized again a point made by Cook and Cook (1933): that more than one stratigraphic unit was deposited in western Nebraska between the time of deposition of the (lower) Harrison and Sheep Creek Formations. Unfortunately, Cook and Gregory continued to call the Marsland (as defined by Schultz, 1938) by the name "Upper Harrison" and called Schultz's referred sediments by the name Marsland, abandoning Schultz's (1938) and others' usage of the name Marsland as a replacement for the name Upper Harrison beds.

Schultz (December, 1941) then further complicated the picture by referring to a type area¹ of the Marsland, southwest of Marsland, Nebraska, in sect. 23 to 27, T. 28 N., R. 52 W., and sect. 19 and 30, T. 28 N., R. 51 W., ignoring the fact that he (1938) had proposed the name Marsland Formation as a substitute for the name "Upper Harrison" and that that unit already had a well-defined type area and section of long precedence. Schultz and Stout (1961) repeated the assertion that the type Marsland Formation is near the town of Marsland, Nebraska, and used the terms "type locality" (p. 32) and "type section" (p. 49), stating that University of Nebraska State Museum Collecting Locality Bx-22 occurs in that section. Schultz, in his abstract (December, 1941), objected to Cook and Gregory's arguments as follows: "Certain deposits near

¹ Several rock units occur in the 7 square miles mentioned by Schultz. Much of the surface of the southern part of the area is in a unit correlated with the type section of the Box Butte Member (supposedly) of the Sheep Creek Formation by Cady (1940, p. 665). Cady gave a measured section of the correlated Box Butte in sect. 26, T. 28 N., R. 52 W. Schultz did not discuss this complication and presented no measured sections. From published evidence (e.g., Schultz and Stout, 1941, p. 43) it is clear that Schultz meant to exclude the correlated Box Butte. The true Box Butte may actually be a third unit between the Harrison and Sheep Creek, but this matter needs confirmation.

Matthew, 1924		Cook and Cook, 1933	Schultz, 1938	Lugn, 1938	This Paper
U. Snake Creek	<i>Pliohippus leidyanus</i> zone?	Upper Snake Creek	_____	“Snake Creek” = correl. of upper Ogallala	Upper Snake Creek
	<i>Hipparion affine</i> zone				
L. Snake Creek	<i>Merychippus paniensis</i> zone	Lower Snake Creek	_____	Sheep Creek	Lower Snake Creek
		Upper Sheep Creek			
lower pt. Sheep Cr.	<i>Merychippus primus</i> zone	Lower Sheep Creek	Sheep Creek		Sheep Creek
			Hemingford Group		Type Box Butte?
		unnamed beds		Sediments referred to Marsland	Runningwater
		Upper Harrison		Marsland (replacement name for “upper Harrison”)	Marsland
		Lower Harrison	Arikaree Group	Harrison	Harrison
		Monroe Creek and Gering undifferentiated	Arikaree Group	Monroe Creek	Monroe Creek
				Gering	Gering

FIG. 1 (continued).

