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Biostratigraphy/ecostratigraphy of the early Pennsylvanian Osha Canyon formation at Guadalupe Box, Jemez Mountains, New Mexico

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BIOSTRATIGRAPHY/ECOSTRATIGRAPHY OF THE EARLY PENNSYLVANIAN OSHA CANYON FORMATION AT GUADALUPE BOX, JEMEZ MOUNTAINS, NEW MEXICO

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Abstract—The Osha Canyon Formation is a 27-m-thick sequence of limestone and shale of Morrowan age that is well exposed above and north of Guadalupe Box in northern New Mexico. It is richly fossiliferous, especially in its lower half, where attached brachiopods such as *Schizophoria* are abundant in intercalated shale and calcarenite limestone at the type section. Elsewhere in the formation are exposures where different sediment types, and therefore different environments of deposition, prevailed. These environments include low areas that accumulated micrite and an environmentally adapted, spinose productid fauna and shale-limestone cycles in which the brachiopods are silicified to a high degree. The Osha Canyon Formation preserves brachiopod-dominated fossil assemblages that mostly reflect changes in its marine ecology, expressed both stratigraphically and geographically, during part of Morrowan time.

INTRODUCTION

The canyon of the Rio Guadalupe in the Jemez Mountains of northern New Mexico exposes sediments from the entire Pennsylvanian System, including, at its base, the Morrowan-age Osha Canyon Formation. Deposited unconformably on 2 m of unfossiliferous Log Springs Formation and 6 m of Mississippian Espirito Sancto Formation (Armstrong and Mamet, 1974) that overlie the Precambrian basement of granitic gneiss, the Osha Canyon Formation contains diverse fossil assemblages (Fig. 1) that vary both stratigraphically and geographically. Krainer and Lucas (2005) redefined the formation to include an additional 5 m of fossiliferous marine limestone and shale that are poorly exposed at the type section and were not included by Duchene et al. (1977) when the Osha Canyon Formation was first defined in a stratigraphic section at Guadalupe Box. In an attempt to sort changes in the fauna within the formation, the Osha Canyon Formation can be divided into three sections based on stratigraphy and invertebrate fossil assemblages. The upper section includes beds 14 and 15 of Krainer and Lucas (2005), i.e., the uppermost limestone bed and the shale below it that were not included in the original formation definition. Just below the disconformable contact with the basal coarse, terrestrial sandstone of the overlying Sandia Formation, these beds consist of sand-sized fragments of crinoids, bryozoans, and spiriferid brachiopods. These limestones also contain abundant grains of quartz sand. Cementation is by calcite.

TYPE SECTION

At the type section, the strata below the upper 3 m of mostly limestone consist of 9 m of poorly exposed, marly shale with limestone nodules. The fossil assemblage of unbroken specimens in these 12 m of the upper part of the Osha Canyon Formation is dominated by the brachiopods *Anthracospirifer, Linoproductus,* and *Antiquatonia*; each represents more than 20% of the specimens in the brachiopod assemblage. *Derbyia, Sandia,* and *Schizophoria* are each less than 1% of the assemblage (Table 1). Diversity in terms of number of brachiopod species is about 15. The environment of deposition of the upper member is interpreted to be a shallow, open-marine stenohaline shelf. Water depth was the main determinant of lithology, with the upper limestone facies being deposited in shallower water above wave base and the underlying nodular shale accumulating in deeper water below wave base. The upper section is, therefore, a shallowing upward sequence.

The middle section encompasses beds 10–13 of Krainer and Lucas (2005), while, in the original stratigraphy of Duchene et al. (1977), this part is probably represented by their beds 5–8. At the type section, the fauna of the middle section differs from that of the upper section (Table 1) in the following ways: *Anthracospirifer, Linoproductus,* and *Antiquatonia* are each less than 5% of the assemblage. *Composita* is dominant at over 50% abundance and averages smaller in size than is usual in the upper and lower members. *Hustedia* becomes common at over 10% abundance, and *Punctospirifer* and *Sandia* are each fairly common at about 5%. Diversity of brachiopods for this middle section is about 14 species, which make up about 90% of the specimens. Non-brachiopods, which include bryozoans, rugose corals, and echinoid spines and plates, are present but rare, while crinoid stems are common. According to Krainer and Lucas (2005), these abundant fossils are found in beds of bioclastic grainstone, decimeters thick, intercalated with beds of marly shale of similar thickness. The limestone was deposited in a shallow, high-energy environment above wave base, while the shale accumulated in deeper, low-energy water below wave base.

