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# Lithofacies of the Pennsylvanian Osha Canyon Formation at the type section, Jemez Mountains, New Mexico

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# LITHOFACIES OF THE PENNSYLVANIAN OSHA CANYON FORMATION AT THE TYPE SECTION, JEMEZ MOUNTAINS, NEW MEXICO

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ABSTRACT.—The Pennsylvanian Osha Canyon Formation at the type section in the Jemez Mountains (northern New Mexico) is a 27.3-m thick succession composed of fossiliferous marly shale with intercalated limestone beds and a mixed siliciclastic-carbonate sandstone bed on top. Limestone is represented by bioclastic grainstone, locally grading into packstone. The mixed siliciclastic-carbonate sandstone forming the uppermost part of the section contains up to 20% skeletal grains. Sediments of the Osha Canyon Formation were deposited in a shallow-marine shelf environment with normal salinity. Fossiliferous marly shales indicate low-energy conditions below wave base; intercalated limestone beds and sandstone on top were deposited under high-energy conditions above wave base. Deposition of the Osha Canyon Formation occurred during a period of relative tectonic quiescence with some weak tectonic pulses, which probably caused minor sea-level changes. Increased siliciclastic influx in the upper part of the Osha Canyon Formation points to increased tectonic activity.

#### INTRODUCTION

In the Jemez Mountains of northern New Mexico, the Osha Canyon Formation is a relatively thin (up to 27.3 m thick) Pennsylvanian lithostratigraphic unit of limestone and shale between Mississippian strata (or Proterozoic basement) and the overlying Pennsylvanian Sandia Formation. Since its initial recognition by DuChene (1973, 1977) and DuChene et al. (1977), few new data have been presented on the Osha Canyon Formation. Here, we present new information on the lithostratigraphy, microfacies and depositional environments of the Osha Canyon Formation at its type section (Figs. 1-3).

## LITHOSTRATIGRAPHY

The type section of the Osha Canyon Formation is just north of Guadalupe Box in the Jemez Mountains (DuChene et al., 1977, fig. 5) (Fig. 1). The base of the section is at UTM zone 13, 340524E, 3956143N, and the top is at 340563E, 3956156N (datum: NAD 27).

At the type section (Fig. 1), the Osha Canyon Formation is 27.3 m thick. It is underlain by red and greenish shale of the Mississippian Log Springs Formation, and sharply overlain with an erosional contact by coarse-grained, trough crossbedded fluvial sandstone of the Sandia Formation (Figs. 2-3). DuChene et al. (1977) reported a total thickness of 21.6 m, and they assigned the fossiliferous, carbonate-cemented sandstone of our unit 15 to the overlying Sandia Formation. But, given that the fossiliferous sandstone of our unit 15 is of marine origin and the lithologic break to nonmarine, unfossiliferous sandstone occurs on top of this unit, we include our unit 15 in the Osha Canyon Formation.

At the type section (Figs. 1-3), the Osha Canyon Formation is composed of red, purple and greenish marly shale (80.6% of the type section), interbedded light-gray and reddish, ledge-forming limestone beds (10.3%), and a mixed siliciclastic-carbonate sand-stone (9.1%) at the top of the section. Marly shales are poorly

exposed, and contain abundant, well- preserved brachiopods and a few small solitary corals and bryozoans in the middle part (units 10, 12) of the section. A few brachiopods are also found in the greenish, mostly covered shale containing small gray limestone nodules in the upper part of the section (unit 14). Brachiopods also occur in shale of units 6 and 8 (Fig. 2).

DuChene et al. (1977) reported several genera of solitary rugose corals and fragments of several species of tabulate corals, the bryozoans *Fenestella, Septopora, Rhombopora* and *Tabulipora*, two gastropods and one bivalve from the lower part of the section. According to Duchene et al. (1977), the largest, most conspicuous brachiopod is *Schizophoria oklahomae* Dunbar and Condra. All tabulate corals are restricted to the lower part of the section, and the abundance and diversity of chonetid brachiopods increase upsection.

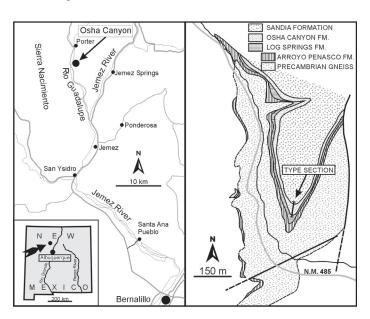


FIGURE 1. Location map of Osha Canyon Formation type section.

