2010 Creation Geology Society Abstracts

1. Submarine Liquefied Sediment Gravity Currents: Understanding the Mechanics of the Major Sediment Transportation and Deposition Agent during the Global Flood

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What was the mechanics of the process that transported more than one hundred million cubic miles of sediment during the global flood? Tractive currents and turbidity currents are both inefficient transport agents because sediment must be entrained by fluid turbulence that moves ten times more water than sediment. Turbulence and exceedingly large flow volumes create friction that defeats sediment movement. Much higher sediment movement efficiency can be achieved by liquefied sediment gravity currents. These are concentrated suspensions (about 50% by volume sediment) that move sand and mud particles as thin, laminar currents beneath the mass of the ocean. Therefore, the ocean is not the direct cause of sedimentation, only the host body for its submarine liquefied currents. These sediment flows are liquefied so that fluid pressure between the grains disperses the sediment, and gravity acts to propel the slurry over very low slopes. Turbulence of fluid and kinetic energy of water are not primary factors in sediment transport. Therefore, the sediment moves the fluid, not the fluid moves the sediment.

Liquefied submarine currents resemble mechanically modern mudflows, debris flows, pyroclastic flows and snow avalanches. Dynamic analysis of submarine debris flows indicate that a several-meter-thick current twice the density of seawater moves as a steady current over gentle slopes at a velocity of 6 to 8 meters per second. This velocity allows subcritical flow with enough dynamic pressure and lifting pressure to create a hydroplane. Solid-body modeling of the head of a liquefied gravity current shows that it acts like a wing with lifting pressure greatly exceeding frictional forces. Liquefied currents literally fly beneath the ocean with extreme mechanical efficiency. Slight shear within the liquefied sediment mass sustains internal fluid pressure creating a dispersed sediment condition with very low intergranular friction. Rheology of liquefied sediment gravity currents probably follows a nonlinear, viscoplastic, shear-thinning formula (Herschel-Bulkley rheological model). Low strength of the slurry and its shear-thinning rheology further contribute to transport efficiency. High density of the slurry and low friction on the interface with seawater inhibits turbulence within the shearing mass. Flume experiments simulate several features of these liquefied currents. Such currents were likely the major transportation agent for sediment during the global flood.

How does a sediment-transporting current make the transition to a sediment-depositing current?

Flow transformation is the process whereby a moving fluid changes fundamental flow characteristics and abruptly changes to a different category of moving fluid. A sediment-laden, fast-moving, liquefied suspension can transform by the penetrative action of shear from a laminar to a turbulent condition. This flow transformation allows a uniform and steady current to absorb a large volume of water, decrease its velocity significantly, and, thereby, deposit a significant quantity of sediment. By this process a liquefied and laminar current can be transformed into a nonliquefied and turbulent current (either a tractive current or a turbidity current). Flume experiments illustrate the abruptness of flow transformation and also produce the sedimentary structures diagnostic of turbulent, tractive currents.

The lower half of the Redwall Limestone of Arizona and Nevada contains a wide variety of sedimentary structures diagnostic of a fast-moving liquefied current and its transformation to a tractive current. These structures are of three types: (1) bedforms diagnostic of both upper and lower flow regimes, (2) graded structures indicating abrupt flow transformation during rapid sedimentation, and (3) imbrication of fossils suggesting hindered settling and abrupt freezing of a sediment-water suspension. Whitmore Nautiloid Bed within the lower Redwall Limestone of Arizona appears to represent the packstone deposit from the turbulent tail of the liquefied sediment gravity current. The distal grainstone equivalent of the bed in Nevada appears to represent the deposit of the turbulent current after flow transformation. Thinly bedded lime-mudstone rhythmites that overly Whitmore Nautiloid Bed are understood to be more dilute "wave-modified turbidites" from a sustained sediment gravity current modulated by the bidirectional surge of water waves. Extremely rapid, submarine sedimentation characterizes the process that formed the lower half of the

Redwall Limestone.

2. Persistence of Dolomite in the Coconino Sandstone, Northern and Central Arizona

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Study of hundreds of thin sections, in conjunction with x-ray diffractometry data from numerous outcrops located in northern and central Arizona have revealed the unexpected and persistent presence of dolomite within the Coconino Sandstone. Expanded from a previous study which reported bedded dolomite at Andrus Point (Cheung et al., 2009), a closer examination was conducted on sandstone samples from other localities. The results indicate the presence of dolomite occurring as dolomitic ooids, dolomitic clasts and dolomite cement within the quartz-rich Coconino sandstone.

Dolomitic ooids were found at Trail Canyon and Whitmore Canyon. Dolomitic clasts were found at most localities in northern Arizona. At Warm Springs Canyon, dolomitic clasts (mohs hardness = 3.5) can be as large as granule size (~2 mm) within the surrounding matrix of harder and smaller quartz grains (mohs hardness = 7, medium to fine sand-size, 0.50 - 0.125 mm). This type of grain-size inversion is also found with other softer minerals in the rocks, such as mica and potassium feldspar. Some dolomite and chert clasts are observed undergoing internal dissolution. Dolomite dissolution is a slow process under normal pressures and temperatures (Sherman 2000) and requires non-equilibrium conditions for increased dissolution.

