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The Johnnie Oolite: A Remarkable Early Flood Deposit in the Death Valley Region, California, USA

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Abstract

The Johnnie Oolite bed is a significant and regionally widespread carbonate deposit exposed in the Death Valley region of the central Southern Great Basin of California, USA. Most modern oolitic deposits occur in warm waters off tropical and temperate regions such as the Bahama Islands. These are well studied and understood. Oolite deposits found in the geologic record leave some investigators perplexed. In ancient environments, mode of deposition, association with confining sediments, chemistry of sea water and the range, size, and development of ooid formation differ from modern exposures.

The Johnnie Oolite bed, averaging 6 feet thick, is a carbonate grainstone composed mostly of ooids, peloids, and lithic fragments was deposited in a high energy environment. Several field exposures of the Johnnie Oolite were observed and investigated. It is stratigraphically bounded above and below by shale deposits. The ooids in the Johnnie Oolite bed are cross bedded and normal to inversely graded. In places, clasts of carbonate mud oriented edgewise are floating within the oolite bedding. In the Nopah Range, the upper middle oolite bed is disrupted and contains rip-up clasts, fluid escape structures, and an erosional bedding plane. These sedimentary structures, their relationship to the enclosing shale beds and the thin section analysis indicate rapid deposition by strong currents in a deeper marine environment, consistent with the earliest stages of the Noachian Flood.

Johnnie Oolite grainstone is interpreted as a mass flow with physical properties of strength and competence and super saturated with $CaCO_3$. The ooids and peloids likely formed in transit after the breakup of the initial Fountains and the deposits of the Kingston Peak Fm and Noonday Dolomite. The Kingston Peak Fm is considered the initial Flood deposit in the study area.

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Introduction

The Johnnie Oolite carbonate bed (JOB) is a grayish to pale yellow-orange colored stratigraphic marker bed averaging 6 feet thick and located in the Death Valley and Mojave Desert area of the central region of the southern Great Basin, southwestern United States (Figure 1). This marker bed stands out like a ribbon in many distant mountain views and helped early geologists map the regional geology. The JOB is constrained within the upper Rainstorm Member of the Johnnie Formation, a heterogeneous formation of carbonate, quartzite, siltstone, shale, and minor conglomerate. It thickens westward from 0 feet in the eastern region up to 5000 feet and is "extensively exposed in the Death Valley region and Kingston Range area, CA" (Stewart, 1970). The JOB also outcrops 85 miles to the north at the Nevada Test Site and 65 miles south within the Providence Mountains outside of the study area (Figure 2) and is regionally extensive up to 10,000 square miles in areal extent. A similar oolite bed is found in Sonora, Mexico so the extent could be greater if the two oolite beds correlate (Corsetti et al., 2002). For comparison the areal extent of the state of Maryland is 9775 sq. miles.

According to Corsetti et al. (2002), "The Johnnie Oolite is the most awesome oolite bed in the world." However, many questions remain unanswered. For example, how were the ooids formed during rapid deposition of sediment during Noah's Flood? There are many carbonate beds throughout the Johnnie Formation but few if any beds contain the abundance of ooids observed in the JOB. Some questions for consideration: did the ooids form in a shallow wave induced environment? Did a selective chemical/physical environment contribute to their formation? Did they grow in situ after deposition? Did ooids form earlier and only transport with carbonate bedding?

Figure 1. The Johnnie Oolite carbonate bed at the Gunsight mine in the southern Nopah Range, Mojave Desert. The pale-yellowed colored Johnnie Oolite bed outcrops right of the mine workings and the razor back continues up the slope left of middle background at sky line. The bed stands out like a ribbon in the Death Valley region, which helped pioneer geologists mapping the area. The Johnnie Oolite bed extends an aerial coverage of 10,000 sq. miles or more in the Death Valley/Mojave Desert region. This is comparable to the aerial extent of the state of Maryland.

Geologic Setting of the Death Valley and Mojave Desert Region

The western edge of the North American continent (WNA) has undergone a diverse geologic history that produced complex structural and geomorphic landforms and provenances. In this paper, the writer accepts the Catastrophic Plate Tectonic (CPT) model of Austin et al. (1994) to explain the occurrence of tectonic upheaval and rapid sedimentation of the strata observed in the Death Valley and Mojave Desert region (DV/MD). The Johnnie Formation, specifically the upper Rainstorm Member which contains the JOB, is the focus of this paper. A brief discussion of the occurrence of underlying strata and the nature of deposition will help us understand the catastrophic nature of debris flow deposition and erosion found in the DV/MD area during the early Genesis Flood time. Refer to Figure 3 for a simplified stratigraphic column depicting the strata that are discussed next.

In the CPT model, some of the "breakup of the fountains" (Gen 7:11) are thought to have occurred along the edges of pre-Flood continental oceanic margins, coincident with zones of oceanic sea floor subduction. In the DV/MD region, Sigler and Wingerden (1998) report that initial Flood deposits are contained within the Kingston Peak Formation (KPF). As the WNA continental edge was likely down-warped at the start of the Flood (Baumgardner, 2006), the underlying pre-Flood and basement