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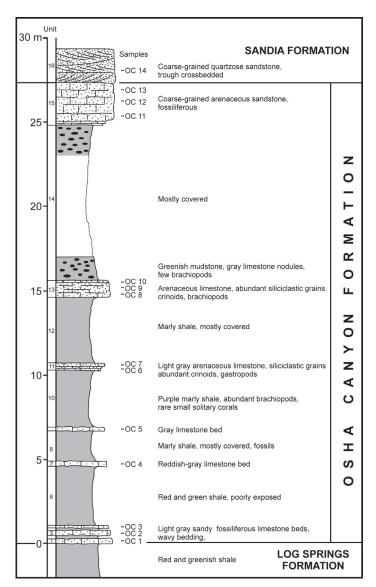


FIGURE 2. Type section of the Osha Canyon Formation.

The ledge-forming limestone beds are 0.1 to 1 m thick, wavy bedded, and composed of abundant large fragments mostly of brachiopods and crinoids, and subordinately of bryozoans, gastropods and other organisms. Limestones also contain siliciclastic grains including abundant quartz grains and subordinate granitic rock fragments. Limestones in the lower part of the section contain large brachiopod fragments and crinoid stem fragments composed of several segments.

Intercalated in the shale are ledge-forming limestones, in the lower part forming 0.2-0.3 m thick limestone beds. These limestone beds are light-gray to reddish, display wavy bedding and contain abundant crinoids and some siliciclastic grains. The thicker limestone horizons of units 11 (0.4 m thick) and unit 13 (1 m thick) are light-gray, arenaceous, and contain abundant crinoids, some brachiopods, bryozoans, gastropods and other

skeletal grains. A thin brachiopod coquina bed with abundant *Composita* and *Hustedia* (DuChene et al., 1977) is intercalated in limestone unit 13. The limestone horizon of unit 11 consists of three limestone beds separated by thin shale intercalations, and the limestone horizon of unit 13 is indistinctly bedded.

#### MICROFACIES

Bioclastic grainstone is the typical microfacies of the limestones at the Osha Canyon Formation type section, locally grading into bioclastic or crinoidal packstone (Figs. 4-5). The grainstone is mainly composed of grains >0.5 mm. Fine-grained grainstones with grain size ranging commonly between 0.1 and 0.3 mm are also present. All grainstones are poorly laminated to nonlaminated, and poorly to very poorly sorted, containing some skeletal grains up to a few cm in size. Elongate grains are typically oriented parallel to bedding. Locally, normal graded bedding is observed.

The most abundant skeletal grains are echinoderms (crinoid stem fragments; Figs. 4A, 4E, 5C), bryozoans (Figs. 4B, C, D, F, 5B) and shell debris (Fig. 5A) mainly derived from brachiopods. Fragments derived from gastropods and ostracods, echinoid spines and brachiopod spines are rare; occasionally trilobite fragments (Fig. 5E) and smaller foraminifers (*Tetrataxis*) occur.

Some of the crinoid fragments are partly or completely silicified. Bryozoan fragments are commonly surrounded and filled with dark gray micrite, indicating reworking from a low-energy muddy depositional environment (Fig. 4B). Many other skeletal grains display thin micritic envelopes. Shell fragments are commonly replaced by coarse calcite; their outline is marked by thin micritic envelopes (Fig. 5A).

A few rounded peloidal grains composed of dark micrite are present. The grainstone of the lowermost limestone bed (unit 1) contains abundant angular quartz grains 0.2 to 0.5 mm (up to 4 mm) in size. Limestone beds above contain only small amounts of siliciclastic grains (<3%). The grainstone is lithified by coarse, blocky calcite cement; locally small amounts of micritic matrix are present.

Unit 15 of the Osha Canyon Formation type section is composed of indistinctly bedded, fossiliferous, medium- to coarse-grained sandstone. In thin section, the sandstone appears nonlaminated to indistinctly laminated and poorly sorted. Most siliciclastic grains are angular to subangular, although a few subrounded and rounded grains are present too. In the lower part (sample OC 11), skeletal grains such as crinoid and bryozoan fragments, shell debris, ostracods and brachiopod spines occur, constituting about 5% of the rock. A few micritic carbonate lithoclasts are also present. The amount of skeletal grains increases upsection; sample OC 12 contains about 20% skeletal grains, mostly derived from crinoids, bryozoans and brachiopods (Fig. 5D).