Dolomite cement is found in most localities in northern Arizona, but also occasionally can be found in central Arizona as well. These cements have precipitated as microcrystalline and fine crystalline euhedral rhombs. Most models of dolomite precipitation require supersaturated marine or hydrothermal environments (Arvidson 1996). Dolomite can form in low temperature, low pressure conditions; but the synthesis is extremely complex (Deelman 1999). Moreover, based on most laboratory tests, dolomite cannot be formed in a non-marine setting.

Specific conditions for dolomite synthesis coupled with the variety and regional extent of dolomite types challenges the conventional interpretation of an aeolian depositional environment for the Coconino Sandstone. Furthermore, this data suggests that a brief marine incursion could not produce the varieties of dolomite nor textures (i.e. dissolution features) observed in the Coconino. These observations, along with others, suggest it may be time to reevaluate depositional models for the Coconino Sandstone. This study is being undertaken as part of the Flood-Activated Sedimentation and Tectonics (FAST) project of the Coconino Sandstone; funded by the National Creation Science Foundation (NCSF) and Calgary Rock and Materials Services Inc. We thank them for their generous support.

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3. Permian Cross-bedded Sandstones and Their Significance for Global Flood Models

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Sandstones interpreted as eolian in origin occur throughout the stratigraphic record and are widely distributed geographically. They are particularly well developed in the Permian, with classic examples described from the Colorado Plateau (e.g. the Coconino Sandstone, the De Chelly Sandstone) and northwestern Europe (e.g. the Yellow Sands of NE England, the Rotliegendes of Germany). These sandstones have been interpreted as eolian based on six main criteria: (1) well sorted, well rounded, fine-to-medium quartz grains displaying pitted or frosted surfaces; (2) minor feldspars and absence of mica; (3) ubiquitous large-scale cross-bedding with high-angle dips; (4) other sedimentary features such as low amplitude ripples, avalanche and slump structures, raindrop impressions, lag deposits and mud cracked horizons; (5) absence of marine fauna and/or presence of terrestrial and/or non-marine fauna; and (6) occurrence of well-defined animal tracks similar to those produced in modern dry sand settings. Critics have suggested that sandstones of this type could not have been formed during the global Flood described in the Bible.

However, many features of these sedimentary rocks are difficult to reconcile with an eolian origin. Our studies suggest that the Coconino Sandstone in central and northern Arizona is in fact a commonly bimodal sand in which only the larger grains are rounded to well rounded and the finer fraction is most often subangular. While it is claimed that mica is absent from the Coconino (Young and Stearley 2008 p.305) and from eolian sands generally (Moorhouse 1959 p.343) we have found mica across the Coconino outcrop and throughout stratigraphic sections. Furthermore, the average cross-bed dips seem to be consistent with underwater deposition and less steep than would be expected in eolian deposits. We have also documented the presence of dolomite beds, clasts and ooids in the Coconino Sandstone and shown that the formation commonly interfingers or intergrades with sediments that were clearly laid down underwater. Finally, careful field and laboratory studies indicate that the vertebrate tracks in the Coconino are best interpreted as having formed subaqueously (Brand 1979; Brand and Tang 1991). The literature on other Permian sandstones of putatively eolian origin suggests that they are similar in many respects to the Coconino. The Yellow Sands of NE England, for example, are fine-to-medium, poorly to moderately sorted sands with average cross-bed dips of

18° (Pryor 1971). Most grains are subrounded, with <15% being well rounded and substantial amounts of subangular and angular grains. In addition, these sandstones contain moderate amounts of silt and clay, including muscovite mica.

Nevertheless, creationists have yet to develop a detailed alternative model of how these sandstones were deposited. It is proposed here that they were formed by rapidly migrating subaqueous sand waves in shallow water under the influence of strong unidirectional currents during a major transgression of the oceans onto the continents. The fields of large sand waves formed under tidal conditions in modern shallow seas and estuaries probably provide the closest modern analogue (Garner 2008). The sand in these Permian deposits may have been derived from the re-mobilisation of pre-Flood coastal or desert dunes or the catastrophic erosion of igneous and metamorphic rocks during the Flood. Careful textural, mineralogical and provenance studies are now needed to determine the origin of the sand in formations such as the Coconino.

This study is being undertaken as part of the Flood-Activated Sedimentation and Tectonics (FAST) project funded by the National Creation Science Foundation (NCSF).

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4. Deep Ocean Interaction in a Post-Flood Warm Ocean Scenario

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Explanations for the Pleistocene Ice Ages in the context of a recent creation have ranged from denial of the existence of ice ages to a single contracted ice age with multiple surges. This second position mentioned in The Genesis Flood (Whitcomb and Morris, 1961) and modified by Oard (Oard, 1979) relies on a warm ocean in the wake of a global flood. The warm ocean provides a ready source of water vapor, which can be deposited over cold polar land masses as snow. Since a warm ocean prevents land masses from cooling sufficiently to accumulate snow, it is necessary to propose a cooling mechanism to offset the heat flux from the ocean. The most likely mechanism is reflection of sunlight by high concentrations of volcanic aerosols in the atmosphere. Two validity studies of this scenario were performed by Spelman and Vardiman. Spelman looked at the sensitivity of atmospheric parameters to different sea surface temperature distributions (Spelman, 1996) and Vardiman studied the enhancement of precipitation due to hot mid-ocean ridges (Vardiman, 1998). Over the past decade no additional simulations have been published using this scenario.