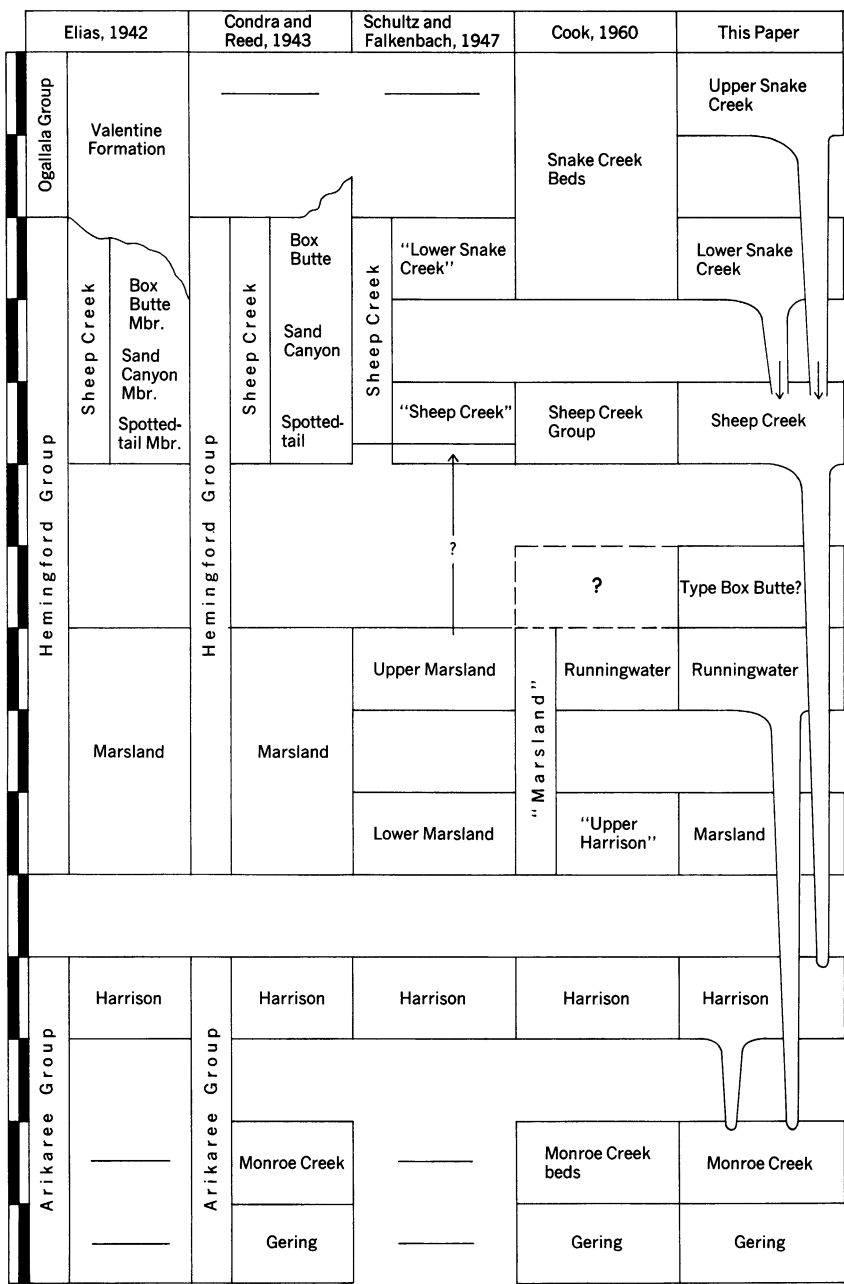


FIG. 1 (continued).

