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# Sedimentary Provenance of the Wedington Member, Fayetteville Shale, From Age Relations of Detrital Zircons

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by

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**ABSTRACT**

U-Pb geochronology of detrital zircons collected from the Chesterian Wedington Sandstone allows interpretation of sediment provenance and dispersal patterns in the southern midcontinent during the Late Mississippian. Detrital zircons analyzed from six samples of Wedington Sandstone yielded a final result of 565 concordant analyses used for interpretation. Results are plotted as Probability-Density Plots to interpret the spectrum of ages. Significant peaks occurred at 350-500 Ma, 950-1250 Ma, 1300-1500 Ma, 1600-1800 Ma, 1800-2300 Ma, and >2500 Ma. These peaks are interpreted as sourced by crystalline rocks within the Laurentian craton from Taconic-Acadian, Grenville, Midcontinent Granite-Rhyolite, Yavapai-Mazatzal, Paleoproterozoic, and Superior Provinces. The high percentage of grains derived from Acadian, Taconic, and Grenville Provinces indicate the Appalachian Mountains were the primary source of sediment during the Chesterian. The Midcontinent Granite-Rhyolite and Yavapai-Mazatzal Provinces were the second most prevalent source terranes, indicating the Nemaha Ridge was uplifted and supplying a significant amount of sediment by the Late Mississippian. Sediments were likely transported from both eastern and western sources into a drainage basin moving sediments south into northwest Arkansas, where they were deposited on the Arkoma shelf as a small constructive delta complex.

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Thanks to Department of Geosciences and Ralph Davis, for offering the opportunity to achieve and education in something I hold so dear (Rocks!).

Special thanks to all those whose work came before mine and served as stepping stones to getting the project completed: C. McNully, T. Cochran, Chuck Price, Daniel Allen, Walter Manger, Doy Zachry, George Gehrels, William Dickinson, and many more that contributed to North American Geology over the past century.

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# I. INTRODUCTION

The Chesterian series of northern Arkansas is a third order depositional sequence bounded by type one unconformities at top and bottom (Moyer and Manger, 2006). The sequence is dominated by the Fayetteville Formation, a thick terrigenous clastic formation composed mostly of black shales, with the Wedington Sandstone Member in the upper middle-section. The sequence is bounded above and below by two thinner limestone units, the Pitkin and Hindsville Formations, respectively. Since the sequence is bounded by limestones, the region must have been located in the "Limestone Belt" for the duration of deposition. The switch in deposition from carbonates to terrigenous clastics demonstrates that the carbonate factory was suppressed by an influx of clastic material. From this, it can be inferred that a new source of clastic sediment appeared during this time or that new sediment transport routes opened across Laurentia.

In a broad perspective, much work has been done using detrital zircon analysis to interpret how sediments were being transported across Laurentia during the Mississippian (Gehrels *et al*., 2011; Thomas, 2011a). In the southern Ozarks, along the southern margin of Laurentia, sandstone deposition during the Chesterian was limited to the Wedington Sandstone Member of the Fayetteville Formation and the Batesville Sandstone. The thickness of the Wedington Sandstone (up to 108 feet), and its relatively coarse grain size, make it a good candidate for interpreting how clastic sediment was moving across the region. The deltaic geometry of the Wedington also gives a good constraint on localized sediment transport direction. For these reasons, the Wedington was chosen for detrital zircon analysis.

The Wedington Sandstone is a fine to medium grained sandstone with moderately sorted, subrounded to rounded grains (Price, 1981). Petrographic studies have shown that it ranges from a sublitharenite to a quartzarenite on QFL diagrams (Allen, 2011). Stratigraphically, it is located in the upper-middle section of the Fayetteville shale (Figure 1). The formal Wedington Sandstone Member divides the Fayetteville Formation into two informal members, the organic rich lower Fayetteville shale and the less organic upper Fayetteville shale (Price, 1981). The lower Fayetteville shale was deposited during transgression and maximum flooding interval of the Chesterian cycle. Still stand conditions following shale deposition allowed the Wedington to be deposited as a small constructive delta prograding to the southeast. Shale deposition of the organic poor upper Fayetteville member followed delta progradation as the Chesterian cycle entered highstand and then regressive conditions (Moyer and Manger, 2009).