Simulation of climate has progressed significantly over the past ten years and a number of models are available to study the validity of a rapidly developing ice age due to warm oceans. Current climate models not only simulate the circulation of the atmosphere, but also the circulation of the ocean, build up of sea ice and response of land surfaces. Two models from the Goddard Institute of Space Studies (GISS) are used for this study. GISS Model II (Hansen, 1983) simulates the atmosphere at a resolution comparable to the studies done by Spelman and Vardiman. This earlier model can also be run efficiently on a desktop computer in order to explore a number of preliminary scenarios. The GISS Model E (Schmidt, 2006) is designed to be more flexible and makes it easier to use different ocean models and aerosol parameterizations.

To limit the scope of this study, only the heat flux from the ocean surface and between the ocean mixed layer and deep ocean is studied. The mixed layer includes the first 50 - 100 meters of the ocean's surface. It varies with latitude and season and is mixed by thermal gradients and wind-shear. The deep ocean interacts weakly with the mixed layer due to stability of the lower ocean beginning at the thermocline. Regions of sinking and upwelling through the mixed layer do exist due to the thermohaline circulation and interaction with continental boundaries; however, in modern day oceans this interaction has a minimal effect on climate variability over the time period of centuries.

If the deep ocean was warmer in the recent past, then there would be an enhanced vertical circulation over the full depth of the water column. If the full depth of the ocean were treated as a mixed layer, the thermal adjustment timescale would be 40 years (Marshall, 2008). Model II and Model E are used to calculate the heat flux entering the mixed layer from the deep ocean. By comparing current ocean heat fluxes with that of a warm deep ocean it is possible to verify the cooling rate of the deep ocean and to infer an enhanced interaction between the deep ocean and the mixed layer. This enhanced interaction not only includes heat transport, but also nutrient transport, which may have implications for the ocean biome.

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5. Potential Mechanisms for the Deposition of Halite and Anhydrite in a Near-critical or Supercritical Submarine Environment

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The formation of geologic salt deposits has long been an area of concern for creation geology. Uniformitarian geology has pictured these deposits as forming due to the evaporation of seawater, hence their designation "evaporites". Both creationist (Nutting, 1984; Williams, 2003) and uniformitarian (Hardie and Lowenstein, 2004) literature have noted problems with evaporation models and creationist literature has suggested a hydrothermal model as a more likely mechanism for evaporite formation (Nutting, 1984; Williams, 2003). This contribution will review some hydrothermal mechanisms for rapid deposition of these salts and discuss possible evidence that could be used to identify these mechanisms in the geologic record.

Submarine hydrothermal fluids possess significant salinity. At near-critical temperatures (~400°C and 250-290 bars), hydrothermal fluids undergo a phase separation into a vapor and NaCl-rich brine, containing higher concentration of NaCl than the original fluid (Von Damn et al., 2003). Salt will be concentrated in this brine and as it is pushed upward, it will both cool and be placed under lower pressure, leading to halite (NaCl) precipitation (Berndt and Seyfried Jr., 1997). Creationist models assume extensive hydrothermal activity at the time of the Flood, so this mechanism would have the potential to deposit a significant amount of salt. Deposits formed in this way would be expected to be primarily composed of halite; anhydrite ($CaSO_4$) is significantly insoluble in high-temperature water (Hovland et al., 2006). Any anhydrite present would have precipitated before the halite and therefore would be found stratigraphically lower than it in the geologic record. Furthermore, near-critical hydrothermal fluids have been noted to contain unusually high Fe/Mn ratios (Von Damn et al., 2003); the presence of similar ratios in fluid inclusions in the halite might indicate it formed under these conditions.

Another mechanism for "evaporite" formation is suggested by Hovland and coworkers and involves both sub-critical and supercritical processes (Hovland et al., 2006). Hovland's mechanism requires a source of extremely high heat , such as a magma chamber, below a porous seabed. In Hovland's model, the sediment primarily serves to protect the halite from redissolution; during the rapid sedimentation of the Flood, capping by newly deposited sediments could achieve the same protection. In either view, the saline water is heated by the magma chamber, leading to the precipitation of anhydrite in areas of less intense heat and supercritical conditions leading to halite precipitation in the most intense heat (405°C and 300 bars), directly above the heat source (Hovland et al., 2006). In a supercritical environment, water behaves like a non-polar liquid; therefore it will be a far better solvent for organic compounds than salts and will precipitate any halite it contains. This entire process would be expected to generate halite deposits directly above the heat source, with anhydrite deposits flanking the halite (figure 1).

Geologic salt deposits have likely formed by a variety of mechanisms. There is not one simple answer for their origin. However, if a thorough understanding of the mechanisms for rapidly precipitating salts and criteria for determining which mechanism was responsible for a given deposit are developed, it should be possible to understand these features on a case-by-case basis. This contribution is a step towards developing those mechanisms and criteria.