Siliciclastic grains consist mostly of mono- and polycrystalline quartz, including a few stretched metamorphic quartz grains. A few metamorphic rock fragments of fine-grained quartz and altered feldspars were also recognized. The sandstone is cemented by calcite.

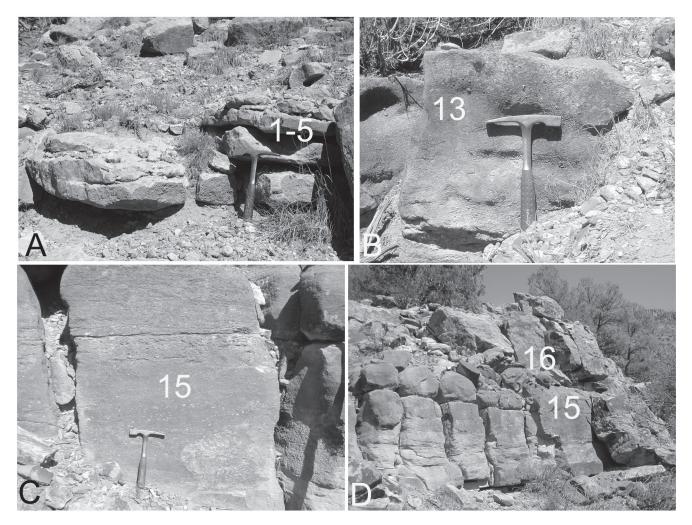


FIGURE 3. Outcrops of the Osha Canyon Formation at the type section. Numbers referred to numbered units in the measured section (Fig. 2). A, Limestones at base of section. B, Sandy limestone in middle part of section. C-D, Top bed (unit 15) of Osha Canyon Formation and overlying sandstone (unit 16) at base of Sandia Formation.

In the uppermost part of this unit, the sandstone locally grades into fine- to medium-grained, poorly sorted crinoidal grainstone/packstone (Fig. 5E). Grain size is mostly < 0.5 mm; individual crinoid fragments are up to 5 mm in diameter. Besides crinoids, bryozoans and brachiopod shells, and rare ostracods and brachiopod spines are present. This microfacies contains up to about 10% silt- and sand-sized mono- and polycrystalline, angular to subangular quartz grains. The rock is cemented by calcite, and locally small amounts of micrite occur.

With a sharp, erosional contact, medium- to coarse-grained, trough-crossbedded sandstone of the basal Sandia Formation overlies unit 15 of the Osha Canyon Formation.

The basal sandstone of the Sandia Formation is moderately to poorly sorted. The most abundant grain type is monocrystal-line quartz. Polycrystalline quartz and detrital feldspars are sub-ordinate. Feldspars are intensively to completely altered to clay minerals. A few metamorphic rock fragments composed of fine-grained quartz and micas, and a few detrital micas (muscovite) are present. Detrital quartz grains frequently display authigenic

overgrowths, and the remaining pore space is filled with fine-crystalline silica (?chalcedony); matrix is absent (Fig. 5F).

## DISCUSSION

Sediments of the Osha Canyon Formation were deposited in a shallow marine shelf environment. The fossils of stenohaline organisms such as corals, crinoids, brachiopods and bryozoans indicate normal salinity. The fossiliferous marly shales formed in a shallow-water, low-energy environment below wave base, whereas the limestones and the mixed siliciclastic-carbonate sandstone at the top of the type section reflect deposition in a shallow marine, high-energy environment above wave base.

The grainstone belongs to the microfacies of coated bioclastic grainstone with sparry cement (Wilson, 1975; Flügel, 2004) containing abundant bioclasts with micritic envelopes ("cortoids"). Such micritic envelopes commonly are formed by micritization caused by microborers in very shallow environments, but may also form by precipitation of microcrystalline calcite. Crinoidal