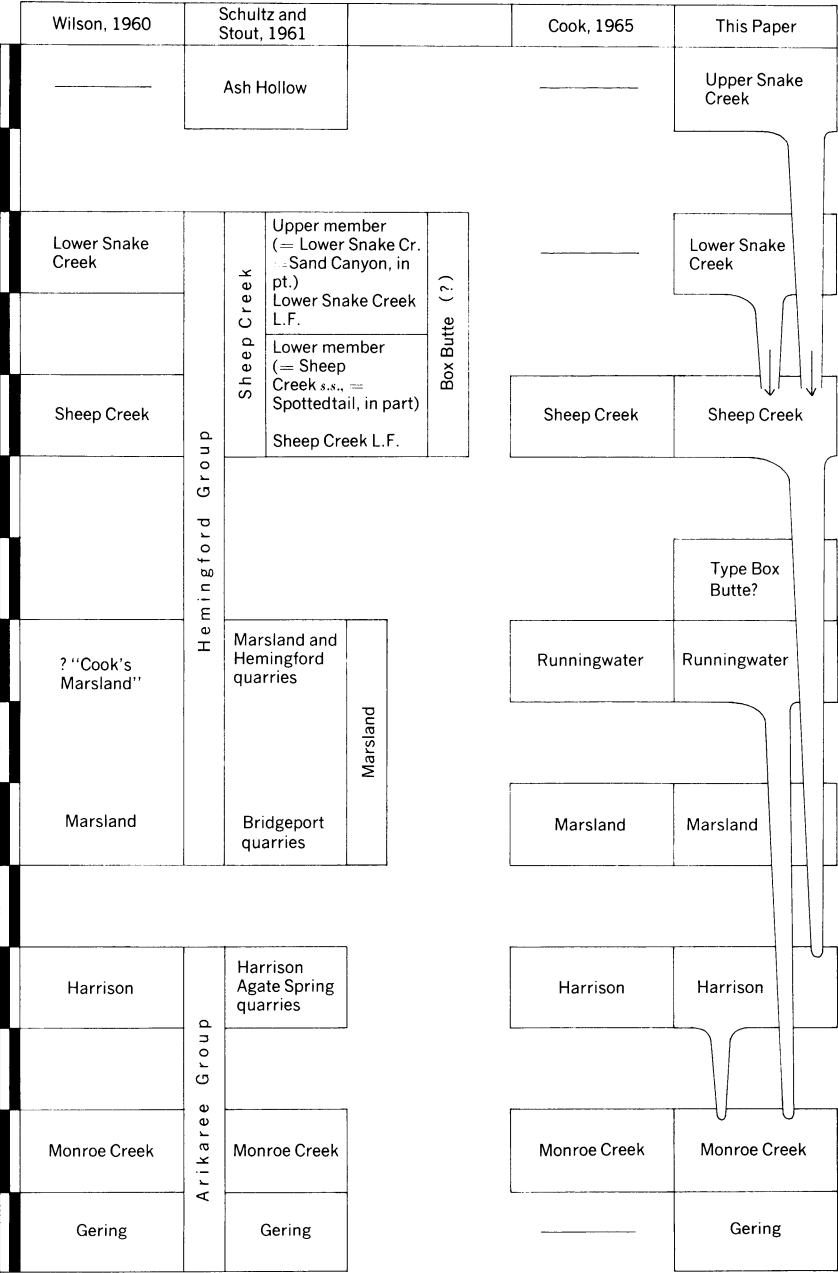


FIG. 1 (continued).

Agate, Nebraska, recently suggested as intermediate between the Harrison and the Marsland are considered to be contained within the Marsland formation since these deposits can be traced directly into the type section area of the Marsland and since the faunas are also similar." He also stated that, "in Nebraska and Wyoming, the Marsland includes all the deposits formerly called 'Upper Harrison.'" Cook (1948, p. 49) continued to emphasize the distinctness of a set of beds intermediate between Peterson's Upper Harrison beds and Matthew and Cook's Sheep Creek beds and later (1960, p. 205) supplied but did not adequately define¹ the term Runningwater Formation for this younger, post-Marsland (as originally renamed by Schultz, 1938), pre-Sheep Creek rock unit² and again used the term "Upper Harrison" for the older rock unit, even though Schultz's name Marsland was originally proposed in 1938 as a substitute for the name Upper Harrison beds and Peterson's (1906) type designation of that stratigraphic unit is prior to Schultz's "type area" and Schultz and Stout's "typical section," and so on, which contain Runningwater sediments beneath the correlated Box Butte of that area. If the older and younger units could be *contained within* (Schultz, December, 1941; see also Cady and Scherer, 1946) the same formation, it might be possible to accept the term Marsland Formation for both. In that case, the sediments referred to in Peterson's (1906) type area and section³ near the Wyoming-Nebraska border (see also Osborn, 1909, p. 73, pl. 2, sect. A; 1918, p. 14, fig. 8)⁴ would serve as the original type basis of the Marsland Formation as a whole and of a lower Marsland Member (American Commission of Stratigraphic Nomenclature, May, 1961, p. 652, art. 10, h), and Cook's (1965) type Runningwater might serve as the type of a restricted upper Marsland Member, but as shown elsewhere these two rock units are at least as separate and distinct from each other as are

¹ See Ashley and others (1933) and American Commission on Stratigraphic Nomenclature (May, 1961) for the appropriate rules. See Cook (1965) for validation of the term Runningwater Formation.

² See also Cook and Cook (1933, p. 31, lines 13-16; p. 44, chart, unnamed beds) and Cook (1948, p. 49; 1965).

³ As emended later to omit sediments at Spoon Butte. See Peterson (1909, pp. 74-75) and Cook (1915, pp. 74-75; 1948, p. 50; 1951, p. 90). See also Ashley and others (1933, p. 436, art. 10).

⁴ The section runs from Spoon Butte approximately northward to Squaw Butte and Squaw Creek. Spoon Butte is in sect. 3, 4, 5, 9, 10, and 15, T. 27 N., R. 60 W., Goshen County, Wyoming. "Squaw Butte" is one of those names used by research workers but by no one else. The local ranchers call this landmark Coliseum Butte (sect. 15, T. 33 N., R. 57 W., Sioux County, Nebraska, about 1½ miles east of the Wyoming state line at the head of Squaw Creek).

the rock units bearing the old designations Harrison and Upper Harrison beds. Curiously, the use of the terms Upper Marsland and Lower Marsland¹ has created exactly the same sort of confusion that Schultz strove to avoid by substituting the term Marsland for the term Upper Harrison beds.² The confusion has merely migrated upward in the stratigraphic section. Similar confusion has arisen frequently with regard to the Tertiary of Nebraska, mainly because rock units there have seldom been rigorously defined in geological publications.