Although previous studies have detailed the stratigraphy and petrology of the Wedington Sandstone, there are few constraints on the source of the clastic sediments of the Fayetteville Formation. Uranium-lead (U-Pb) detrital zircon geochronology has emerged as a powerful tool for evaluating sediment provenance, sediment transport pathways, and sedimentary stratigraphy (Thomas, 2011a; Gehrels, 2010). The ages of detrital zircon grains in sandstones give absolute ages of the bedrock from which the sand grains are derived. Analysis of detrital zircons in sandstones allows an interpretation of sedimentary provenance by matching the ages of zircons with the ages of potential crystalline source terranes (Thomas, 2011a). Interpretations from detrital zircon ages must account for sediment transport pathways as well as paleogeography, tectonic settings, stratigraphy, and sediment mixing (Gehrels *et al*., 2011). Detrital zircon analysis can also be used to determine maximum depositional age of sedimentary rocks based on the youngest ages of zircons analyzed, as well as a stratigraphic correlation tool (Gehrels, 2010).

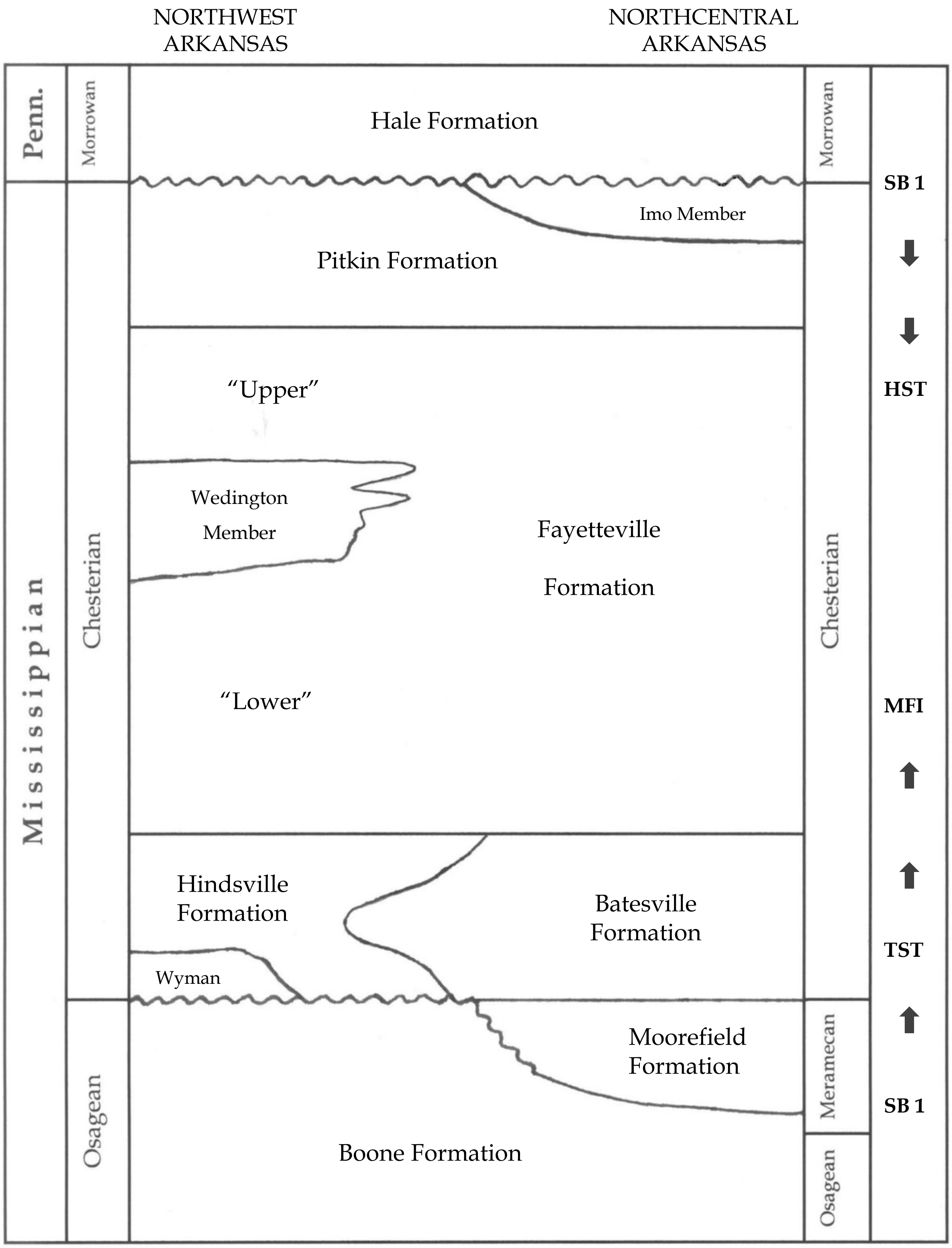


**Figure 1. Generalized stratigraphic column for the Chesterian interval of northern Arkansas with a diagrammatic column showing the sequence stratigraphy of the Chesterian third-order sequence (SB 1 = Type 1 Sequence Boundary; TST = Transgressive Systems Tract; MFI = Maximum Flooding Interval; HST = High-stand Systems Tract) (From Allen, 2010).