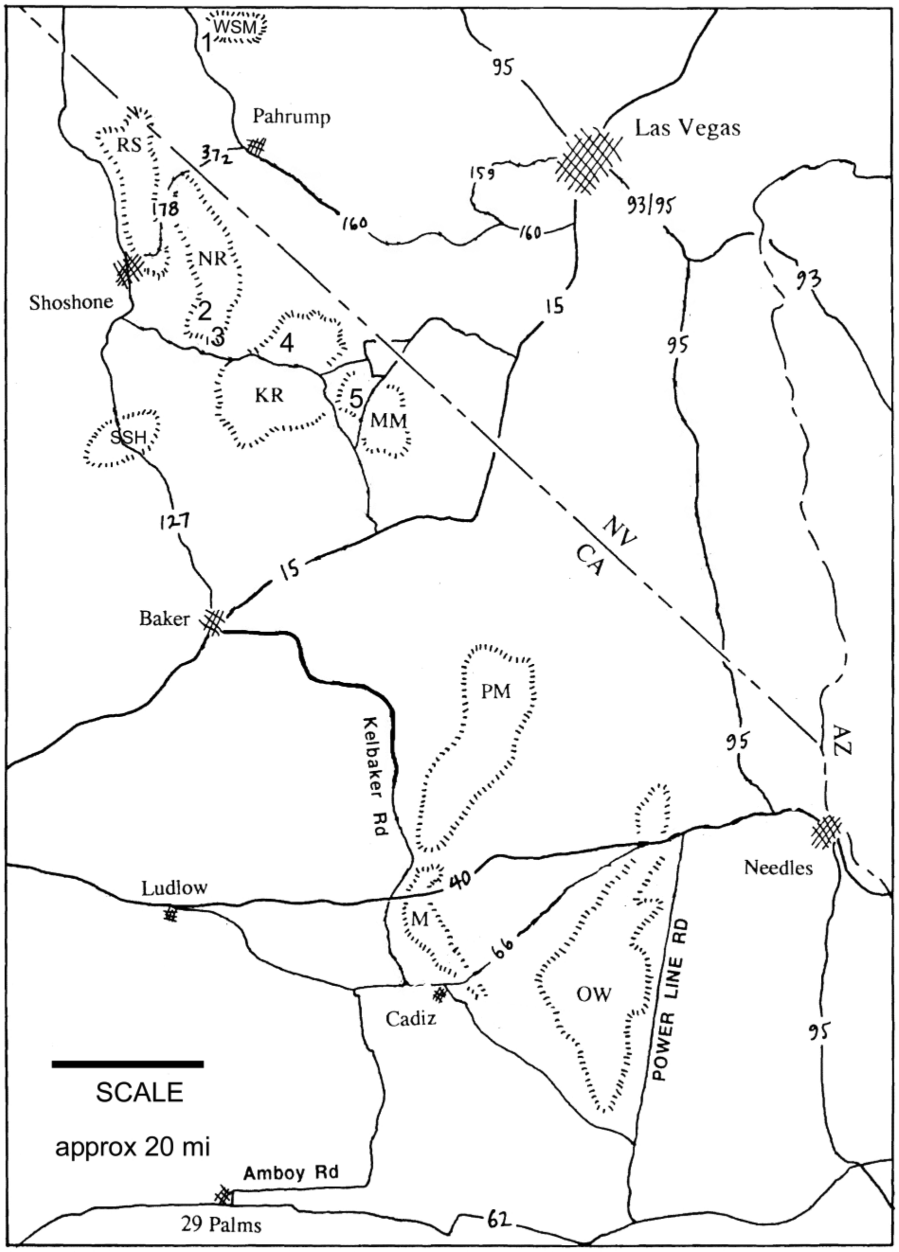

Figure 2. Location map of areas where outcrops 1 thru 5 were visited and samples collected. Mountain ranges: KR-Kingston Range; M- Marble Mnts; MM-Mesquite Mnts; NR-Nopah Range; OW-Old Woman Mnts; PM-Providence Mnts; RS-Resting Spring Range; SSH-Salt Spring Hills; WSM-Western Spring Mnts. Modified from Geological Excursions in Southern California and Mexico. Walawender and Hanan, editors, page 147.

terrane was unroofed and deposited in the KPF as debris flowed. Mega clasts and blocks of rock—some larger than the average house—were observed and mapped (Sigler and Wingerden, 1998). The underlying metamorphic basement complex, the Crystal Spring Fm, and the Beck Spring Fm are also considered pre-Flood (Austin and Wise, 1994). The Noonday Dolomite overlies the KPF, and according to Wise (2001), is a debris flow. Wise (2001) states that "on every lithology, the basal Noonday locally contains clasts of the underlying lithology." Locally in the DV/MD area, the Noonday debris flow has eroded all the lower strata and rests on basement. This created erosional relief of several thousands of feet, all possibly occurring within a few days or weeks early in the Flood. The Johnnie Formation rests conformably on the Noonday Dolomite in the DV/MD region. But towards the south, in the Providence Mountains (Figure 2), it is found resting unconformably on basement rock (Bahde et al., 1997).

From the field relationships of early Flood strata we can discern that sediments were deposited and eroded quite rapidly during the upheaval at the start of the Flood near the edge of WNA. Debris flows may have eroded earlier debris flow deposits and then were eroded themselves by sequential flows. Uplifted sections of pre-Flood and early Flood strata allow us to observe and study early Flood processes. Through all the upheaval and destruction, God opened an erosional window for us to understand what He declares in His Word.

Ooids and Oolite Deposits

Ooids are rounded to ellipsoidal carbonate grains 0.5 mm to 2.0 mm in diameter but can grow larger (Scholle and Ulmer-Scholle, 2003). *Ooid* refers to the individual grains and the term *oolite* refers to a rock containing ooids. The purely descriptive term ooid "fish egg" and oolite "egg stone" are derived from the ancient Greek. Descriptive terms should supersede genetic terms. A genetic term implies a preconceived process whereas many geological processes can render similar results. In this paper the terms *oolite* and *ooid* will be used interchangeably. Modern calcareous ooids as seen in Figure 4 are composed

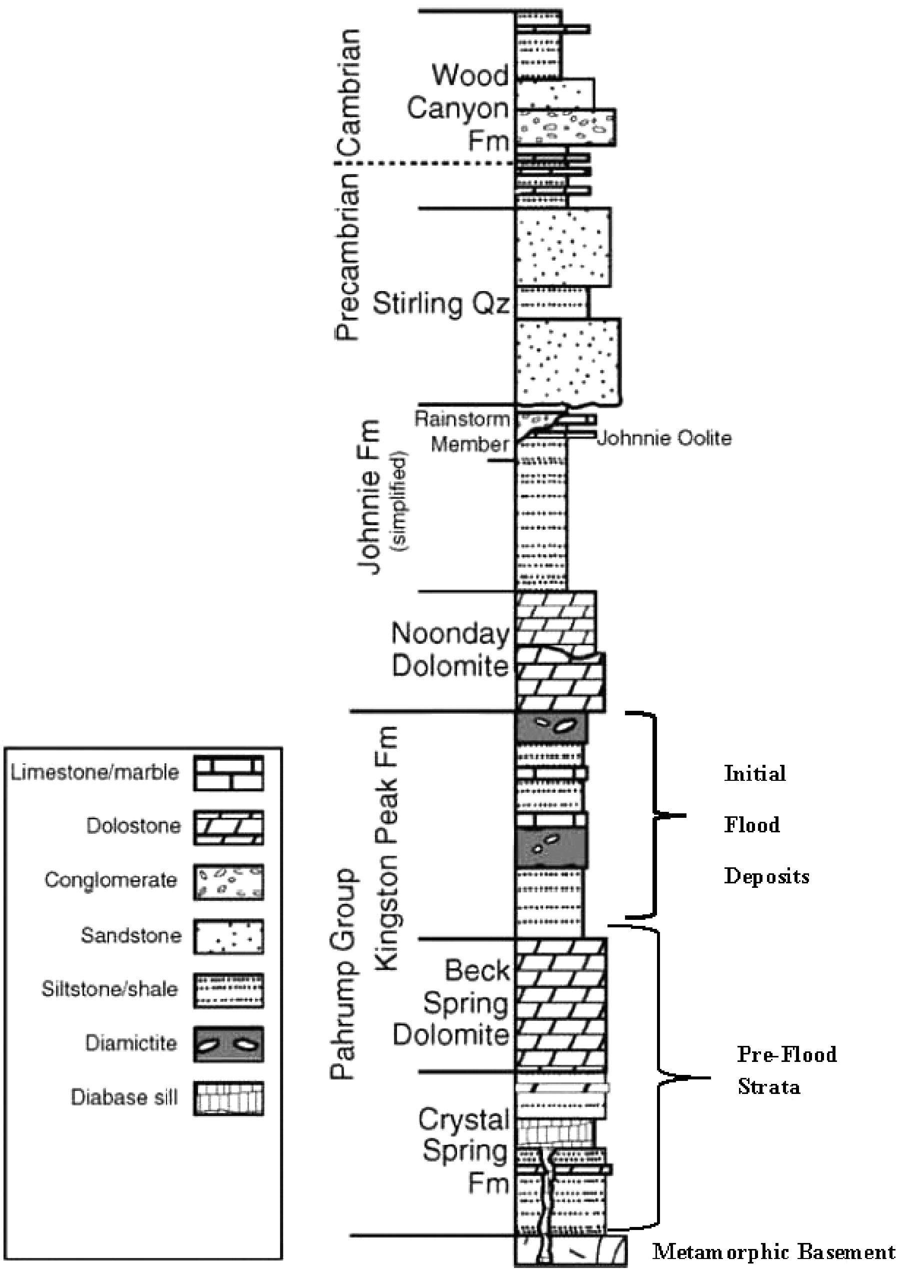

Figure 3. Simplified columnar section of strata in the study area. Modified from Clapham and Corsetti, Deep Valley incision in Neoproterozoic Johnnie Fm.