I would prefer to avoid the use of the concept Marsland Formation to encompass more than one post-Harrison, pre-Sheep Creek rock unit of formational rank, and therefore follow Schultz (1938) and others³ in the use of the term Marsland as an objective synonym (at the rank of a formation) of the term Upper Harrison beds. Cook's (1960) term Runningwater Formation has now been validly proposed in accordance with the Code of Stratigraphic Nomenclature (Cook, 1965), and the type Runningwater is part of the same unit as that referred to as Upper Marsland by Schultz and others.

The truly important question at issue is not so much what the names of these post-Harrison, pre-Sheep Creek rock units in western Nebraska should be, but whether more than one important and recognizable sedimentary cycle is involved in this part of the Nebraska Miocene and whether the sediments should be assigned to a single or to several formations. In my view, in agreement with Cook and Cook (1933), Cook and Gregory (1941), and Cook (1948, 1960, 1965), at least two formations are present, a position vigorously opposed as late as 1961 by Schultz and Stout (1961, p. 7).

SHEEP CREEK FORMATION

The Sheep Creek Formation was originally described and named by Matthew and Cook (1909, pp. 362, 363). At its type locality, sect. 30, T. 26 N., R. 55 W. (Osborn, 1918, pp. 17, 102; selected by subsequent

¹ Introduced without definition by Schultz and Falkenbach (1947), in the sense of two rock units, in contrast to "the upper part of the Marsland" and "the lower part of the Marsland" of Schultz and Falkenbach (1940, 1941) and Schultz (1938, 1942a), which indicate relative position within a presumed single unit. See footnote 1 on page 14.

² Use of the term Upper Marsland in the sense of a formation rather than a member would not be logically consistent with the use of the term Marsland Formation as a replacement for Upper Harrison beds. If it is necessary to replace the term Upper Harrison beds, then, by the same reasoning, it would also be necessary to replace the term Upper Marsland.

³ Lugn (1938, 1939), Schultz and Stout (1941, p. 4), Wood *et al.* (1941), Schultz (1942a, 1942b), Condra and Reed (1943), Schultz and Falkenbach (1949), Lugn and Lugn (1956, p. 100), Cook (1965).

designation by Elias,¹ 1942, p. 126), the Sheep Creek is overlain by channels of the type (Upper) Snake Creek Formation,² there being no intervening Lower Snake Creek beds³ reported at that particular locality. Elias (1942, pp. 128–132) subdivided the Sheep Creek Formation of Matthew and Cook (1909) into two rock units. The lower unit was named the Spottedtail Member and “includes all rocks originally included in the Sheep Creek by Matthew and Cook (1909) except the uppermost 10 to 20 feet in the midst of which is the dark-gray volcanic ash. These uppermost beds are differentiated from the Spottedtail by quite different remains of grasses and by a lithologic change which follows an apparent hiatus in sedimentation.” Elias correlated the topmost 10 to 20 feet of the type Sheep Creek Formation with sediments in “Sand Canyon,” 13 miles south and 5 miles west of Hay Springs, Nebraska, which Elias made part of the type section⁴ of his Sand Canyon Member of the Sheep Creek Formation. If Elias’ correlation is accepted, the Sheep Creek of Matthew and Cook is divisible into the Spottedtail Member below and the correlated lower part of the Sand Canyon Member above. If it is not accepted, then a new name should be applied if two members of the Sheep Creek Formation are maintained in the vicinity of the Sheep Creek type locality and no correlation with the Lower Snake Creek beds or other previously named sediments is demonstrated.

Elias also stated (1942, p. 129): “To the described type locality of the Spottedtail belong *Merychippus primus*, *M. secundus*, *M. tertius*, and *M. quartus* of Osborn, but not *M. quintus* whose jaws were collected in the basal part of the Sand Canyon.” This statement is an erroneous reading of Osborn’s section, in that Osborn (1918, pp. 17, 102) depicted that the type specimen of *Merychippus isonesus quartus* was collected *above* the occur-

¹Judged from Osborn’s section and Albert Thomson’s field notes for 1908, Elias’ type Sheep Creek may not extend to the base of either Matthew and Cook’s Sheep Creek or Elias’ own Spottedtail Member. Elias (1942, p. 128) stated that the Spottedtail is 170+ feet thick, and gave the correct location, in contrast to other published maps.

²Lugn (1939, p. 1257) regarded this term as valid. Schultz and Stout (1961, p. 49) referred these sediments to the Ash Hollow Formation.

³See Matthew (1924, p. 65) for the first published use of this term (*contra* Schultz, 1942a, p. 6). The published *recognition* of the presence of a fauna intermediate between the faunas of the type (Upper) Snake Creek and Sheep Creek beds dates from Matthew (1918, p. 184), amplified by Matthew (1923).