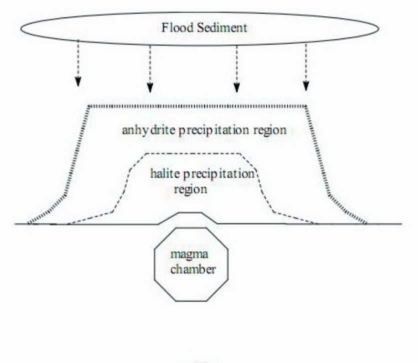

Figure 1

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6. Dinosaur Tracks, Eggs, and Bonebeds Explained Early in the Flood

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Despite being able to explain many big-picture observations of the rocks and fossils, there are still a few hundred earth science challenges to the Flood model of earth history. One of these challenges is the existence of billions of dinosaur tracks, millions of dinosaur eggs, and scavenged bonebeds on thousands of feet of Flood strata. Such observations seem to imply too much time to have happened early in the Flood before dinosaurs were all dead by Day 150.

However, a closer examination of the bonebeds, tracks, and eggs indicates many unusual features for a uniformitarian environment. Unique features of bonebeds include the observations that some dinosaur graveyards are huge, monospecific, and lack babies and young juveniles. Unique features of dinosaur tracks are that practically all trackways are straight, tracks are always on flat bedding planes, and baby and young juvenile tracks are rare. Several unusual features observed with dinosaur eggs are that they are practically always laid on flat bedding planes, despite their significant porosity that would result in the death of the embryo, and nest structures are very rare. Such observations from all across the world suggest that another hypothesis is needed.

An hypothesis will be presented to explain the dinosaur data, which has been previously suggested in the creationist literature (Brand 1997, p. 293; Oard 1995). This is the BEDS (Briefly Exposed Diluvial Sediments) hypothesis, which postulates that after rapid sedimentation during the Genesis Flood, the distance between the top of the sediment and the Floodwater surface became shallow. Such sediments would then become vulnerable to exposure by local drops in relative sea level caused by five mechanisms operating during the early Flood. These five mechanisms are: (1) local tectonics that uplifts the area out of the Floodwater, (2) tsunamis, (3) tides, (4) gentle tectonics at a distance that causes traveling waves at the surface, and (5) the dynamics of Flood currents (Barnette and Baumgardner 1994; Prabhu et al. 2008). There would of course be local rises in relative sea level inundating the BEDS. There could be hundreds of local sea level oscillations of various amplitudes and periods on BEDS during the first 150 days of the Flood due to all five mechanisms. Interference patterns from all the mechanisms would reinforce sea level lows and highs.

Dinosaurs swimming in the water, finding refuge on log mats, or trapped on higher refuges then could walk on BEDS and lay eggs. A gentle, local rise in relative sea level would cover up the tracks, eggs, and dead dinosaurs, preserving and eventually lithifying or fossilizing them. Because of all the oscillations in local sea level, there could be multiple layers of tracks and eggs at any one location.

The BEDS hypothesis also can potentially explain a number of other seemingly puzzling features associated with dinosaur tracks and eggs, such as true mudcracks, raindrop imprints, coprolites, ripple marks, “paleosols,” burrows and tracks of invertebrates, possible social insect nests, and bird tracks. BEDS can also explain these features when not associated with dinosaur tracks.

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7. YEC Geology in the Classroom: Educational Materials, Challenges and Needs

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Introduction

Students in the U.S. are often introduced to Earth Science courses during middle/high school or as a science elective in undergraduate studies. Educators who are free to introduce young-Earth creation concepts into the geology classroom (e.g., YEC-affirming Christian school and home-school educators) have few choices for sources of academic materials or modules. Here I survey the present situation, and provide an outline for a coordinated effort among YEC ministries, educators, and professional societies to provide materials that convey current YEC geological knowledge in media applicable to high school and/or introductory undergraduate courses.

Present Situation

Textbooks

At present, no publically available YEC textbook exists covering undergraduate geology or Earth science. High school textbooks on the topic (typically for 8th or 9th grade) are developed by non-geologists, and often contain numerous errors and/or are significantly out-of-date with respect to current creation geology. Old-Earth textbooks may be preferable, particularly if the instructor is capable of augmenting the course with YEC geology modules.

Specific lectures can, of course, be constructed on the basis of the instructor’s own knowledge and reading of well-researched YEC writings on geology (excellent sources include Austin 1994, Wise 2002, Brand 2009, and Snelling 2009). Such sources have clear discussions of YEC geological arguments at various levels of technicality. However, none provide instructor resources (lecture plans, slides, or test banks) that facilitate classroom incorporation, particularly for educators with heavy teaching loads or minimal geological expertise.

Audio-Visual Media

The inclusion of documentaries and other video media is commonplace in both high-school and undergraduate courses to complement existing educational modules. Yet few are amenable to thorough incorporation and student assessment, as certain difficulties are commonplace: a) videos are simply recordings of lectures given to lay audiences; b) material is covered too rapidly for student note-taking; c) topics may prove too advanced for student comprehension; d) videos are longer than class periods, and must be broken up or abbreviated.