Figure 4. Modern calcareous ooids from a beach on Joulter's Cay in the Bahamas display their spherical shape and size. They are highly polished from vigorous wave action. Photo from Wikipedia free encyclopedia.

of aragonite or Mg-calcite coatings but may have ferruginous, siliceous, phosphatic, or other coatings (Scholle and Ulmer-Scholle, 2003).

Ooids require a suitable physiochemical environment for inorganic or microbial precipitation with repeated rotation of grains in order for the coatings to form (Scholle and Ulmer-Scholle, 2003). Within a fluvial environment, chemical precipitation starts around a nucleus or seed agitated by water and supersaturated with carbonate, forming the rounded ooids. The seed could be organic matter, shell fragment, fossil, or sand grain. A concentric growth structure or cortical layer grows around the seed with repeated chemical precipitation. There are two common types of ooid structures: radial and tangential. Most modern day oolites have concentric microstructure composed of tangentially arranged needles of acicular aragonite (Tucker, 1982). This type of microstructure forms a lateral banding around each cortical layer. The microstructure of radial ooids has their crystalline needles within each cortical layer jutting outward like the spokes of a bicycle wheel. Figure 5 displays the various microstructures of ooids. The internal structure of ooids is clearly seen in thin sections. Figure 6 shows the radial microstructure of ooids from the Jurassic Carmel Fm in Utah.

Modern oolites form in a variety of physiochemical environments ranging from shallow marine to lagoons, lakes, rivers, and caves (Thomas and Groves, 2002). As an example, an interesting and unique oolite deposit was found and collected in the Carlsbad Caverns of New Mexico in 1925 by Dr. Willis Lee. According to Hess (1929), the cave pearls, as Dr. Lee referred to them, formed in shallow pools, which collected water supersaturated with calcium carbonate from dripping stalactites; the splash provided agitation for the spherical grain to grow. Oolites are found in strata encompassing all of the geologic rock record.

The deposits of modern and ancient oolites may indicate the physical energy of the environment in which they are formed and infer the chemical composition of formation waters (Wilkinson and Landing, 1978). Li et al. (2015) present a summary concerning the value of ooids found in sediments:

> Ooids are valuable proxies indicating paleoceanographical conditions, such as water energy levels, water depth, salinity, sedimentary settings, climate conditions, as well as sensitive aqueous chemical conditions.

Davies et al. (1978) state that most tangentially structured ooids form in vigorously agitated waters whereas the radial type develops in a less agitated environment. Also, most ancient oolite deposits consist of radial structure and recent deposits are tangential in structure. There are exceptions however; recent oolite deposits in the Great Salt Lake are composed of radial structure (McGuire, 2014). McGuire found that the radial structures formed in high energy environments displayed large clear radial crystals, whereas lower energy environments formed smaller radial crystals. In some instances, episodes of growth are destroyed by abrasion but continued precipitation continue to create additional cortical layers. Experimental results by Trower et al. (2017) suggest a dynamic equilibrium exists between the buildup and the erosion of the ooid until the grain reaches maximum size reflective of the environment in which it formed. Ooids in older deposits most likely will undergo physical and chemical change due to diagenesis—the change occurring after lithification.

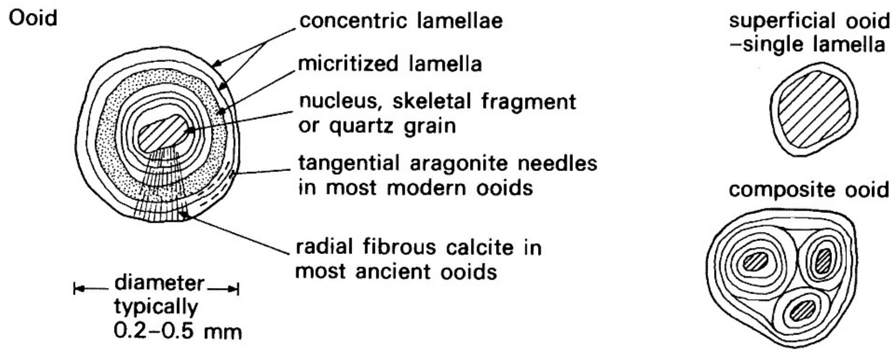

Figure 5. Sketches of the various micro crystalline arrangements in ooids. Modified from Tucker (1982).

Figure 6. Thin section of Ooids from Jurassic Carmel Fm in Utah. Note the radial concentric growth pattern and cortical layers. Photo from Wikipedia free encyclopedia.

Oversized or giant ooids occur throughout ancient rock strata and are puzzling to some researchers. For example, why are oversized ooids abundantly found in ancient oolitic deposits but are lacking in modern day oolitic deposits? Li et al. (2015) tabulated and summarized the occurrence of oversized ooids and found that they occur in the Late Archean through Late Jurassic along with their smaller counterparts. Additionally, oversized ooids are found in abundance and are wide spread in some carbonate rocks of Late Permian and Triassic. To explain this paradox, researchers suggest increased ocean temperatures and carbonate saturation during "giant" ooid growth. Between the Permian and Triassic Systems a mass extinction event is claimed to have occurred on earth according to the evolutionary worldview. This episode is labeled the Permian-Triassic mass extinction (P-T). Evolutionists claim that this extinction event caused the oceans and biosphere to be subjected to extreme chemical and physical conditions such as increased water temperature, calcium carbonate, and water alkalinity (Li et al., 2015). According to Li et al. (2015), the P-T

> is not only a dramatic loss in biodiversity…but also coincided with the formation of abundant unusual sedimentary structures. Of these, ooids were wide spread in shallow marine carbonate settings during the Permian—Triassic transition and giant ooids occurred more frequently at this critical period.

It is not surprising that unusual sedimentary structures and deposits are found within Flood rocks. Due to the breakup of the "fountains of the great deep" (Gen. 7:11), colossal volumes of lava, water, and steam were released, "some with high mineral content and/or rare chemistries and high temperatures" (Morris, 2012). Extreme oceanic water chemistry and temperature changes were likely occurring during the Genesis Flood. This may help explain the extreme chemical conditions for ooid growth in the past geologic rock record.

The Johnnie Formation and Johnnie Oolite

Uniformitarian/evolutionary scientists advocate a very complicated and protracted history concerning the development of the western edge of North America (WNA). Ignoring pre-Rodinia time a billion or so years ago, and its supposed ancient landmasses, they believe that the history of WNA starts with the breakup of super continent Rodinia around 750 million years ago. Eventually the proto-WNA continent transitioned to a passive margin over tens of millions of years. According to this evolutionary model, the predominantly siliciclastic Johnnie Formation strata formed during final rifting and passive margin phase with concurrent subsidence of the WNA approximately 550 Ma (Stewart, 1972; Summa, 1993; Bahde et al., 1997). A passive margin represents less tectonic, volcanic, and intrusive activity. However, it includes increased sedimentation from the interior craton coupled with transgressive marine deposits. This evolutionary model attempts to explain the deposition of Neoproterozoic through Cambrian strata found in the southwest Basin and Range and Death Valley region over a time frame of many millions of years. See Figure 3 for the sequence of the strata. However, the same rock data interpreted within a biblical worldview suggest otherwise.

The upper-most Johnnie Formation is called the Rainstorm Member and is considered the most widespread member within the formation (Stewart, 1970). The Rainstorm Member is further subdivided into three units. From bottom to top they are informally named the siltstone unit, the carbonate unit, and the siltstone-quartzite unit. The Johnnie Oolite bed (JOB)—the focus of this paper—occurs in the lower siltstone unit of the Rainstorm Member. The siltstone unit is composed of purple and greenish silty platy shales.