⁴“At and around the junction of sections 11, 13, and 14, T. 29 N.; R. 47 W., Dawes County, Nebraska” (Elias, 1942, p. 130). This locality is approximately 55 miles from the type Sheep Creek Formation and 15 miles from the type Box Butte Member, on a drainage locally known as Sand Canyon. This is not to be confused with the Sand Canyon on the south side of the Niobrara River.

rence of the type specimen of *M. i. quintus*, between that specimen and the prominent ash in Elias' correlated Sand Canyon Member. In addition, there is unfortunately another factor to be weighed: Osborn's celebrated section of the Sheep Creek does not agree with Albert Thomson's field notes for 1908, the only surviving field records, which show that A.M.N.H. Nos. 14184 (field no. 40), 14185 (field no. 41), 14181 (field no. 37), and 14183 (field no. 39) were *all* collected between 6 and 10 feet below the prominent ash depicted by Osborn and others. A.M.N.H. No. 14180 (field no. 32) was reported by Thomson to have been found 20 feet below the ash; A.M.N.H. No. 14179 (field no. 31), 50 feet below the ash. A.M.N.H. No. 14187 was applied to a miscellaneous lot of specimens, including the composite type specimen of *Merychippus isonesus primus*. This lot may have originally been included under Thomson's field no. 42, collected by W. D. Matthew, 50 to 100 feet below the prominent ash bed. If Thomson's notes and my interpretation of them are correct, therefore, Osborn's section was not drawn to scale and is misleading, though the relative *sequence* of specimens may be correct and may have been determined by inquiry of W. D. Matthew or of Thomson. Osborn's section may represent no more than about 100 feet of sediments at the top of Matthew and Cook's Sheep Creek Formation. Indeed, if actually drawn to scale and if a maximum of 4 feet is assigned to the prominent ash, Osborn's section could represent a thickness of only about 35 feet from the top of the Sheep Creek to the bottom of the sediments depicted in the drawing.

A sample of the prominent ash bed¹ in the uppermost exposed sediments of the type section of the Sheep Creek Formation, mentioned in Matthew and Cook's original description, by Osborn (1918, pp. 17, 102), by Elias as lying above his Spottedtail Member in the middle of his correlated Sand Canyon Member, stratigraphically above the occurrence of the type specimens of *Merychippus isonesus quintus* and *M. i. quartus*, and referred to the lower Sand Canyon ash by Swineford, Frye, and Leonard (1955) has been dated by the potassium-argon method. It has yielded an anomalously young absolute date of 14.7 million years (Evernden, *et al.*, 1964, pp. 168, 184; KA 891) for the various fossil horses that under-

¹ Another thin ash occurs about 20 feet below the prominent ash in *Aphelops* Draw, SE. $\frac{1}{4}$, NE. $\frac{1}{4}$, sect. 30, T. 26 N., R. 55 W. This ash is presumably the Spottedtail ash of Swineford, Frye, and Leonard (1955, p. 244). A potassium-argon date for this ash would have the advantage of being bracketed by Sheep Creek fossils. Cady (1940, p. 665) suggested a similarity between this ash and one in a (referred) measured section of his Box Butte Member, which occurs in sect. 26, T. 28 N., R. 52 W., one of 7 square miles mentioned by Schultz (1941). The ash in sect. 26 should also be dated.

lie it stratigraphically. Evernden and his co-authors assigned a late Bars-tovian age to this ash, which occurs in the type section of the Sheep Creek Formation but stratigraphically higher in that unit than the highest sediments known to bear the restricted "Lower Sheep Creek" fauna of Cook and Cook (1933) cited by Wood and his co-authors (1941, p. 12). Cook and Cook's "Upper Sheep Creek" fauna apparently came from the lower part of the Lower Snake Creek beds in Sinclair Draw, which Cook regarded as "Sheep Creek" (personal communication; see also Elias, 1942, p. 127).