In fairness, nearly all of the YEC video resources available were not produced with classroom incorporation in mind. Therefore, some of the shortcomings are problems of application rather than intended audience, format, or content. Nevertheless, the lack of audio-visual media intended specifically for classroom use presents limitations on the use and/or robust incorporation of available videos for courses integrating YEC geological arguments.

Currently, educators can make use of several existing educational resources that are easily integrated into geology curricula. For example, the *Flood Geology* video (produced by AiG's Creation Museum) contains several short video segments that are excellent YEC supplements to discussions of various geological (and biological) concepts and processes. Video segments from *Thousands…Not Billions* (produced by ICR and CRS) are highly informative and visually compelling, though the segments are sufficiently technical that they require additional lecture explanations in undergraduate courses (and likely overly technical for early high school application).

Coordinated Resource Development

YEC ministries, educators, and professional societies each possess unique capabilities that, when properly coordinated, can overcome the present obstacles and produce suitable educational materials for high school and undergraduate use. Capabilities of each group include: YEC ministries have significant experience in publishing and distributing text and audio/visual materials; educators can guide technical content level, instructional needs, and knowledge of current academic standards and trends; YEC professional societies have a network of academics and researchers who may act as editors and reviewers.

Though a thoroughly new, comprehensive course(s), complete with textbook, lecture sets, etc., may be a long-term goal, a more practical, short-term goal is a series of modules incorporated into existing geology courses. Such modules would intersect key points of disagreement between YEC and old-Earth models (e.g., plate tectonics, radioactive dating methods, paleontology). Such modules, with sufficient educator resources (instructor's guides, slides, and test bank questions) would greatly facilitate the incorporation of current YEC geology among high school and undergraduate courses which possess the freedom to present it.

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8. Radiohalos in Multiple, Sequentially-Intruded Phases of the Bathurst Batholith, NSW, Australia: Evidence for Rapid Granite Formation During the Flood

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The Bathurst Batholith outcrops over an area of 1600 km^2 west of Sydney. It consists of an enormous pluton (the Bathurst Granite) and numerous smaller related satellite plutons and dikes. Though often deeply weathered, the granite is well exposed in road and railroad cuts, and in the hills around its margins which have been mapped in detail, where the contact metamorphosed, host fossiliferous sedimentary strata have been more resistant to weathering (Packham, 1969; Snelling, 1974).

The major pluton, when viewed in its regional context, clearly cuts across the prevailing strike of the fossiliferous sedimentary strata. It is elongated east-west, while the regional strike of the host strata is north-south. This is unequivocal evidence that the intrusion of the batholith structurally disrupted the regional fabric of the host strata sequence, which is confirmed by exposure of buckled and twisted bedding in the steep contact zone. Elsewhere limestones in the contact zone were metamorphosed to skarns and calc-silicate hornfels by the hot magma.

A major dike-like granite body 12.8 km long and often 0.8 km wide forms the Evans Crown ridge, cutting across the Bathurst Granite and the surrounding host strata. This dike's central portions are coarse and even grained like the Bathurst Granite, but the margins are chilled, testimony to intrusion of the dike as hot granite magma. Some of the chilled margin rocks exhibit pronounced flow-banding texture. Rapid cooling of this large dike is also evident from the graphic quartz-feldspar intergrowths, myrmekitic outgrowths and reaction-rimmed grains in it.

Many minor granite dikes cut across the margins of the Bathurst Granite out into the surrounding strata. Up to 45 m wide, these granite dikes have the same composition as both the Bathurst Granite and Evans Crown Dike, often with the same porphyritic texture. Both reaction textures and mineral intergrowths suggest the phenocrysts crystallized prior to injection of the dikes into the Bathurst Granite, and also across the Evans Crown Dike. Alteration zones marginal to the sharp contacts of the dikes with the wallrocks indicate the magma was still hot when injected, and the dikes are frequently flow-banded parallel to these contacts.

Abundant ^{238}U and ^{210}Po radiohalos are present in biotite flakes of all samples of the Bathurst Granite and Evans Crown Dike. ^{214}Po and ^{218}Po radiohalos are only present in some samples of the Bathurst Granite. A few ^{210}Po and ^{238}U radiohalos are also present in biotite flakes within some samples of the dikes that cut across the Bathurst Granite or the Evans Crown Dike.

Field and textural data have established that these granite phases were sequentially intruded while still hot. The Bathurst Granite intruded the fossiliferous sedimentary strata, and was then itself intruded by the Evans Crown Dike. Finally granite dikes intruded both the Bathurst Granite and Evans Crown Dike. All this had to occur within the Flood year, so these multiple granite phases were not created cold by fiat (Gentry, 1988). Instead, the Po radiohalos indicate they were formed rapidly below 150°C via hydrothermal fluid transport of Rn and Po from the zircon grains, embedded in the biotite flakes, that are often the radiocenters of the U radiohalos (Snelling and Armitage, 2003; Snelling, 2005). Furthermore, their presence in all three sequentially-intruded granite phases is evidence that all this intrusive activity, and the cooling of all three granite phases to 150°C, must have occurred within days so that these Po radiohalos then formed within subsequent days to weeks.