The JOB is a grayish to pale yellow-orange dolomitic grainstone primarily composed of ooids ranging in diameter from 0.125mm to 1.0mm and larger. The matrix is very fine dolomitic cement containing lithic fragments of quartz, feldspars and mafic minerals. At all outcrops the JOB is constrained by upper and lower silty shale beds and is laterally and vertically uniform in thickness. Observations in the field by the author of this paper support the work previously reported by Wright and Troxel (1966).

Methods

Five outcrops of the JOB were visited at the following locations: the western Spring Mountains, the southern Nopah Range (Gunsight mine and Noonday mine areas), the western Kingston Range, and the Mesquite Mountains (Figure 2). Field observations of the JOB attempted to record: sedimentary structures within the bedding; contacts with encompassing shale beds; the sedimentary structure of surrounding beds; general thickness and strike and dip of bedding; and any disruption or faulting of the JOB. Samples were collected for thin section analysis. In thin section, the structure, size, and shape of ooids, sorting, post depositional diageneses, and chemical replacement can be observed. No attempt was made to analyze flow direction from the observed cross beds. At outcrops, cross beds were hard to find, sporadic, and most very faint. Most cross beds are seen by the differences in grain size. Also, due to the brittle nature of carbonate, exposures have been fractured and eroded. According to Stewart (1972), the most likely flow direction of the Johnnie Formation is from north-east to south-west. This is based on the fact that the Johnnie strata thicken to the southwest to about 5000 feet thick. The thickening of Johnnie strata follows the trend of upper Precambrian and lower Cambrian strata which all thicken from north-east to south-west.

Results and Discussion

Cross Bedding, Graded Beds, and Sorting

At all outcrops, except in the Mesquite Mountains, the JOB displays various types of bedding. The Mesquite Mountains are highly fractured due to a subsequent thrust fault within the area which destroyed all sedimentary structures. At all other locations very faint to some moderately developed small-scale cross bedding occurs in outcrop but varies from place to place. Where it is developed, it displays sub-parallel to planar beds delineated by grain size (Figure 7). No large-scale cross bedding was observed in outcrop. Normal and inverse grading is also observed in the JOB (Figure 8). Within the graded bedding strata, ooids range from fairly well

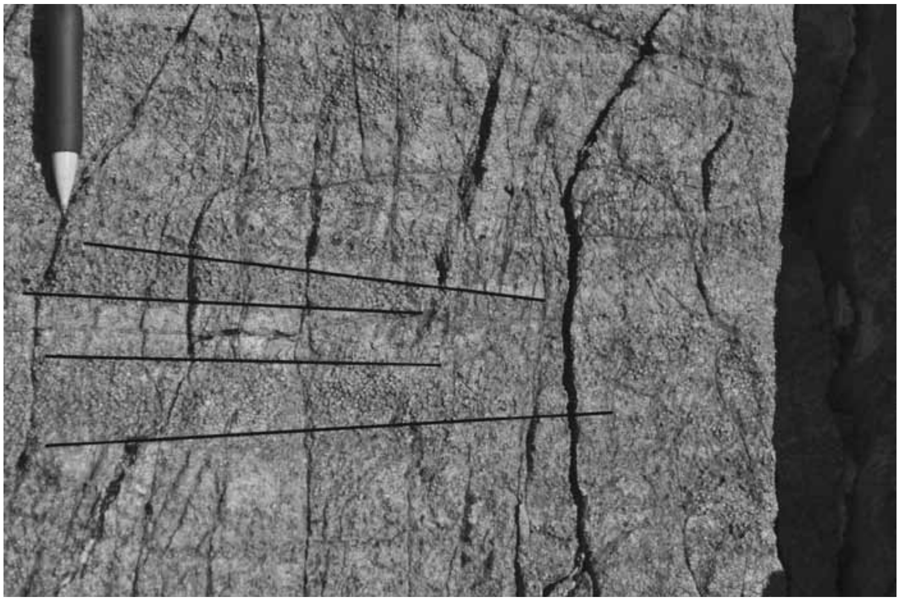

Figure 7. Planar to sub parallel cross beds are depicted by solid lines. The lighter color beds are finer grained ooids. Cross beds in the Johnnie Oolite bed (JOB) at outcrops are very faint and difficult to see. The differences in grain size accentuate the boundaries. Cross beds in JOB indicate strong currents as opposed to ripple type structures found in shallow water environments. The yellow tip of the pencil for scale is 0.60 inches long.

Figure 8. The sample depicts coarse to fine then coarse grained ooids as seen between the lines. Note the sharp boundaries between graded bedding. Pencil is for scale and the black clip is 1.4 inches long. Ooids in this sample are fine to coarse sand size and considered as sand grains in a deposition environment. The sharp boundaries between the layers are a result of rapid flow conditions during the deposition. Normal graded beds transition from a coarse grain to finer grain with loss of current velocity. The inverse graded beds shown here suggest rapid flow conditions as found in debris flows. There appears to be some mixture at the boundaries.

to poorly sorted; but in some beds the ooids appear to be unsorted or massive.

Graded bedding is an indicator of flow conditions during sedimentation. Stronger currents carry larger sized grains while weaker currents carry finer-grained particles. A normal graded bed displays larger grains at the base with fine at the top of bed. Inversely graded (smaller to large grain sequence) is not common but can result when a stronger flow occurs above weaker flow conditions. According to Tucker (1982), inverse grading can form during debris flows and massive or unsorted grains are an indicator of rapid deposition. The majority of bedding observed within the JOB is poorly sorted to unsorted, containing ooids ranging from 0.5mm to approximately 2mm deposited within a mud matrix.

Recent studies show that the deposits of subaqueous debris flows can produce various sedimentary structures dependent on their physical properties during the flow. Marr et al. (2001) conducted flume experiments with slurries of low water/high mud content and high water/low mud content. The high mud slurry produced a deposit that was less structured while the low mud slurry produced a deposit with graded bedding and water escape structures.

Elveroi et al. (2010) conducted flume experiments using a slurry of water, sand, and differing amounts of clay content ranging from high content (25%), medium content (15%), to low content (5%). The results showed that the slurry with the high clay content remained compact and intact. The medium and low clay slurries started to weaken, losing their cohesion. The low clay slurry became turbulent with the break-up of the sediment load due to increased water content during the flow. The studies suggest that during the debris flow, if physical properties change, the debris flow can produce a deposit with various types of graded bedding.

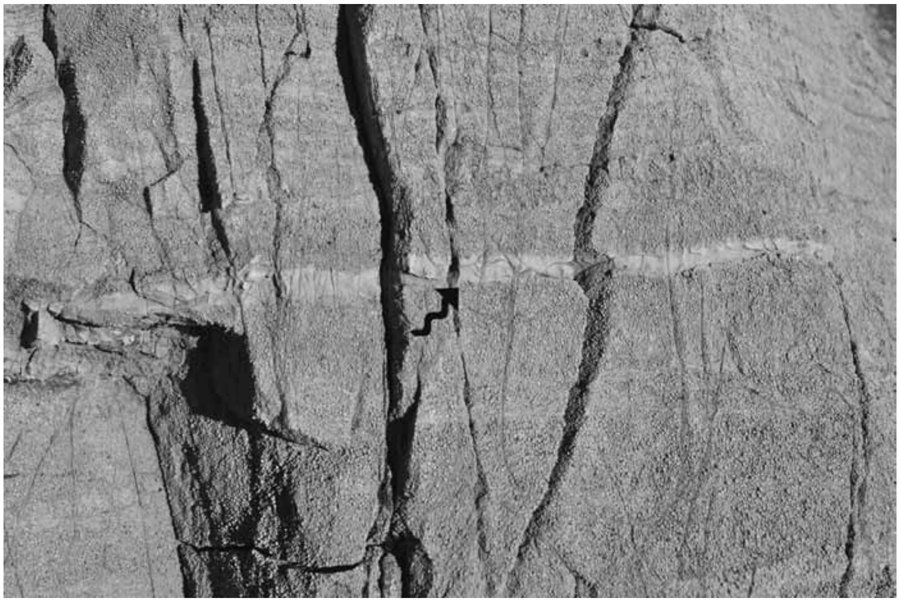

Figure 9. The arrow points to lenticular bedding approx. 0.75 inch at thickest area. The lenticular bedding is devoid of ooids and composed of micrite or carbonate mud. Lenticular bedding can occur when flow conditions change. The flow direction is obliquely or diagonally out of the photo indicating southerly flow.