Of the various published statements about Sheep Creek stratigraphy after 1909, Lugn's (1938, p. 225; 1939, pp. 1254-1258, 1264, 1265) concept of the Sheep Creek Formation is especially important in that it affects the content of the type sediments of the Hemingford Group. Lugn regarded Matthew's (1923) Horizon 2 (*Merychippus paniensis* Zone, = Lower Snake Creek of Matthew,¹ 1924, p. 65) both (1938) as "simply Sheep Creek beds in place and in proper stratigraphic sequence" and (1939) as channel fills within the Sheep Creek Formation. This allocation became widespread and appears in many papers by students of the geology of western Nebraska. Schultz and Falkenbach (1940, pp. 220, 242, 247; 1941, pp. 76, 92, 93; 1947, p. 223) considered the Lower Snake Creek beds as part of the Sheep Creek Formation, though they also retained Matthew's (1924) terminology "for convenience," utilizing the term Sheep Creek to designate the quarries of Stonehouse Draw and their equivalents and the term "lower Snake Creek" for various localities in Sinclair Draw and elsewhere. In 1947 they stated (p. 233): ". . . the writers find that the fauna may be divided into two horizons according to Matthew, 1924. Perhaps the terms Lower Sheep Creek fauna and Upper Sheep Creek fauna would simplify the matter, the former equaling Matthew's 'Sheep Creek' and the latter equaling 'Lower Snake Creek'." In later papers (1949, pp. 80, 83, 105; 1954, pp. 156, 157, 212) Schultz and Falkenbach depicted "Lower Snake Creek" and "Sheep Creek" as separate superposed formations of the Hemingford Group on charts, though from their text and from references cited in their text it is evident that the "Lower Snake Creek" deposits were considered in these papers to belong to the Sheep Creek Formation. Lugn and Lugn (1956, p. 100) referred to "Snake Creek Channels 0-75 ft.," but these are the type Snake Creek, not the Lower Snake Creek. The latter de-

¹ Schultz (1942a, p. 6) incorrectly attributed authorship of the Lower Snake Creek beds to Matthew and Cook (1909).

posits were not mentioned by Lugn and Lugn, who presumably believed them to be part of the Sheep Creek Formation. Schultz and Stout (1961, pp. 7–9, 32) continued to refer the Lower Snake Creek beds and other sediments to the Sheep Creek Formation. The terms Lower Snake Creek L. F. (local fauna) and Sheep Creek L. F. were used for fossil remains.

In the vicinity of the type locality the base of Matthew and Cook's Sheep Creek Formation (base of the type Spottedtail Member of Elias, 1942) appears to channel into the Harrison Formation, though as long ago as 1911 the possibility that Upper Harrison beds might also be present was considered by Cook (1915, p. 74). Schultz and Falkenbach (1947, p. 203), on the grounds of lithology and a specimen identified as *Merychys elegans*, have suggested that Upper Marsland¹ may be present below the quarries, i.e., that part of Matthew and Cook's Sheep Creek Formation, coextensive in part with the type section of Elias' Spottedtail Member of the Sheep Creek, is actually Upper Marsland (see also Schultz and Stout, 1961, p. 8, fig. 3, "Spottedtail, in part," implying that part of the Spottedtail is not Sheep Creek). Elias (1942, p. 128) thought that the lower 60 feet of the type Spottedtail was somewhat similar to the Box Butte Member of the Sheep Creek.² Both suggestions are worthy of further study. The stratigraphic relations of Cady's various Box Butte sediments still appear unclear. Schultz and Stout (1961, p. 8) suggested that the Box Butte, although originally described as the uppermost member of the (correlated) Sheep Creek, is possibly as old as the base of the Sheep Creek. They also stated (p. 7): "The Hemingford includes the Marsland and Sheep Creek formations, but the latter is now considered to include only two rather poorly-named members, the restricted 'Sheep Creek' below and the 'Lower Snake Creek' above. The divisions proposed by

¹In 1947 (except in their chart 2) Schultz and Falkenbach began occasionally to use the terms Upper Marsland and Lower Marsland in the sense of distinct rock units, rather than "upper part of the Marsland Formation" or "lower part of the Marsland Formation" (sequence within one unit). Thus, from designation of upper or lower relative position within a single rock unit (Schultz and Falkenbach, 1940, pp. 280, 289; 1941, pp. 2, 93, 94; Schultz, 1938; 1942a, p. 5) the meaning of "upper" and "lower" was occasionally shifted to imply two distinct rock units apparently in the sense of members, though these were nowhere defined in print and the exact meaning is unclear. Presumably, "Lower Marsland" is Marsland proper, = Upper Harrison beds of Peterson (1906). Equally presumably, "Upper Marsland" would correspond to part or all of Schultz's (1941) "type locality of the Marsland," to Cook's (1960, 1965) Runningwater Formation and correlated sediments. This allocation is not certain, however, because Schultz and Stout (1961, fig. 3, p. 13) even refer to a threefold division of the Marsland, still without adequate published definition.