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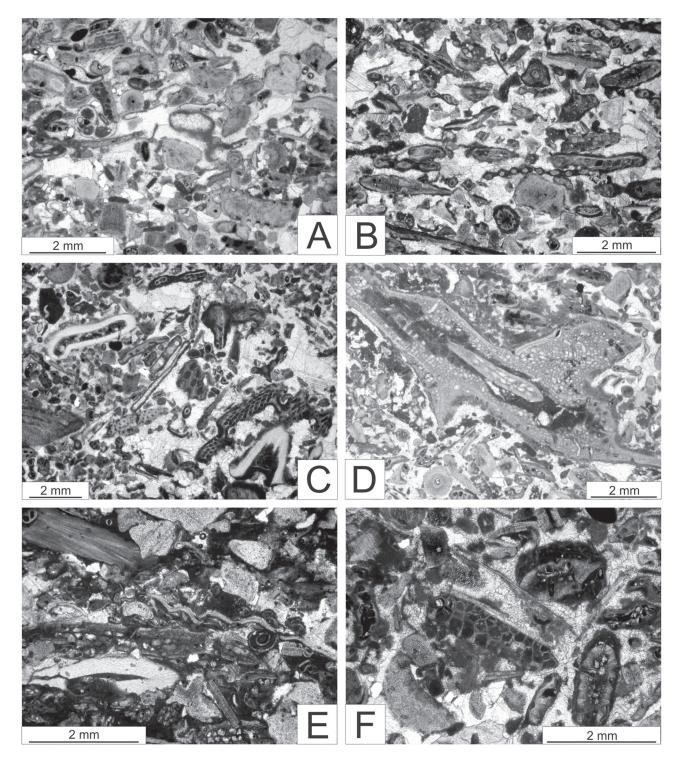


FIGURE 4. Thin section photographs of limestones of the Osha Canyon Formation at the type section. **A,** Bioclastic grainstone containing abundant crinoid fragments, and subordinate bryozoans, shell fragments and gastropods. Angular quartz grains are present. Sample OC 1, unit 1. **B,** Bioclastic grainstone with abundant fenestrate and other bryozoan fragments surrounded by dark micritic rims. Subordinate are crinoids and some shell fragments. The rock is cemented by coarse, blocky calcite. Sample OC 2, unit 3. **C,** Poorly sorted, coarse-grained grainstone containing bryozoan fragments, shell debris, echinoderms, trilobites and small mciritic peloids, cemented by blocky calcite. Sample OC 3, unit 5. **D,** Poorly sorted, coarse-grained bioclastic grainstone with a large, bifoliate, cyclostomid bryozoan fragment. Sample OC 5, unit 9. **E,** Bioclastic packstone containing crinoid fragments, bryozoans, shell debris, ostracods and a trilobite fragment (lower left). Sample OC 6, unit 11. **F,** Coarse-grained bioclastic grainstone with crinoid fragments, bryozoans, shell debris and a few angular quartz grains cemented by blocky calcite. Sample OC 5, unit 7.