This could possibly explain the unsorted to graded beds observed in the JOB.

Mud Clasts and Disrupted Bedding

Lenses of intercalated carbonate mud (micrite) layered within the JOB are a common occurrence at all outcrops. The mud lenses are devoid of ooids or contain few ooids. Mud layers form sharp contacts with surrounding oolite beds (Figures 9 and 10). Additionally, outsized mud clasts were observed floating within the oolite bed nearly perpendicular to bedding or edge-wise (Figure 11). Large clasts within a finer matrix characterize the strength or competence of the sedimentary bed during flow. Clasts oriented edge-wise (long axes perpendicular to bedding) can also give an indication of flow direction.

Restricted to outcrops in the Nopah Range and observed in the middle of

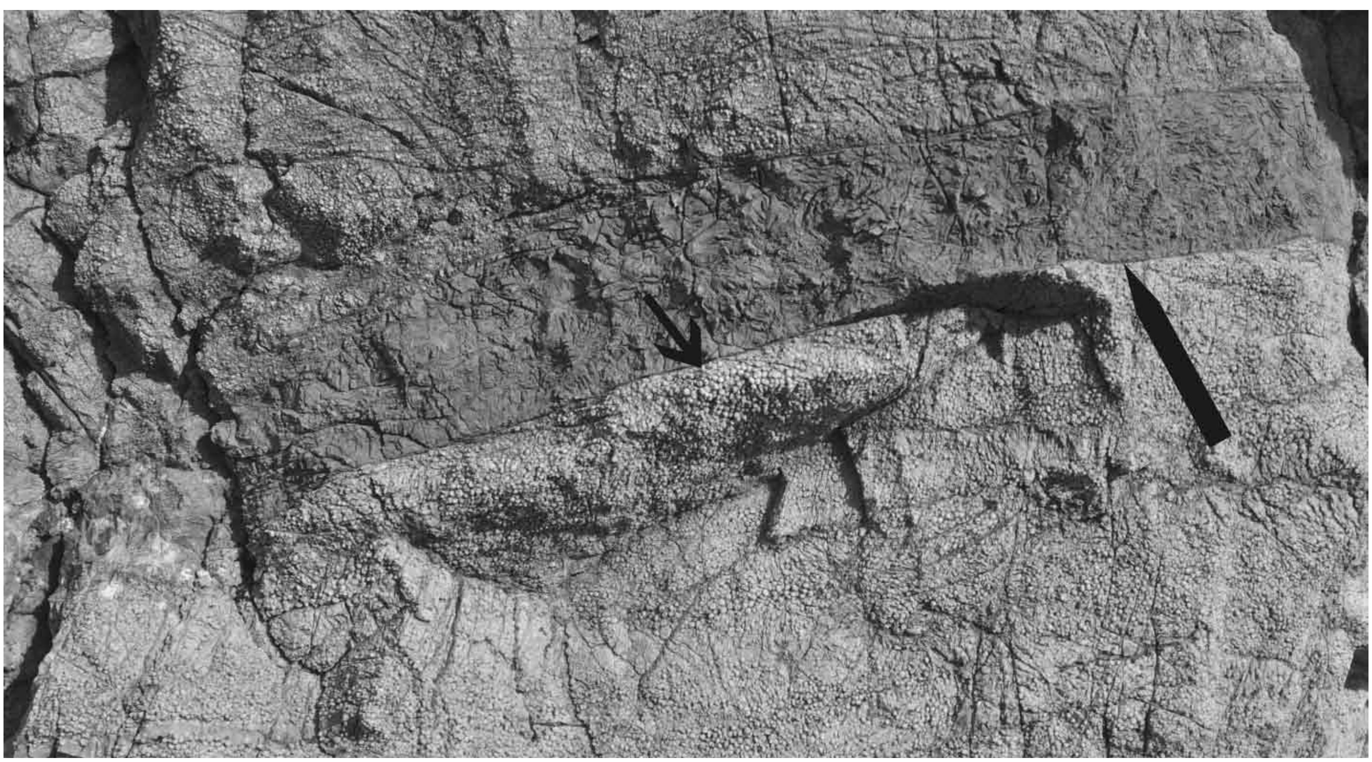

Figure 10. A 1.5 inch thick carbonate mud layer, containing sparse ooids, intercalated within the oolite bedding. Note the sharp boundaries at both arrows and the angular discordance with oolite bedding at smaller arrow. Conditions within the flow can fluctuate. Direction, strength of current and mechanical competence can render differences in sedimentary structures within a single flow.

the JOB is a layer containing numerous disrupted beds. Figure 12 shows a fluid escape structure and numerous floating mud clasts within an unsorted matrix of ooids. Figure 13 shows a large rip up clasts containing rounded clasts of previously formed ooids. Also observed at this location is an erosional bedding plane which cuts the lower half of the JOB (Figure 14).

Disrupted bedding can occur during deposition of sediments and also in a post-depositional setting. Both bedding disruption and fluid escape structures most likely result from rapid deposition of overlying sediment as well as liquefaction during earthquakes (Sylvester and Lowe, 1978; Tucker, 1982).

The subject of gravity-driven sediment flows and mechanics is very complex. Gravity-driven sediment flows, such as debris flows, grain flows, and turbidites, have the capacity to carry large (outsized) clasts within the flow. Simply stated, large clasts are carried along in a hyperconcentrated flow due to buoyant forces. Buoyancy is partially due to the ratio of clay and water within the matrix and size of granular solids, but other physics are involved (Hampton, 1979; Lewis and McConchie, 1994). The higher the mud content versus water within the matrix enhances the competency or strength of the flow and the ability to "lift-up" and carry the entrained larger clasts. In the case of the JOB, the abundance of carbonate mud probably contributed to the strength of the flow. Conditions in a hyperconcentrated flow can change as the flow proceeds. An increase or decrease in water and clay within the matrix and amount of granular solids can change the mechanics. As stated earlier, this could explain the various graded-beds found in the JOB.

Recent studies and flume experiments have also shed some light on the ability of some debris flows to run out over long distances on gentle slopes and obtain great speeds (Mohrig et al., 1998;

Figure 11. Edge wise mud clasts floating in Johnnie Oolite bed. The two clasts appear imbricated suggesting left to right flow favoring a southerly flow direction. The clast contains a few ooids. The on-edge clasts carried along within the carbonate bed indicates the debris, in this case the ooid grains, was competent to buoyant and carry along the clasts. Top of bed is located at the top of photo. The yellow tip of the pencil is approx. 0.60 inches in length.