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9. Radiocarbon in Permian Coal Beds of the Sydney Basin, Australia

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The Sydney Basin is a broad structural trough into which a thick sequence of Permian-Triassic sedimentary units were deposited (Packham, 1969; Herbert and Helby, 1980). The Triassic Hawkesbury Sandstone is well known from its outcrops in spectacular cliffs around Sydney Harbour and the adjacent coastline. In the Blue Mountains Plateau to the west the underlying Narrabean Group sandstones are exposed in widespread prominent cliffs. Directly beneath these Triassic units are the upper Permian Illawarra Coal Measures, which contain the Katoomba Seam (up to 2.4 m thick), the Middle River Seam (up to 12 m thick), and the Lithgow Seam (up to 6.9 m thick). Abundant fossilized plant remains, especially *Glossopteris* sp., are in the seams, and in the associated sediments.

The Kurrajong Heights No. 1 well, sited on a structural high in the central western part of the Sydney Basin, was drilled in 1955 to 4,756 feet (1,449.6 m) below the collar to test for oil and natural gas (Stuntz et al., 1968). In 1962 the well was deepened to a total depth of 9,132 feet (2,783.4 m). The well penetrated 740 feet (255.6 m) of Triassic Hawkesbury Sandstone, 2,175 feet (662.9 m) of Triassic Narrabean Group sediments (interbedded sandstones and shales), 1,580 feet (481.6 m) of Permian Coal Measures (shales, siltstones, sandstones, and coal seams), and then 3,370 feet (1,027.2 m) of the underlying Permian Capertee Group sediments (shales, some carbonaceous, siltstones and sandstones, sometimes conglomeratic), before bottoming in 1,267 feet (386.2 m) of basalt and rhyolite of unknown age, but assumed to be Permo-Carboniferous.

Samples of drill-cores from the wells were obtained - four from coal seams between 3,060 and 4,455 feet (1,032.7 and 1,357.9 m), and one from a carbonaceous shale at the base of the Capertee Group at a depth of 7,797.3 feet (2,376.6 m). These were sent for high precision AMS analyses to the IsoTrace Radiocarbon Laboratory at the University of Toronto, Canada. Prior to combustion and analysis, each sample's carbon was extracted by hot, strong HCl and NaOH, and by an acid/chlorite bleach (AAAOx), followed by complete degassing at high temperature under vacuum. The results reported by the laboratory were the average of four separate analyses of each sample (high precision), corrected for natural and sputtering isotope fractionation, using the measured $^{13}C/^{12}C$ ratios. The sample ages were quoted as uncalibrated conventional dates in years before present (BP), using the Libby ^{14}C meanlife of 8,033 years, with the errors representing the 68.3% confidence limit.

The Permian coal beds yielded radiocarbon dates of 42,860±570 years and 42,860±720 years for two adjoining samples, and 40,910±4,080 years and 48,760±1,740 years from the two other deeper samples. The sample of carbonaceous shale with contained plant fossils from 7,797.3 feet (2,376.6 m) yielded a radiocarbon date of 36,090±340 years. These results are similar to and within the same range of dates recorded from the conventional literature (Giem, 2001), and obtained from US coal beds of various conventional ages (Baumgardner et al., 2003; Baumgardner, 2005). This confirms that pre-Flood vegetation buried during the Flood about 4,300 years ago yields dates of 30,000-50,000 radiocarbon years, which is a start towards devising a scheme for recalibrating all published radiocarbon dates.

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10. How Does an Underwater Debris Flow End? Flow Transformation Evidences Observed within the Lower Redwall Limestone of Arizona and Nevada

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Deposits of underwater debris flows exhibit complex characteristics that make the identification of lateral flow regimes difficult. In order to better understand these issues, this study analyzed the deposit of a large flow event through northern Arizona and into southern Nevada. The flow's deposit is identified by the laterally contiguous Whitmore Nautiloid Bed, which is the uppermost bed of the Mississippian Whitmore Wash Member, Redwall Limestone in northern Arizona. The bed is traceable into southern Nevada as a crinoidal lime packstone located in the upper-middle of the Anchor Limestone Formation of the Monte Cristo Group. The proximal end of the flow event is in Arizona and the flow progressed westerly into Nevada. This study did not locate the terminus of the flow but analyzed four locations from proximal (east) to distal (west) end including: 1) Squaw Canyon, Arizona, 2) Virgin River Gorge, Arizona, 3) Mormon Mountains, Nevada, and 4) Meadow Valley Mountains, Nevada. No discontinuity was identified westerly and indications of flow transformation distally are apparent, indicating the flow ended by flow transformation and not frictional freezing. Bed thickness inflated distally except where the deposit exhibited increased hyperconcentrated characteristics at Meadow Valley Mountains. Vertical particle sorting also increased distally suggesting a change from a hyperconcentrated to a concentrated flow regime. Matrix or clast support is a characteristic of the flow regime and deposit and is not correlated to either proximal or distal flow locations. Underwater debris flow events are found to transform in complex ways. Based on the work of many outstanding researchers, flow regimes and deposits are generally classifiable.