The lower deposits of the Osha Canyon Formation at the type section, which include beds 1–9 of Krainer and Lucas (2005) and beds 1–4 in the original stratigraphy of Duchene et al. (1977), consist of similar thin beds of alternating bioclastic limestone and light-gray marly limestone, but the fauna

FIGURE 1. Invertebrate fossils from the Osha Canyon Formation at Guadalupe Box, New Mexico. References used for fossil identifications include: Sutherland and Harlow (1973) for photographic representations and detailed descriptions of the brachiopods; Duchene et al. (1977) for lists of fossils from specific beds at the type section (exposures 1 and 2); and Kues (2005) for a list of the fossils found at the northernmost exposure (exposure 7).

(1) *Schizophoria oklahomae* 1a) brachial view, exposure 1; 1b) pedicle view, strongly silicified, exposure 4. **(2)** *Derbyia bonita* brachial view, exposure 7. **(3)** *Neochonetes platynotus* 3a) pedicle view, exposure 7; 3b) brachial view, exposure 7. **(4)** *Desmonesia nambeensis* 4a) pedicle view, exposure 7; 4b) brachial view, exposure 7. **(5)** *Parajurasania sp.* 5a) pedicle view, exposure 7; 5b) brachial view, exposure 7. **(6)** *Linoproductus nodosus* pedicle view, exposure 7. **(7)**. *Antiquatonia coloradoensis* 7a) pedicle view, exposure 7; 7b) brachial view, exposure 7. **(8)** *Echinaria n. sp*. pedicle view, exposure 7. **(9)** *Sandia welleri* 9a) pedicle view, exposure 7; 9b) brachial view, exposure 7. **(10)** *Hustedia gibbosa* brachial view, exposure 7. **(11)** *Rhipidomela trapezoidea* pedicle view with red silicification, exposure 7. **(12)** *Composita gibbosa* 12a) brachial view, exposure 7; 12b) pedicle view, exposure 7. **(13a)** *Anthracospirifer newberryi* pedicle view, exposure 7. **(13b)** *Anthracospirifer curvilateralis* anterior view, exposure 7. **(13c)** *Spirifer goreii* pedicle view, strongly silicified, exposure 7. **(14)** *Punctospirifer morrowensis* 14a) brachial view, exposure 7; 14b) anterior view, exposure 7. **(15)** *Beecheria stehlii* 15a) pedicle view, exposure 7; 15b) brachial view, exposure 7. **(16)** *Rhyncopera magnicosta* 16a) brachial view, 16b) brachial view, and 16c) anterior view, all from exposure 4. **(17)** crinoid stems, exposure 7. **(18)** crinoid spines, exposure 7. **(19a)** echinoid plate, exposure 7. **(19b)** echinoid spines, exposure 7. **(20)** rugose coral, exposure 7. **(21)** gastropod steinkern, exposure 7. **(22)** nautiloid cephalopod, exposure 4. **(23)** trilobite 23a) posterior view of an enrolled specimen; 23b) anterior view of the same specimen, exposure. **(24)** bivalve steinkern, exposure 7.

TABLE 1. Osha Canyon Formation exposures and percent abundances of the brachiopods (This table is based on similar diagrams in Grasso, 1986.) A = abundant, C = common, F = frequent, O = occasional, R = rare.

1. Units 1–4 of Krainer and Lucas (2005) at the type section, n = 62 specimens (lower section)
2. Units 10–13 of Krainer and Lucas (2005) at the type section, n = 470 specimens (middle section)
3. Units 10–13 at utility pole #2, 500 m north of Guadalupe Box, n = 477 specimens (middle section)
4. Micrite bed and the strata below it, 600 m north of Guadalupe Box, n = 323 specimens (lower section)
5. "West Hill" locality, 600 m north of Guadalupe Box, n = 140 specimens (unknown stratigraphic level)
6. Uppermost Osha Canyon Formation, west side of FR 376, 900 m north of Guadalupe Box, n =109 specimens (upper section)
7. Exposure on Forest Road 376, 6 km north of Guadalupe Box, n = 578 specimens (unknown stratigraphic level)