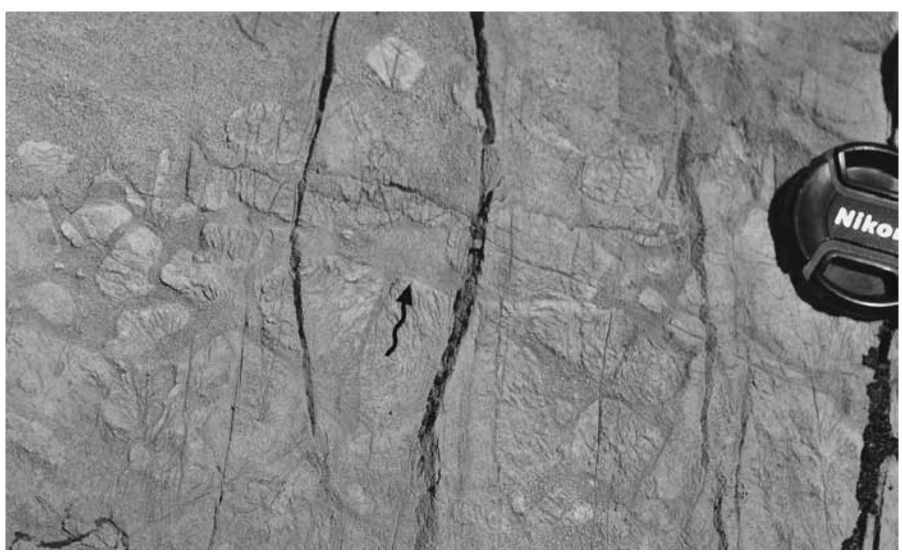

Figure 12. The disrupted layer in the Nopah Range. The arrow points to a fluid escape structure shaped like a mushroom. As the bedding is disrupted either by rapid overburden of sediment or shaking during earthquakes, the grains become fluidized and can move upwards in this case. Lens cover for scale.

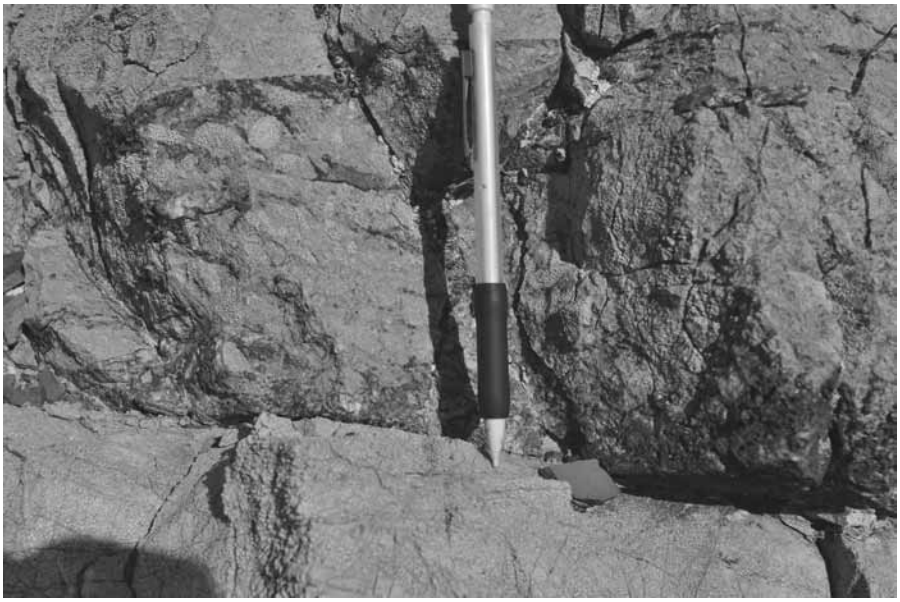

Figure 13. Disrupted layer within the middle of the Johnnie Oolite bed located in the Nopah Range. Note the rounded clasts of oolite within the disrupted layer. The length of the pencil is 6 inches.

Marr et al., 2001; Elverhoi et al., 2010). Hydroplaning can occur at the head of a clay rich debris flow. When the debris flow hydroplanes, the front, or head, is lifted up and cushioned by a thin layer of water which reduces friction at the base of the flow. This is analogous to a car losing traction and sliding when encountering a thin layer of water on the road.

The Johnnie Oolite deposit exhibits characteristics of a coherent mass flow. It contains a high amount of clay (micrite), most likely had the ability to hydroplane over the sharp boundary with the lower shale bed, and run-out over great distances at a very significant velocity. This is evident from its areal extent.

Hummocky Shale Beds

Above and below the JOB are deposits of silty shale beds. The shale beds

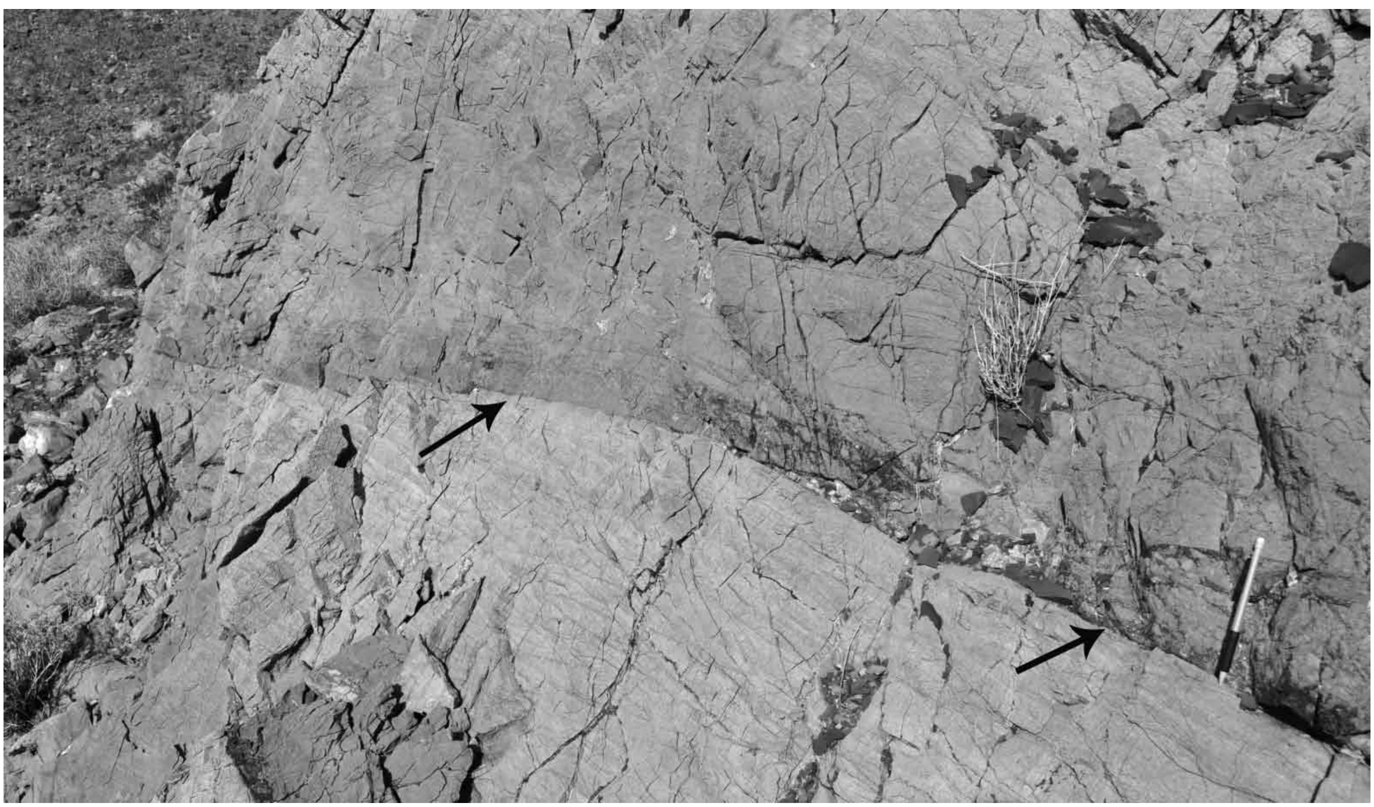

Figure 14. The arrows point to an apparent erosional surface. The oolite bed above the arrows was deposited after the lower bedding. Very faint discordant bedding is observed at the erosional boundary. Note the rounded rip-up clasts (Figure 13) to the left of the mechanical pencil. The pencil measures six inches in length.

encapsulate the oolite bed creating impervious boundaries. The contact of the lower shale bed and the JOB is sharp with rare scour and mixing of sediments only a few inches into the boundary; the lower shale bed displays hummocky cross stratification (Figures 15 & 16). The shale beds are non-carbonaceous. The occurrence of a fairly uniform carbonate bed sandwiched between two non-carbonaceous, siliceous silty shale beds is perplexing to some geologists. Uniformitarian dogma asserts that carbonates are usually shallow marine platform deposits while most shales form in slightly deeper marine waters.

