# Reply

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Lucas (2002) has criticized our tentative correlation of the North American Chickasha Formation with Russian continental strata that date from the late Kazanian (Reisz and Laurin, 2001) and argued instead, on the basis of marine biostratigraphic and magnetostratigraphic evidence, that the Chickasha Formation is substantially older than the Late Kazanian and likely Leonardian in age. We would like to comment on some of his statements and then discuss their implications. There is no magnetostratigraphic evidence (in Oklahoma) that the Chickasha is substantially older than the Russian Kazanian. Lucas's argument is based on his interpretation of the age of the Blaine, which partly rests on the presence of the ammonoid *Perrinites hilli* in this formation. This species used to be considered an index fossil of the Leonardian (Miller and Furnish, 1940; King, 1942). However, *Perrinites hilli* ranges from the middle Leonardian (Artinskian) to the Guadalupian (at least the Roadian) (Clifton, 1946). Thus, its presence in the Blaine Formation is compatible with a Guadalupian age. In addition, Lucas's literature-based review on the age of the Blaine Formation that partly overlies the Chickasha is somewhat selective—he has used Fay's (1964) work, but ignored the fact that Fay assigned the Oklahoma Blaine Formation to the Guadalupian, not to the Leonardian. He has also cited Ross (1987) but ignored the fact that this worker assigned the San Angelo and Blaine to the Roadian. If we follow Ross's (1987) proposed correlations for these formations and if we accept the interpretations of other papers cited by Lucas (2002), then we reach the conclusion that the Pease River Group is entirely of early Guadalupian age (Fig. 2). However, much of the stratigraphic work has been done in Texas, and its applicability in Oklahoma remains uncertain. The lateral correlations between Permian strata of Oklahoma and those of Texas are poorly documented because lateral continuity between these strata has not been demonstrated (King, 1942), partly because of the confounding effects of the Wichita Mountains (Oriel et al., 1967). Therefore, Lucas's (2002) statement that ''It has long been known that the Blaine represents the same cycle of deposition as the Leonardian lower San Andres Formations and that the San Angelo Formation is equivalent to the Leonardian Glorieta Sandstone'' is misleading. For example, the type Glorieta Sandstone, found in central New Mexico, pinches out eastward, and its lateral continuity with the San Angelo has not been demonstrated (Oriel et al., 1967). Nevertheless, we have a classic case of potentially conflicting evidence provided by terrestrial and marine fossils, and we were well aware of this. Although we presented the first evidence of direct correlations between American and east European terrestrial parts of Pangea, we admitted in our conclusions that the correlations between these continental strata remain problematic, and we hoped that more geologic work (especially field work rather than the use of the literature) would effectively test this hypothesis.

Lucas cannot refute one of the main points of our paper: The *Macroleter* specimen from Oklahoma is the first known terrestrial vertebrate from the Chickasha Formation that is a characteristic member of the Russian Late Permian fauna from Mezen. This point still stands unchallenged, and it is important because *Macroleter* is part of the typically Russian northern Dvinosaurid-Chroniosuchid faunal province. Thus, our paleobiogeographic conclusions stand.

The slightly older age of the Chickasha Formation implied by the literature (Fig. 2) would strengthen our hypothesis (Reisz and Laurin, 2001) that much of early parareptile evolution took place in North America and western Europe and then in contiguous parts of Pangea (Li et al., 1993). It would also suggest that the parareptilian evolutionary radiation in North America spanned most of the later part of the Early Permian and that typical groups of parareptiles that are found in strata of late Kazanian age in Russia were also present earlier in what is now North America. An early Guadalupian age for the Chickasha Formation strongly suggests either that parareptiles did not become extinct in North America or that if they did, this extinction took place later, in the Late Permian.

Lucas's inclusion of the Chickasha in his proposed pelycosaur-dominated tetrapod assemblages of the North American Permian and his inclusion of Mezen fossils in the therapsid-dominated assemblages of Russia are misleading. Indeed, the most startling feature of the Chickasha and Mezen terrestrial vertebrate assemblages is their similar composition, as indicated in our original paper. The Chickasha assemblage lacks the sphenacodontids, ophiacodontids, and edaphosaurids typical of Cisuralian age and is characterized by caseids and varanopseids, groups that appear to extend throughout most of the Kazanian (in the Verkhnekimzhensk and Leshukonsk Members of the Mezen complex and at the slightly older locality at Pinega, south of the Mezen complex). Furthermore, at Mezen and Pinega, no specimens of dinocephalians, gorgonopsians, or pareiasaurs that characterize Tatarian localities have been found (Ivakhnenko et al., 1997). The only therapsids found at Mezen are *Biarmosuchus* and two endemic taxa, but these small therapsids are only represented by a handful of specimens, whereas dozens of specimens of *Macroleter*, nearly a dozen specimens of caseids, and numerous varanopseids have been found at Mezen and Pinega. The Mezen assemblage is not therapsid dominated, does include caseids and varanopseids, but most startlingly lacks one of the most widely known groups of Late Permian reptiles, the pareiasaurs. Thus, we propose three informal terrestrial vertebrate faunal zones for the Permian: A Cisuralian zone, in which sphenacodontids were the

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top predators; an early Guadalupian zone, in which varanopseids were top predators, but caseids and basal parareptiles (*Nycteroleter* and *Macroleter*) are also common, and a Tatarian (late Guadalupian and Lopingian) zone (Fig. 2) in which therapsids were top predators, but pareiasaurs were also common. Most fossiliferous localities of the Chickasha may be near the beginning of the early Guadalupian (varanopseid-caseid) zone, and Mezen is certainly toward the top of that zone.