**

## A. PURPOSE AND SCOPE

This project proposes a framework for sediment provenance of the Wedington Sandstone Member of the Fayetteville Formation. Determining a sediment source for the Wedington Sandstone will provide valuable insight on how sediments were transported on the southern margin of North America during the late Mississippian, which has been problematic. The project used detrital zircon analysis to identify original sources of sediments deposited in the Arkoma basin during the Chesterian. The ages are then used to establish a provenance framework, which must fit the zircon data into a stratigraphic, sedimentologic, tectonic, and paleogeographic framework (Thomas, 2011a).

## B. STUDY AREA

The study area for the project coincides with the extent of the Wedington Sandstone. The unit is contained within northwest Arkansas and northeastern Oklahoma in the Springfield Plateau, Boston Mountains, and Arkansas Valley Physiographic provinces. The Wedington crops out in a belt approximately 60 miles wide from Stillwell, Oklahoma to Compton, Arkansas. The unit then dips into the subsurface, and extends in the subsurface as far south as Township 9N (Price, 1981). Samples were also collected from older sandstones in north-central Arkansas and southern Missouri for comparison.

## C. METHODS

### Sampling

Six samples of approximately ten pounds each were collected from outcrops of the Wedington Sandstone. The samples were obtained from fine to medium grained sandstones from different lithofacies, based off of the map by Price (1981) and the USGS quadrangle geologic map of Arkansas. These facies include channel, interdistributary bay, delta front, and prodelta facies. The offshore facies is found only in the subsurface and was not available for sampling. Since the laser ablation step requires a minimum size grain in order to obtain an adequate reading (laser diameter =30µm), more samples were taken from the channel facies due to their larger average grain size.