Catherine Summa is an expert on the description of the Johnnie Formation. She completed a Ph.D. thesis on the sedimentology and stratigraphy of the Johnnie Formation from a secular worldview, and although there is disagreement on interpretation, her descriptions are empirical. Summa (1993) considers the JOB a high energy transgressive sheet deposit, which tracked sea level rise and also suggests that the overlying and underlying shale beds formed in a lower energy environment. She also describes hummocky shale beds associated with the JOB at various locations and other sedimentary structures indicating rapid deposition in the strata above and below the JOB.

Hummocky cross-stratification or bedding occurs in very large storms and is observed in recent hurricane deposits. The strong current flow may be unidirectional or oscillatory but the product is a series of thickening and thinning of the sediment forming mega ripples or swales with wavelengths up to 5 meters (Wikipedia, 2018). This information creates a contradiction in the uniformitarian interpretation. How do mega-ripples form in a low energetic current flow?

Thin Section Analysis

The following description of ooid structure and chemistry was summarized

Figure 15. Hummocky shale beds below the Johnnie Oolite bed in the Nopah Range. Shale beds are found at the bottom and top of the Johnnie Oolite bed at all locations. The shale beds encapsulate the oolite bed forming impervious boundaries. The mechanical pencil for scale is 6 inches long. Hummocky beds formed in modern times are the result of strong currents produced during storms such as hurricanes.

Figure 16. Note the sharp boundary at top of shale bed and bottom of oolite bed. Also note just below the camera lens cover there appears to be rip up clasts of the underlying shale bed. Lens cover for scale.

from a report generated from Calgary Rock and Materials Services Inc. where the thin sections were made:

> The ooids in thin-section samples exhibit similar textures and a variety of shapes and sizes from very round, ellipsoidal to oblong. The majority of ooids range in size from fine (0.125mm) to course sand (1mm) but a few are very course (2mm). Ooids display both radial and tangential structure showing minimal mechanical deformation. Radial structure is an indicator of less agitated current conditions while tangential structure represents combination of agitated and quiet waters (Davis et al., 1978). The cores are predominantly dolomitic micrite with minor quartz and feldspar.
>
> The diagenesis of the Johnnie Oolite bed is mostly chemical in nature. Isopachous dolomitic cement coats the outer cortical layers of ooids and within the intercrystalline porosity, coarse sparry dolomite occurs. Where minor fracturing occurs, it is healed by silica and calcite cements. Some ooid cores are partially replaced by silica. (Personal communication)

Thin section analysis enhances macro-observations obtained in the field. Many ooids observed in thin section are poorly developed or not developed at all (Figure 17). Poorly developed ooids, referred to as superficial, contain only one or less developed cortical layer. Also a significant amount of so called "ooids" are just aggregates or clumps (peloids) of mud (Figure 17). It is well established that mud will aggregate and deposit like sand grains (Austin, 2008). Superficial ooids and the abundance of peloids may suggest the lack of time for ooid development during the JOB grainstone mud flow. Differences in sizes, shapes, and sorting of well- to poorly-developed ooids were also observed in thin section (Figures 17 & 18). A few ooid shapes suggested active compaction during

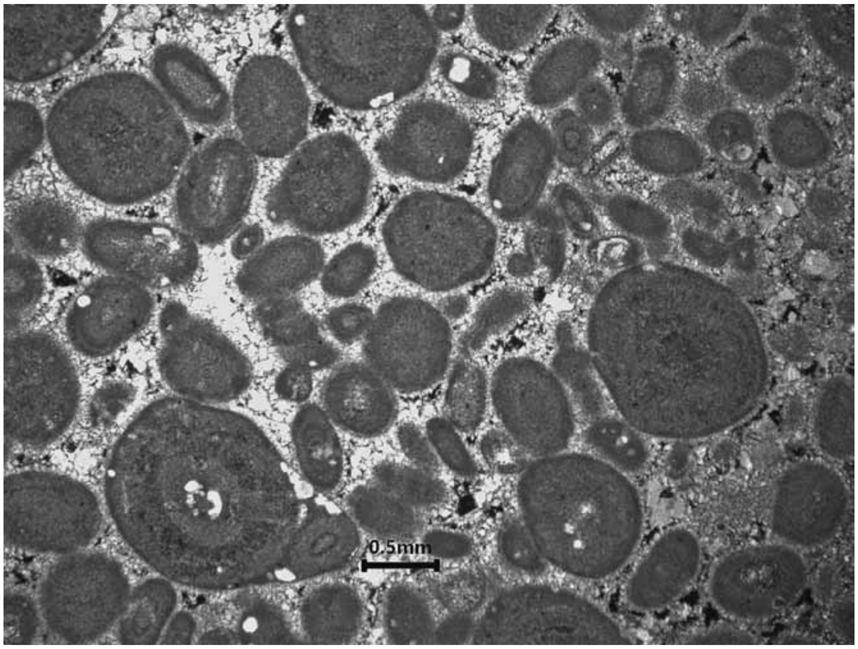

Figure 17. Notice the diversity of ooid shapes and sizes from rounded, oblong, ellipsoidal and rod shaped. A poorly developed composite ooid exists to the left of the scale bar. It probably didn't form together just joined during chemical diagenesis. Most of the ooids shown in sample are poorly developed and considered superficial ooids. Many of the smaller "ooids" are peloids of micrite. Image taken in plain polarized light (PPL).

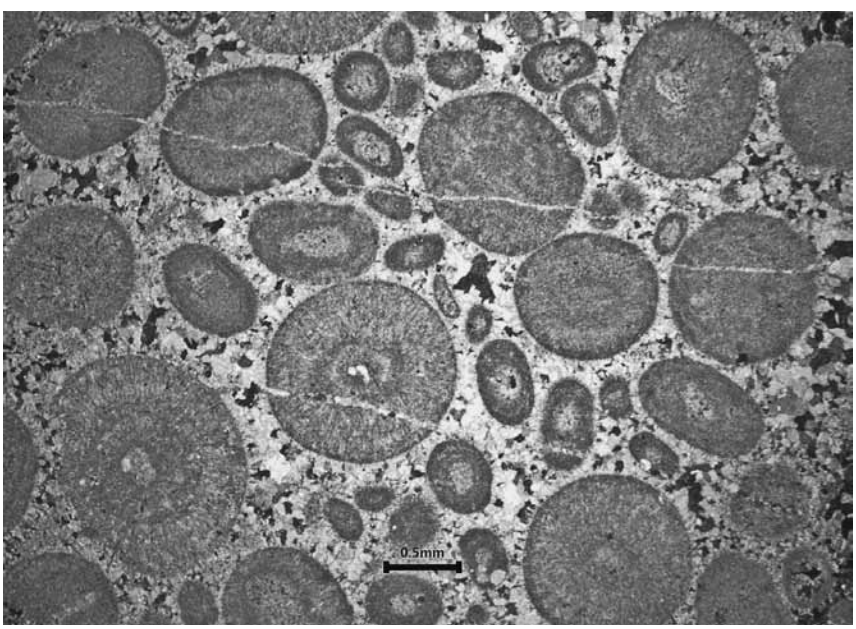

Figure 18. Sample taken in the western Spring Mountains. Note the diversity of shape and sizes of the "ooids." Most of these ooids are not well developed. The fracturing (thin white streaks) healed by quartz and calcite does not displace the ooids therefore it is due to chemical diagenesis not mechanical. Image taken with crossed polars (XPL).

deposition of the JOB. A rip-up clast within the disrupted bedding indicated that some previously formed ooids had been redeposited (Figure 19).