11. Clay Content: A Simple Criterion for the Identification of Fossil Desiccation Cracks?

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In our study of large playa cracks, we discovered that clay content appears to be a critical factor determining whether large playa cracks, soil cracks and mud cracks will form during desiccation. We found this concept well supported in the literature. Modern soils that crack via desiccation have significant amounts of clay sized particles (<1/256 mm or 3.9 µm, a figure sometimes rounded to 5 µm). Basma et al. (1996), Harianto et al. (2008), Yassoglou et al. (1994) and Yesiller et al. (2000) report cracking in soils with clay contents ranging from 13 to 58.3% and silt contents ranging from 21 to 52%. Sediments that have significant amounts of sand and silt and lack clay will not crack via desiccation. Our XRD analysis of the mud cracked Lucerne Dry Lake (California) showed it had 9% clay minerals by volume and 25.9% clay sized particles by mass. Neal et al. (1968) reported clay sized particle analyses from 11 cracked playas (in the table below). They observed (p. 81) that “particle-size measurements in giant-fissured playa areas indicate that sediments contain substantial amounts of < 5µm material.”

Location of playa cracks	% Particle Size			
	<5µm	5-40 µm	40-120 µm	>120 µm
Red Lake, AZ	55	17	28	0
Indian Springs, NV	30	34	36	0
Ivanpah, CA	56	6	38	0
Bicycle, CA	45	14	40	1
North Panamint, CA	32	15	43	0
Rosamond, CA	71	4	25	0
Rogers, CA	65	3	30	2
Coyote, CA	53	10	32	5
Animas, NM	65	7	28	0
Alvord, OR	35	20	32	13
Eldorado, NV	49	9	40	2
Average	51	13	34	2

In our XRD and petrographic analysis of the Hermit Formation in the vicinity of large sand filled cracks (below the Coconino Sandstone), we found that the Hermit Formation lacked the clay sized particles that are commonly present on cracked playa surfaces. Our analysis of the Lucerne Dry Lake sediments (LDL) and seven locations from the Hermit Formation of northern Arizona are reported in the table below:

Sample number	Large cracks present	Average particle size (µm)	Total clay % < 5 µm by mass (XRD)	Weight fraction of clay minerals present (%) in bulk powder (XRD)	Volume fraction of clay minerals present (%) in bulk powder (XRD)
AC-1	No	41.3	3.5	2	2
AP-7	No	38.5	3.1	0	0
HC-1	No	44.4	3.3	0	0
JUS-3	Yes	41.3	2.9	0	0
SFRC-1	Yes	43.7	5.0	2	2
WC-1	No	36.1	3.9	3	3
WSC-20	Yes	44.4	5.5	0	0
LDL-1	Yes		25.9	9	8

We suggest that the sand filled cracks in the Hermit Formation are not the result of desiccation because the Hermit does not have enough clay sized particles to crack via desiccation. The Hermit is clearly very different from the playas analyzed by Neal et al. (1968) and Lucerne Dry Lake. Based on these observations, other hypotheses (besides desiccation cracks) about the origin of the sand filled cracks in the Hermit should be developed. We recommend that other modern mud cracks and other supposed fossil mud cracks be analyzed to further test this suggested new criterion for the identification of fossil desiccation cracks. This study was funded by the National Creation Science Foundation (NCSF) and Calgary Rock and Materials Inc.

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12. Preliminary Report and Significance of Grain Size Sorting in Modern Eolian Sands

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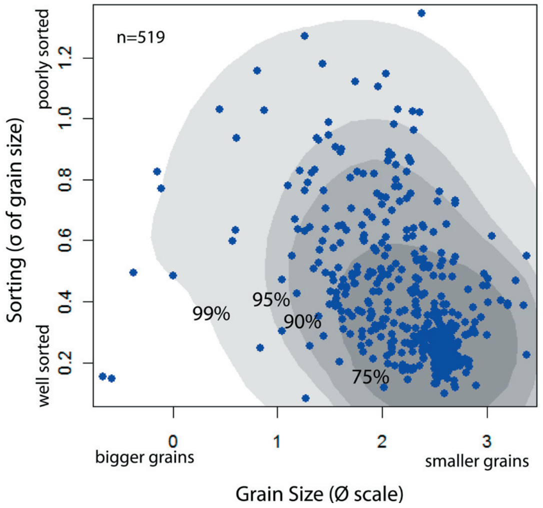
Modern eolian (or wind-blown) sands have been studied by numerous authors. In this study a published data base of 465 inland and coastal dune samples that were collected by E.D. McKee and his colleagues (Ahlbrandt 1979) and 54 inland and coastal dune samples collected by J.H. Whitmore and his colleagues (for a total of 519 samples) were used. This is a preliminary report because Whitmore has analyzed only about half of the dune samples that he has collected. Samples from both groups were collected from a wide variety of dune types and sizes from around the world. They were collected from various locations on the dune (windward slopes, leeward slopes and crests). Interdune deposits were collected, but are not part of this analysis (they are typically poorly sorted). McKee's samples were prepared using ¼ Ø sieve sizes. Various textural parameters were calculated for McKee's data by Ahlbrandt. Mean grain size (M_z) and inclusive graphic standard deviation (a measure of sorting or the spread of Ø units, σ_I) were calculated using the parameters defined by Folk (1968). The samples collected by Whitmore were prepared using ½ Ø sieve sizes. The same textural parameters were calculated using GRADISTAT, a grain size analysis program available online from Kenneth Pye Associates Ltd. That program uses Folk and Ward's (1957) methods. The two data sets were combined and analyzed for this study. The plot below shows sorting versus grain size distribution of the 519 samples. The inner shaded area of the plot is the 75% confidence interval for all samples, followed by the 90, 95 and 99% confidence intervals, respectively. The "R" statistical package was used to make the plot.