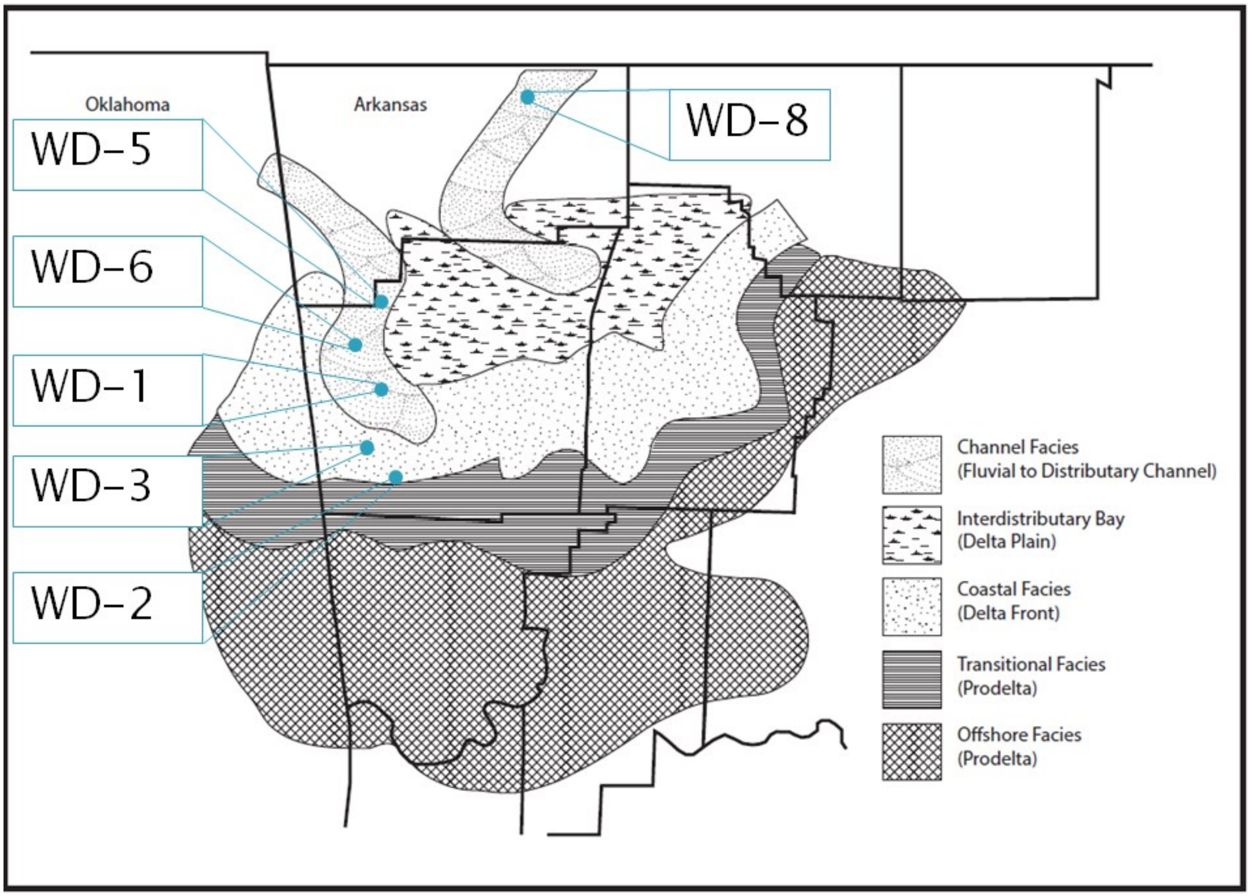


**Figure 2. Lithofacies Map Used to Collect Samples. Demonstrates Distribution of Wedington Sandstone and Locations of Analyzed Samples, (Modified from Price, 1981).**

Four additional samples were acquired and analyzed from other sandstone units in the midcontinent to provide a comparison to the zircon signature of the Wedington. These samples were collected from the Everton, Saint Peter, Bachelor Member, St. Joe, and Batesville Formations. At the same time, another student, Greg Buratowski, collected and analyzed zircons from eight samples of Morrowan Middle Bloyd Sandstone. By comparing the evolution of zircon signatures through time, changes in sediment sources to the basin as well as changes in regional tectonics can be identified. Understanding how deposition in the basin evolved prior to deposition of the Wedington is critical in constructing a model to explain its sedimentary provenance. Depending on their spatial distribution, older sandstones may also constitute potential sources for sediments in a multi-cycle sandstone.

**Procedures**

The samples were crushed at the University of Arkansas in Fayetteville into approximately one-inch diameter pieces that were fed into a disc mill to crush them to a fine sand size powder. Mineral separation was performed at the University of Arkansas at Little Rock. First, the powdered sand was fed onto a Wilfley table to separate the lightest minerals (mostly clay). The heavier portion was dried and then separated using the magnetic separator to get rid of the magnetic minerals. The remaining portion was placed in heavy liquid (Methylene Iodide, $\rho > 3.3 g/cm^3$) for further separation based on the density. The final heavy, nonmagnetic population from each sample was manually picked in alcohol under a binocular microscope using optical and physical characteristics and a needle tool. A statistically valid number of grains must be selected by both random and non-random picking methods to obtain a mixture of different grain types (Gehrels *et al*., 2010). The zircons were then mounted in epoxy and polished to expose a clean surface on which to perform the LA-ICP-MS process.

Cathodoluminesence images were taken to determine internal features of the zircons to assess overgrowths and locate laser targets. Due to the purposes of this study, zircons that contained overgrowths and multiple age zones, ablation pits were targeted at the oldest zone. During the analysis process, each zircon was marked on the image to keep track of points of analysis. This allows post-processing comparison of analyses with CL images.