Most of the thin section samples revealed post-depositional chemical diagenesis. In Figure 20, it appears that the ooid was destroyed by the replacement of dolomitic cement. Sparry dolomitic intercrystalline cement is observed in all samples. Many ooid cores are replaced with silica and calcite and silica also heal fractures within ooids (Figure 18).

Ooids in thin section provide no direct indication of the velocity of the deposit. Ooid formation is a dynamic process, as discussed earlier, and does not require deep time. Under laboratory conditions, ooids have grown at a rate of 0.17 mm per day (Bakr et al., 2015). So it is possible for ooids to form fairly rapidly. Analysis of macroscopic sedimentary structures within the outcrop is necessary to evaluate the flow conditions and rates of deposition.

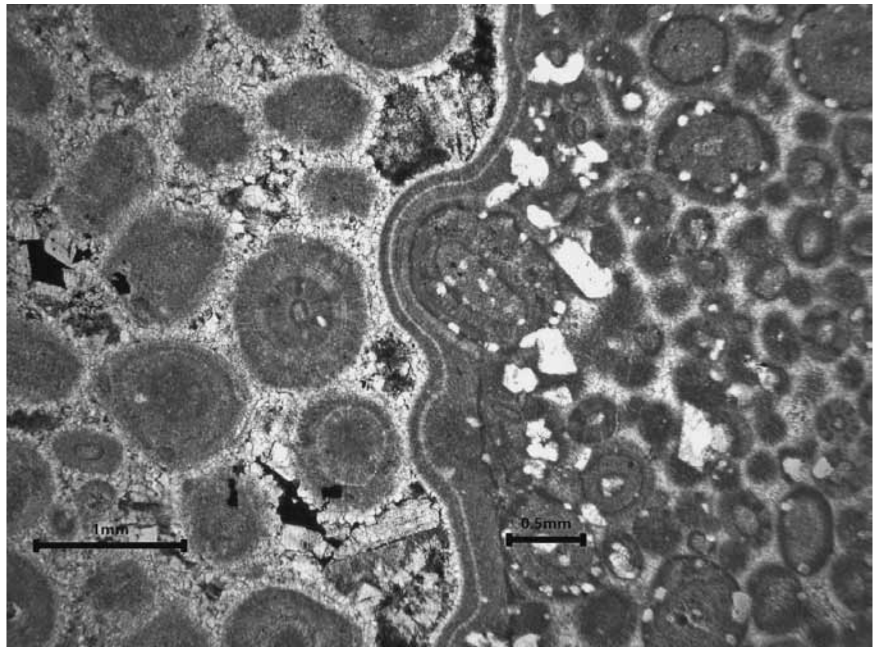

Figure 19. On the right is a rounded rip up clast composed of ooids found in disrupted bedding. Note the smaller ooids within clast with abundance of pseudo ooids or peloids. The Johnnie Oolite bed on the left side displays matrix supported "ooids." Note the Isopachous cement coating the clast on the right side. Also ooids are coated with sparry dolomitic cement occurring post depositional. Image taken in PPL.

Conclusion

The Johnnie Oolite bed (JOB) is a significant deposit for both the secular geologist and the biblical catastrophist. It has helped the pioneer geologists map the stratigraphy without bias, and has revealed to biblical catastrophists the nature of likely early Flood deposits. The JOB is composed of grains of ooids and minor lithic fragments in a mud matrix. During the grain-flow, ooids formed in supersaturated carbonate slurry. Some ooids are well developed but most are superficial or peloids of micrite and vary in size and shape. Field observations of the JOB reveal many sedimentary structures that indicate rapid deposition under mass flow conditions. The ooids display cross bedding to planar bedding and are normal to inversely graded. However, most of the bedding is poorly sorted to unsorted. Outsized clasts within the oolite bedding are an indication of strength and competence

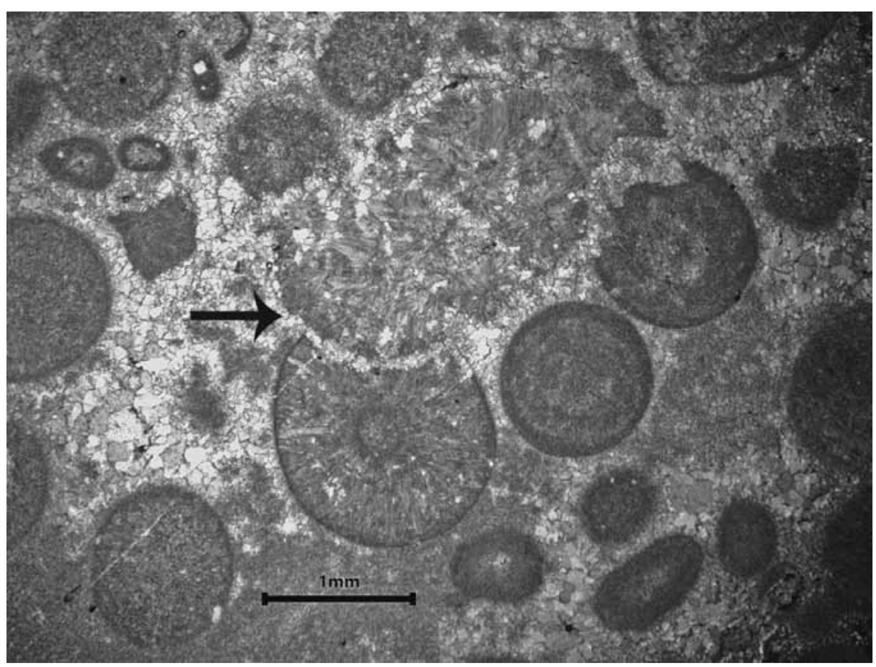

Figure 20. The radial fabric of an ooid destroyed by recrystallization of sparry dolomitic cement. Note the arrow pointing to isopachous cement coating destroyed ooid and the ooid below. Isopachous equant cement texture is generally associated with meteoric zone environment. Image taken in XPL.

during the mass carbonate flow. An erosional bedding plane within the middle of the JOB in Nopah Range contained numerous rip-up clasts and fluid escape structures indicating an energetic depositional environment. The JOB probably lost cohesion and became turbulent during this phase of the flow. Hummocky cross-stratified shale beds enclose the JOB at all locations. Field observations and thin section analysis indicate that flow conditions during deposition of the Johnnie Oolite were fairly rapid while the ooids and peloids formed in transit during the flow event. The JOB is considered a likely early Flood deposit which occurred after the breakup of the Fountains and the deposits of the underlying Noonday Dolomite and the Kingston Peak Fm in the study area.

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