²Type section in sect. 27, T. 28 N., R. 49 W., approximately 32 miles east of the type Spottedtail (Cady, 1940; see also Cady and Scherer, 1946). The fate of the name Box Butte depends upon allocation of sediments in this section.

Elias (1942) are at least partly preoccupied by these two earlier names, and the name 'Box Butte' (Cady, 1940; Elias, 1942; Lugn, 1939) appears also to be invalid." Unfortunately, Schultz and Stout did not publish the evidence for these conclusions.

HEMINGFORD GROUP

The term Hemingford Group was introduced to the literature by Lugn (1938, p. 226; 1939, p. 1253), who stated in 1938: "The Hemingford group is a new division suggested by C. Bertrand Schultz, Assistant Director, Nebraska State Museum, and concurred in by this survey. This is the first publication of the new term. The Hemingford group includes the Marsland and Sheep Creek formations. The Marsland formation is a recent term given by Schultz. The basis for the use of the term Marsland and the redefinition of the Arikaree has been given fully by Schultz."

The lower and upper limits of the Hemingford Group as defined depend upon the lower limit of the Marsland and the upper limit of the Sheep Creek. The former is the base of the old Upper Harrison beds of Peterson (1906), but the position of the latter is subject to various interpretations. If Lugn's concept of the Sheep Creek is utilized, then the upper limit of the Sheep Creek is at the top of the Lower Snake Creek (Lugn, 1938, p. 225), because Lugn regarded the Lower Snake Creek as part of the Sheep Creek at the time he was proposing the Hemingford Group. Most Nebraska geologists and paleontologists have taken this position, with little modification (e.g., Schultz, 1942a, p. 6; Schultz and Stout, 1961, p. 8, fig. 3). Under this scheme, however, the Hemingford Group represents a very long period of time and includes at least three¹ major disconformities representing important erosion cycles and gaps in the fossil record. The geochron of the Hemingford Group has often been confused with the Hemingfordian Land-Mammal Age.

HEMINGFORDIAN AGE

The Hemingfordian Land-Mammal Age (see Savage, 1962) was proposed by Wood and his co-authors (1941, p. 12). This time term was "based on the Hemingford group, including the Marsland and especially, the limited or lower Sheep Creek fauna (Cook and Cook, 1933, pp. 38-40) and not on the formation limits as extended upward (Lugn, 1939b)." Wood and his co-authors showed the Sheep Creek Formation and Hemingford Group extending above the Hemingfordian Age on the plate

¹Two, for those who minimize the Marsland-Runningwater disconformity.

accompanying their paper, but it is not clear whether they regarded the Lower Snake Creek beds as referable to a unit labeled by them Snake Creek Facies. They define the Sheep Creek local fauna (p. 31) as "'Lower Sheep Creek,' Cook and Cook, (1933, pp. 38-40)." Cook and Cook (1933, p. 39) listed both *Merychippus quintus* and *M. quartus* as members of the "Lower Sheep Creek," and reference to Osborn (1918, pp. 17, 102) demonstrates that sediments bearing fossils upon which this faunal concept was based occur within a few feet of the top of the type Sheep Creek Formation of Matthew and Cook (1909), above the Spottedtail Member of the Sheep Creek (Elias, 1942), in sediments just beneath the prominent dark gray ash bed dated by Evernden and his co-authors (1964). Elias (1942, p. 128) noted "an apparent hiatus in sedimentation" between the Spottedtail Member and these overlying sediments and at the same point a change in lithology and of the fossil grasses, so there is evidence that even Cook and Cook's "Lower Sheep Creek" may include a significant disconformity at that point. The term Hemingfordian is applicable up to at least the base of the thick, dark gray ash, however, and, as no break in sedimentation has been observed at the base of the ash or between there and the top of the exposed type Sheep Creek Formation, it is assumed here that all the type Sheep Creek bears Cook and Cook's "Lower Sheep Creek" mammal fauna, and that horses such as *Merychippus quintus* may be expected to occur above as well as below the thick, dark gray ash. If so, the ash dated by Evernden and his co-authors actually pertains to the "lower Sheep Creek" fauna. If not so, the ash is useful only in setting a minimum age for the fauna beneath it.