**U-Pb Detrital Zircon Geochronology**

The zircons were analyzed using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) at the GeoAnalytical Laboratory at Washington State University. Analyses were performed using a New Wave UP-213 laser ablation system in conjunction with a ThermoFinnigan Element2 single collector double focusing magnetic sector ICP-MS. Each sampling consisted of a 6 second warm up, then an 8 second delay to allow the sample to travel through a helium circulation system to the plasma, followed by 35 seconds of rapid scanning of the masses $^{202}Hg$, $^{204}(Hg + Pb)$, $^{206}Pb$, $^{207}Pb$, $^{208}Pb$, $^{232}Th$, $^{235}U$, and $^{238}U$ (Chang *et al*., 2006). At the beginning of each session, the known standards Peixe and FC1 were analyzed until isotopic and elemental fractionation stabilized and the $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ ratio variance approached ±2% (Xie and Heller, 2013). These standards were then run again for every 5-15 collected zircons analyzed. A minimum of one hundred and ten zircons from each sample were analyzed at random, discounting grains that were not zircons or were too small for analysis. Ages were obtained from $^{207}Pb/^{206}Pb$ ratios for samples older than one billion years, and $^{206}Pb/^{238}U$ ratios for samples younger than one billion. Calibration of the measured ages of unknowns was made by comparison to the standards Peixe and FC1.

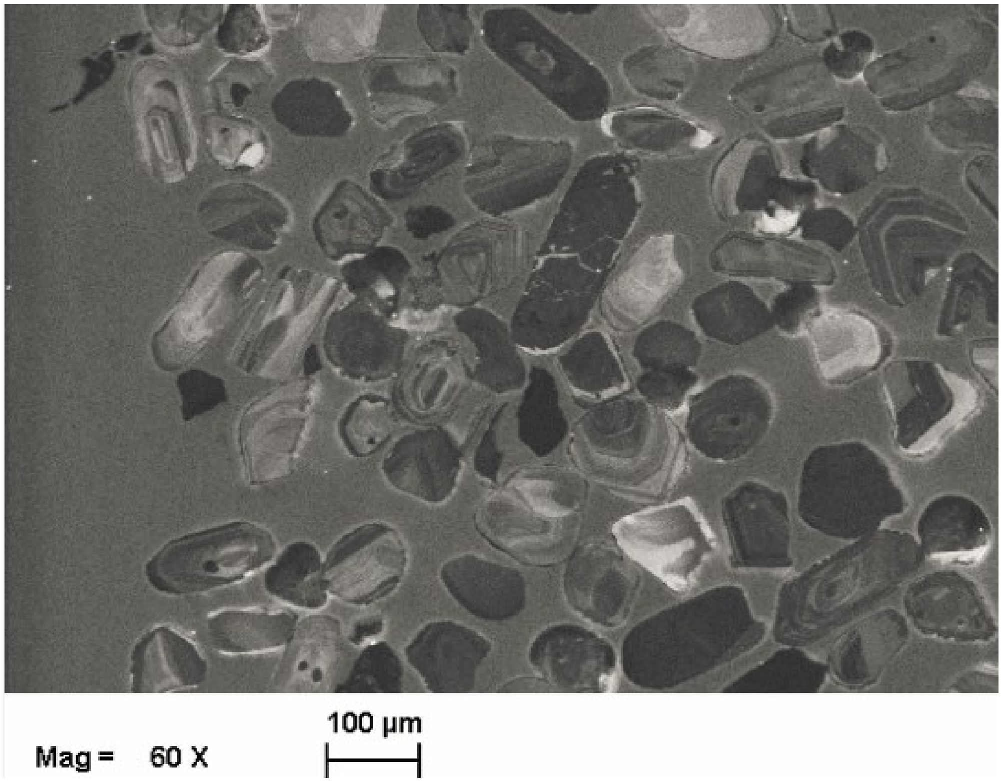


**Figure 3. Cathodoluminescence Image of Mounted Zircons.**

The data acquired from the zircon analysis must be processed and analyzed using an Excel-based program (Chang *et al*., 2006). All grain analyses were evaluated using Concordia diagrams and discordance calculations. A discordance value of less than ten percent was required in order for the data to be considered concordant. This rather strict value (some workers use up to twenty-five percent discordance) was chosen to make different age populations more easily differentiated. The age values are plotted on Probability-Density Plots using IsoPlot 3.0 (Ludwig, 2003), from which can be differentiated into individual populations. Plotting software available from the Arizona LaserChron Center web site was also used to analyze LA-ICP-MS data (http://www.laserchron.com). By interpreting the data based on age clusters and not individual zircon ages, the risk of the data being affected by an individual bad reading is eliminated (Gehrels *et al*., 2006).