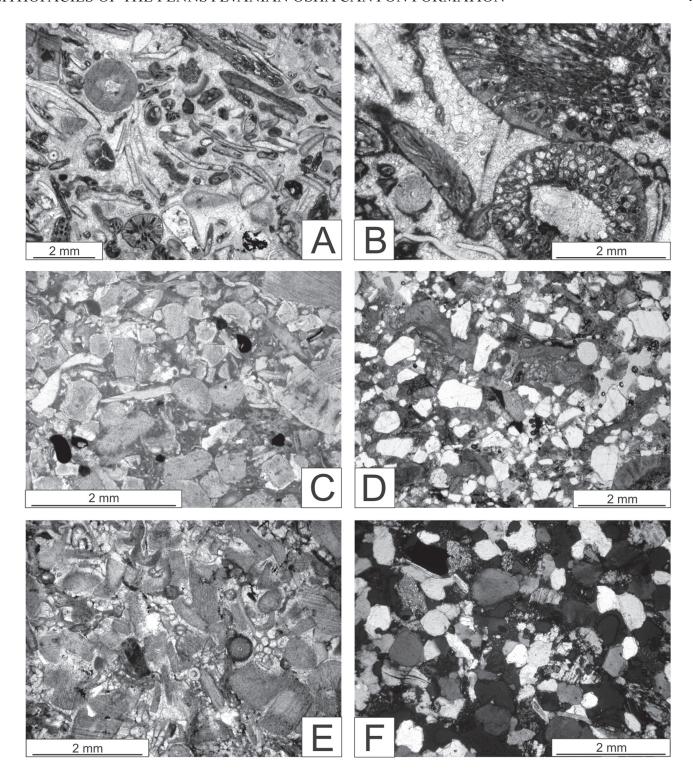


FIGURE 5. Thin section photographs of limestones and sandstones of the Osha Canyon Formation (A-E) and basal Sandia Formation (F) at the type section. **A,** Bioclastic grainstone with shell fragments frequently replaced by calcite and rimmed by thin micritic envelopes. Other skeletal grains are bryozoans, crinoids and echinoderms. The grains are cemented by blocky calcite. Sample OC 8, unit 13. **B,** Bioclastic grainstone containing abundant fragments of cryptostome bryozoans. Sample OC 7, unit 11. **C,** Coarse-grained crinoidal packstone, containing few shell fragments and some micritic matrix. Sample OC 9, unit 13. **D,** Mixed siliciclastic- carbonate sandstone containing abundant angular-subangular quartz grains and a few skeletal grains such as crinoids, bryozoans and shell fragments. The groundmass consists of calcite cement and micrite. Sample OC 12, unit 15. **E,** Crinoidal packstone, also containing a few bryozoan fragments, rare shell fragments, ostracods and brachiopod spines. A few small, angular quartz grains are present. Sample OC 13, unit 15. **F,** Moderately sorted arkosic arenite composed of abundant monocrystalline quartz grains. Subordinate are polycrystalline quartz and detrital feldspars (mostly alkali feldspars); micas are rare. Most quartz grains display authigenic quartz overgrowths. Crossed nicols, sample OC 16, basal Sandia Formation.

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grainstone/packstone is very similar to the Standard Microfacies Type 10 – bioclastic packstone and grainstone with coated and abraded skeletal grains.

The limestones contain a bryonoderm-bryomol grain association with bryozoans, crinoids and mollusk shell fragments as most abundant carbonate grains. The abundance of bryozoans, absence of calcareous algae and rarity of foraminifers in modern shelf carbonates indicate a non-tropical, temperate setting. However, Taylor and Allison (1998) showed that the latitudinal distribution pattern for bryozoan limestone through geologic time changed and that Paleozoic sediments containing abundant bryozoans are more common in tropic settings than elsewhere. The occurrence of corals also indicates that the Osha Canyon formation was deposited in a tropical shelf environment. The absence of calcareous algae may be caused by high-energy conditions and fine siliciclastic influx.

The marly, fossiliferous shales that form the bulk of the Osha Canyon Formation were deposited in a shallow, low-energy shelf environment below wave base and subject to fine-grained siliciclastic influx. Sedimentation of the marly shales was periodically interrupted, and medium-to coarse-grained grainstone (rare packstone) was deposited under high-energy conditions above wave base. The presence of quartz grains in the grainstone/packstone facies indicates that siliciclastic influx persisted during sedimentation of the limestones. The fine-grained siliciclastic material was winnowed and deposited in low-energy areas below wave base, whereas the skeletal grains and the silt- and sand-sized quartz grains accumulated to form the limestone beds.

The depositional environment thus was an open, normal marine shelf setting. Background sedimentation, which occurred under low-energy conditions below wave base, was repeatedly interrupted by short periods of high-energy conditions above wave base. Grainstones and packstones accumulated as thin storm layers (tempestites), The thicker limestone horizon of unit 13 may represent a carbonate sand shoal although due to lack of information about the lateral extent of the limestone beds, a more detailed reconstruction is not possible. DuChene et al. (1977) mentioned that the presence of angular skeletons and unbroken fossils indicates that the organisms lived close to the place of deposition and were transported for only short distances. Commonly, during storms large masses of skeletal grains are reworked and trans-

ported. But as shells are rapidly buried within a tempestite they may be well preserved even when they have been transported from their place of growth.

According to DuChene et al. (1977), tectonic uplift of the nearby Peñasco axis started during the Mississippian and continued as a series of tectonic pulses into Middle Pennsylvanian deposition. The Osha Canyon Formation was probably deposited during a period of relative tectonic quiescence. The siliciclastic material of the Osha Canyon Formation was probably derived from the nearby Peñasco uplift.

Increased siliciclastic influx in the uppermost part of the Osha Canyon Formation (sandstone of unit 15) indicates increased tectonic activity, and the sharp, erosional contact at the base of the overlying nonmarine Sandia Formation points to a major tectonic pulse causing strong uplift of the Peñasco axis, a significant drop in sea-level and deposition of fluvial sandstone. The Osha Canyon Formation was uplifted and largely eroded during late Morrowan or early Atokan time, leaving a few discontinuous remnants that were then buried by nonmarine deposits of the basal Sandia Formation.

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