R. W. Wilson (1960) has presented pertinent evidence for the correlation of various American Miocene faunas with those of Europe (see Schultz and Stout, 1961, pp. 8-9, for undocumented contrary views), but, unfortunately, Wilson introduced without definition the time terms Harrisonian, Marslandian, Sheepcreekian, and Mascallian, and redefined the Arikareean and Hemingfordian Land-Mammal Ages by moving the boundary between those two time units to include in the Arikareean "Quarry A" in northeastern Colorado and certain correlated deposits.¹ With regard to Wilson's actions, Schultz and Stout (1961, p. 7) objected: "Thus an inclusion of the Marsland [²] in the Arikaree, as Wilson (1960) suggests, would seem to have neither stratigraphic nor faunal support, and is indeed contrary to everything known about these beds in

¹ Marsland equals, at least in part, Wilson's concept of Schultz's more recent usage of the term Marsland.

² *Sensu* Schultz and Stout and other authors; i.e., including the Runningwater Formation.

some 25 years of careful stratigraphic study and collecting by the writers and their associates." In defense of Wilson, it should be noted that he did not in fact refer anything to the Arikaree (a rock unit), but extended the Arikareean (a time unit) to apply to certain younger sediments. Nevertheless, Wilson's proposal is unacceptable because the geochron of the Marsland Formation (= "Upper Harrison beds" of Peterson, 1906) is part of the original basis of the Hemingfordian Land-Mammal Age.¹

Wilson (1960, p. 16) also depicted the Lower Snake Creek as representative of late Hemingfordian time, contrary to the definition of the time term Hemingfordian (Wood *et al.*, 1941, p. 12).

Schultz and Stout (1961, p. 8) also employed the Land-Mammal Age term Hemingfordian in a more inclusive sense than was intended by the authors of that concept. Wood and his co-authors specifically excluded from the basis of the Hemingfordian concept sediments of the Hemingford Group above those bearing the "limited or lower Sheep Creek fauna." Hemingfordian time is very definitely not the time equivalent or geochron of the Hemingford Group, only a part of which constitutes the basis of the Hemingfordian Land-Mammal Age.

The time terms Marslandian and Sheepcreekian, used without adequate definition by Schultz and Stout (1961, p. 8), are not equivalent to the inadequately defined Marslandian and Sheepcreekian of Wilson (1960). It should also be noted that Schultz and Stout's Sheepcreekian is a division of their "Hemingfordian," not the Hemingfordian of Wood and his co-authors (1941). Schultz and Stout's "Hemingfordian," like the Hemingford Group, extends to the end of what they recognize as Miocene time in Nebraska, correlated by them with the end of Sarmatian time in Europe. The relationships of these time terms to the Land-Mammal Age term Barstovian (Wood *et al.*, 1941) have not been elucidated by Schultz and Stout.

CONCLUSIONS

The use of the written word to denote various aspects of nature demands that concepts be disciplined by facts and that these facts be readily accessible to any investigator. Precision of definition is a prerequisite to scientific communication about facts. In geology and biology it is paramount that the factual basis for concepts be readily identifiable in nature by other investigators on the basis of the published record of such funda-

¹ That it should not have is beside the point. More than half of the time terms proposed by Wood and his co-authors (1941) similarly involve geochrons rather than time equivalences of biostratigraphic units.

mental data. Terminology must be rigorously defined if confusion is to be avoided.

Formational names should be tied to rocks in the field. The principle is no different from that of zoological nomenclature and the aim is the same: to permit discussion on an agreed basis. The primary requisites for the establishment of formational names should be (1) a map, topographic, geologic, or an aerial photograph; (2) an indication of the location of the type section of each formational or member name; (3) a measured section showing the lower and upper limits of the type section, as well as a description of the rocks in between; and (4) photographs of the outcrops. For paleontological purposes we need the locations of fossils tied stratigraphically and geographically to these data. Until the above requirements have been met, we seem to be wandering around in a sea of concepts and interpretations that cannot be tied to the source of our basic nomenclatural datum: the type section.

The application of a rigorous system of stratigraphic and biostratigraphic nomenclature has long lagged for the continental Tertiary, and a loose usage has often proliferated without adequate definition. The meanings of such terms as "Barstow fauna," "John Day fauna," "Loup Fork," "Sheepcreekian," "middle Marsland," "Arikaree time," and so forth are not clear because they have not been defined adequately in print and are used differently by various authors. Many of the time, rock, and faunal terms, and combinations of these terms, utilized for the Miocene of Nebraska and nearby states mean different things to different authors because the basic data necessary for definition have not been adequately published or are passed on among small groups of geologists and paleontologists mainly by oral tradition. On the other hand, many time, rock, and faunal units were originally given a rigorous or adequate definition which has lapsed into a loose or ambiguous usage by later workers by repeated modification without definition. This paper has attempted to bring some of these original and later usages into focus.

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