			LOCALITY NUMBER (%)						
		TAXON	1	2	3	4	5	6	7
FEEDING TYPE	Epifaunal, pedicle-attached filter feeders	*Schizophoria oklahomae*	67	1.4	-	1.1	-	-	-
		Rhipidomella trapezoidea	-	-	0.4	2.2	-	-	4.4
		Derbyia bonita	-	1.1	0.9	-	23.9	-	1.9
		Hustedia gibbosa	3	16.4	11.4	-	-	5	8.9
		Composita gibbosa	13	53.8	54.9	30.8	18.5	5	8.4
		Spirifer goreii	-	1.1	0.9	4.4	-	-	0.4
		Anthracospirifer newberryi	10	4.7	5.1	2.2	7.6	20	0.8
		Anthracospirifer curvilateralis	5	-	-	1.1	18.5	12.5	2.2
		Punctospirifer morrowensis	-	4.2	7	<1	7.6	7.5	10.1
		Beecheria stehlii	-	0.2	1.1	1.1	-	-	-
		Phricodothyris perplexa	-	4.2	-	1.1	-	-	-
	Epifaunal, reclined filter feeders	*Neochonetes platynotus*	-	2.1	1.7	<1	-	7.5	45.6
		Desmoinesia nambeensis	-	2.6	3.4	2.2	9.8	-	-
		Sandia welleri	-	5.1	7	-	-	-	11
		Echinaria n. sp. A	-	-	0.8	-	1.1	-	-
		Parajuresania sp.	-	0.7	-	45.1	6.5	-	0.8
		Antiquatonia coloradoensis	3	0.7	3.3	2.2	-	22.5	2.2
		Linoproductus nodosus	-	1.4	2.1	6.6	6.5	20	3.3
	Epifaunal filter feeders	Bryozoa	A	O	O	O	O	F	O
		Crinoid stems and plates	O	C	F	O	O	A	C
	Epifaunal mobile collectors	Echinoid spines and plates	-	-	R	O	-	-	F
		Gastropods	-	-	-	R	-	O	-
		Trilobites	-	-	-	-	-	-	R
	Infaunal filter feeders	Bivalves	-	-	-	-	O	-	R
	Epifaunal micro-carnivores	Rugose corals	-	O	R	O	-	-	O
	Nectonic carnivores	Nautiloid cephalopods	-	-	-	R	-	-	-

is somewhat different (Table 1). The large orthid brachiopod *Schizophoria oklahomae* is the most common fossil, though it is a rare component of the middle section deposits. The rest of the assemblage is dominated by abundant bryozoans and *Anthacospirifer* and *Composita* in abundances much less than *Schizophoria*. Recent collections at the base of the type section yield much less diversity compared to the assemblage listed by Duchene et al. (1977), which included tabulate corals as an

important component. This could be due to differences in the freshness of the exposure over time.

ADDITIONAL SECTIONS

An exposure of the lower half of the formation occurs above and below the utility road about 500 m north of the type section. Here the sequence is the same in terms of lithology and fauna as at the type section. This suggests that depositional conditions early in Osha Canyon time were about the same over a lateral distance of 0.5 km. However, another exposure, 600 km north of the type section and apparently also in the lower part of the formation, displays rocks of a lithology (bioclastic wackestone) that is not found at the type section. Here there was a deeper water environment that accumulated a different assemblage of fossils approximately during the same time as the shallower deposition occurred at the type section. The fauna are dominated by productid brachiopods, especially *Parajurasania*, which is present at 45% abundance. *Composita* is also common at 30%, as is *Linoproductus* at 6%, but *Neochonetes*, *Punctospirifer, Hustedia*, and *Sandia* are each less than 1% abundant. Isolated environments of differing depths produced faunas adapted to those specific conditions, while at the same time similarly changing conditions across at least hundreds of meters on the shelf produced essentially the same changes in the fauna during the first half of Osha Canyon time.

Another excellent exposure of Osha Canyon strata that are unlike those of the type section can be found about 6 km north of Guadalupe Box on both sides of Forest Road 376. The fauna from this locality was described in some detail by Kues in 2005. *Neochonetes* (45%), *Punctospirifer* (10%), *Hustedia* (9%), and *Sandia* (11%) are the dominant brachiopods at the present time. Kues (2005), however, identified a total of 27 brachiopod species from this locality, making it the most diverse assemblage yet found in the Osha Canyon Formation. The difference in diversity between 2005 and the present may be due to changes in outcrop freshness. This exposure was burned over in a forest fire in 2018.