A significant observation from the preliminary results of this study indicate that when dune sands consist of fine or very fine sand (2-4 Ø), they tend to be well sorted (nearly all of the 75% confidence interval is less than 0.50, which is considered to be "well sorted"). Based on these data, hypotheses can potentially be generated about overall sorting characteristics expected from ancient eolian sands of various sizes. For example, we might expect fine and very fine ancient eolian sands to be well sorted too. These observations should be used carefully until more data is added to the data base and further statistical analysis is completed.

This study is being undertaken as part of the Flood-Activated Sedimentation and Tectonics (FAST) project funded by the National Creation Science Foundation (NCSF) and Calgary Rock and Materials Inc. Geology students at Cedarville University sieved many of the samples. I am appreciative of their time and work for this project. Thanks go to Cedarville University for laboratory space and equipment. I am appreciative of a colleague who helped me with the statistical analysis and plot.

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13. Preliminary Report on Sorting and Rounding in the Coconino Sandstone

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The only major comprehensive work on the Coconino Sandstone was completed in 1934 by McKee. In his monograph he argued that the Coconino was an eolian deposit based on many criteria, including its well-sorted nature (p. 95) and its rounded quartz grains (p. 96). These arguments continue to be cited by numerous authors. Modern eolian sand dunes are generally well sorted and some are well rounded.

In this study over 400 samples are in the process of being examined from about three dozen locations representing the breadth and thickness of the Coconino. At this writing, almost 60 thin sections have been analyzed from eight locations. Data are collected using a Nikon Eclipse 50i Pol microscope equipped with the Br software package making measuring and tabulating grain sizes relatively easy. Typically the long axes of 400-600 sand grains are counted on each slide. Every grain in the field of view is counted in five to ten regions of each slide, perpendicular to bedding. The full width or length of each slide is always counted to get a representative sample of all the grains present in the thin section. Counting every grain in each field of view, avoids the statistical problems encountered when using the line and grid counting methods (see the discussion in Van der Plas (1962), for example). Overall site statistics are calculated by selecting 300 random grains from each thin section from the site (a site with ten samples would be represented by 3,000 grains).

Mean, mode, d_{50}, and standard deviation were calculated. Using Johnson's (1994) suggestion for sorting (based on the standard deviation of the phi size using long axis measurements of grains in thin section), the sorting of each slide and the sorting of each overall section was calculated (for thin sections, <0.45 Ø is very well sorted; 0.45-0.55 Ø is well sorted; 0.55-0.70 Ø is moderately sorted; 0.70-0.90 Ø is poorly sorted; and >0.90 Ø is very poorly sorted). When examining each thin section, rounding was estimated using the rho scale by Folk (1955); "0" being the most angular and "6" being perfectly spherical.

Results are showing that the Coconino is moderately to very poorly sorted in most thin sections and at most locations throughout the width, breadth and thickness of the formation, which is contrary to what has previously been reported. Most sand grains in the Coconino are in the range of 2.5 to 3.5 rho (4.5 is rounded) which is also contrary to what has been reported. Preliminary results show that grain size slightly increases and rounding improves toward the south. We believe that published claims of "well-sorted" and "rounded" describing the Coconino have not been based on actual thin section data, but are based on the assumption that the Coconino is eolian.

This study is being undertaken as part of the Flood-Activated Sedimentation and Tectonics (FAST) project funded by the National Creation Science Foundation (NCSF) and Calgary Rock and Materials Inc. We thank them for their generous support.

Location	Samples	Mean grain size (Ø)	Size name (uncorrected for sectioning effect)	Standard Deviation of grain size (Ø)	Sorting (after Johnson, 1994)	Rounding score (after Folk, 1955)
ASR	8	3.18	Very fine sand	0.71	Poorly sorted	3.1
CPW	14	3.20	Very fine sand	0.61	Moderately sorted	3.4
JUS	5	3.42	Very fine sand	0.97	Very poorly sorted	2.5
NHT	2	3.97	Very fine sand	0.84	Poorly sorted	2.3
PCT	16	2.96	Fine sand	0.69	Moderately sorted	3.3
SK	2	3.41	Very fine sand	0.91	Very poorly sorted	2.8
TC	4	3.47	Very fine sand	0.71	Poorly sorted	2.4
WC	5	3.18	Very fine sand	0.94	Very poorly sorted	2.7

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