Lastly, Lucas (2002) has proposed the existence of a large gap (called Olson's gap) in the fossil record of terrestrial vertebrates in the Roadian or Ufimian, but this does not seem to be justified. First, our survey of the literature and the presence of *Macroleter* suggest that the Chickasha and much of the Pease River Group fit in this part of the Permian. Second, at least two Russian localities, Inta and Pechora, are classic continental vertebrate-bearing localities of Ufimian age (Ivakhnenko et al., 1997). Thus, the presence of *Macroleter* in the Chickasha and at Mezen and the similarities between these varanopseid- and caseid-dominated localities support Olson's original ideas of continuity and overlap of the North American and Russian continental sequences and their preserved continental vertebrate communities (Olson, 1968).

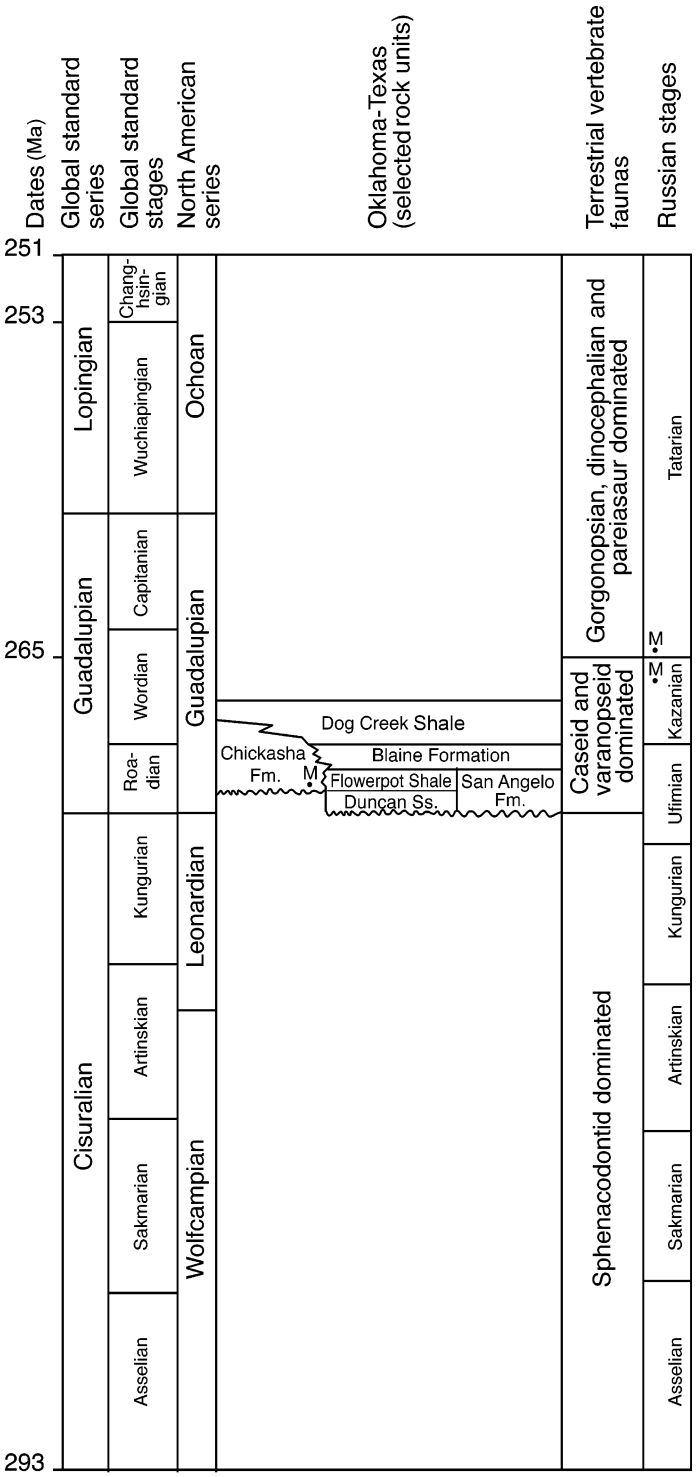


**Figure 2. Permian stratigraphy showing relationships between the Pease River Group (shown in the center as rock units) and the caseid-varanopseid–dominated faunas. Stages and global standard series from Jin et al. (1997). The age of the Chickasha Formation is poorly documented. Abbreviations: Fm—Formation, M—*Macroleter* occurrences, Ss—Sandstone.**

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