The stratigraphy at this locality is simple and cyclic, with shales and limestones alternating three times in a succession that starts with 4 m of exposed shale and totals 12 m in thickness. The limestone beds are all about 1 m thick and consist mostly of unsorted biosparite (packstone) with some sparsely fossiliferous biomicrite (wackestone). The medium-gray shales vary in thickness from 1 m (bed 3) to 5 m (bed 5). Shale-limestone cycles vary in thickness from 2 m to 6 m. Fossil diversity decreases upsection from 17 species in bed 1 (4 m of shale) to 6 species in bed 5 (5 m of shale). Fossils in the shale facies are slightly more diverse than those in the limestone facies. For example, shale bed 1 produced 17 species, as compared to 14 species in limestone bed 2. The degree of silicification of the fossils also varies with lithology, with the lower two shales having a silicification rate averaging 15% of fossils, compared to 3% for the lower two limestones.

Partial silicification of some fossil shells is prevalent throughout the Osha Canyon Formation, but it is especially common in the fossils at this northern exposure. Brachiopods are the most commonly silicified fossils, especially *Composita* and the spiriferids, but crinoid stems and echinoid spines are also sometimes affected. Silicification in bivalves cannot be determined because they are preserved only as rare steinkerns. Both red and gray silicification occur in the Osha Canyon Formation. The red replacement is located under the surface layers of the shells, and the red color is attributed to the presence of ferric iron of unclear origin. Gray silicification occurs at a higher level in the shell, within its outer layer, and frequently distorts the shell's surface in the form of beekite rings, which have been ascribed to episodic silicification (Carey and Green, 2023).

CONCLUSIONS

The changes in relative abundances of brachiopods and other taxa through the Osha Canyon Formation are tied to lithologic differences that suggest ecologic factors such as water depth and temperature drove these changes, but the entire assemblage does not change significantly in taxonomic composition through the section. For example, the biomicrite facies in the lower member at the northern part of the Guadalupe Box area (which is not present at the type section) is dominated by highly spinose productid brachiopods that were epifaunal, reclined filter feeders in that part of the lower Osha Canyon marine ecosystem. The environment of deposition for this facies is interpreted to be a low area in the seafloor where only carbonate mud accumulated in the calm water below wave base. In contrast, the biosparite (brachiopod grainstone) of the *Schizophoria olkahomae* bed at the type section was deposited in much shallower, highly agitated water that was well above wave base. The sediment consists mostly of broken pieces of calcite shells, where the pedicle method of attachment used by orthid and spiriferid brachiopods was successful. The niche of these brachiopods was that of epifaunal, pedicle-attached filter feeders. In the deeper-water, carbonate mud environment, spines on the shells of brachiopods were necessary for attachment to the loose, muddy sediment of the seafloor, resulting in a plethora of productid brachiopods.

Throughout the Osha Canyon Formation, preserved faunas are dominated in terms of number of specimens and number of taxa by epifaunal, filter-feeding brachiopods. Second in abundance are the ubiquitous crinoids and bryozoans, which were filter feeders at a slightly higher level in the water column. Animals that occupied other ecological niches in the Early Pennsylvanian ecosystem usually make up less than 10% of the preserved fauna. For the Osha Canyon Formation, these non-filter-feeding taxa include: echinoids, gastropods, and rare trilobites (epifaunal mobile collectors); rugose and tabulate corals (epifaunal microcarnivores); nautiloid cephalopods and very rare sharks (nektonic carnivores); and bivalves (infaunal filter feeders and deposit feeders). Among these rare taxa, the mollusks are probably underrepresented because most of their aragonitic shells dissolved in the sea water before they could be buried. Similar destruction was probably suffered by the non-calcitic skeletons of sharks and bony fish (nektonic carnivores). The Osha Canyon Formation thus preserves brachio-

pod-dominated fossil assemblages that mostly reflect changes in its marine ecology, expressed both stratigraphically and geographically, during part of Morrowan time.

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Looking northward from Arroyo Peñasco near San Ysidro. The brown knob on the left is Proterozoic basement, overlain to the right by eastward dipping Mississippian and Pennsylvanian strata. Jurassic and Cretaceous strata dipping into the San Juan Basin are seen in the distance in the upper left of the photo.
Photo by Spencer G. Lucas