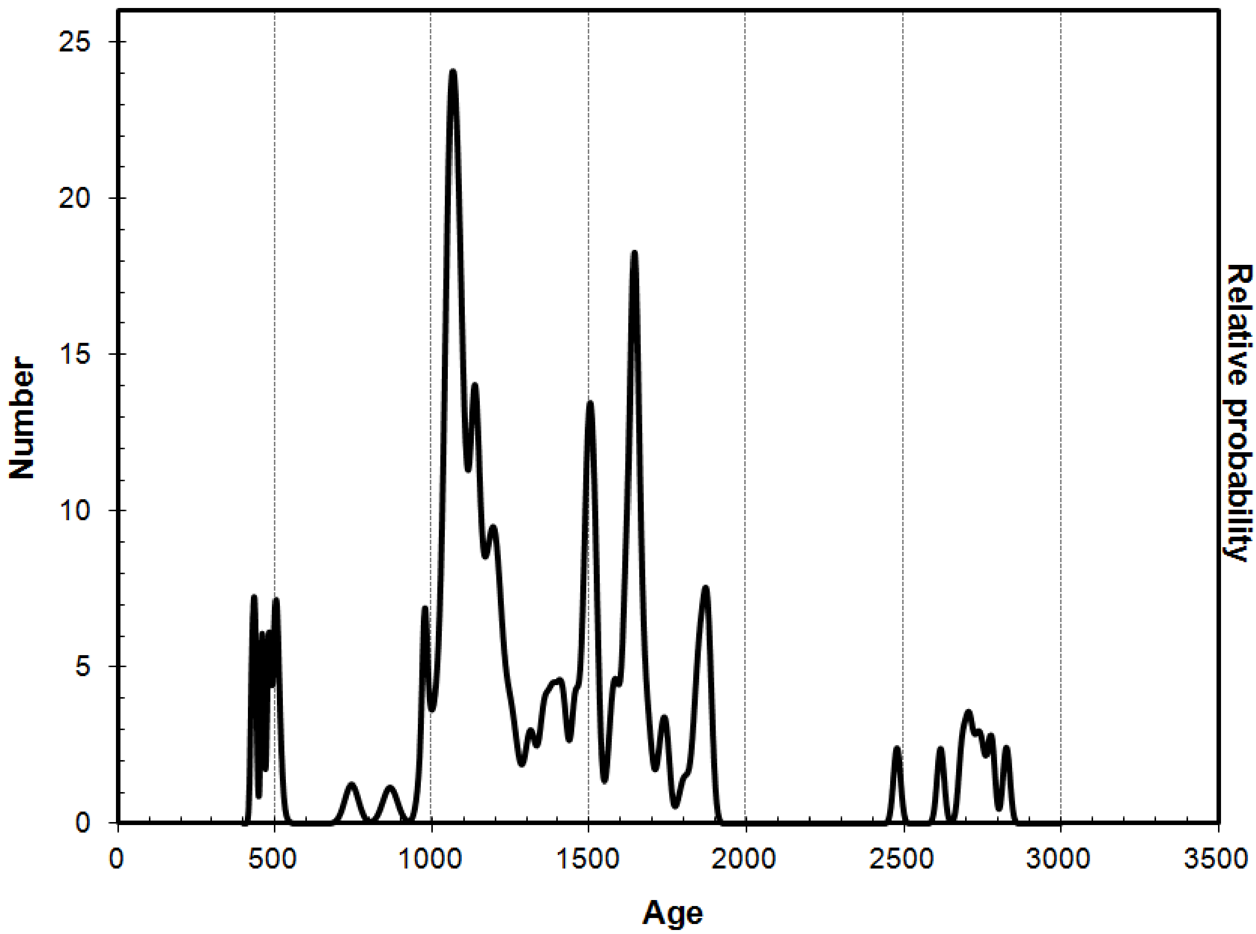


**Figure 4. Probability Density Plot showing zircon age distributions for Sample WD-8. Diagram constructing using IsoPlot 3.0 (Ludwig, 2003).**

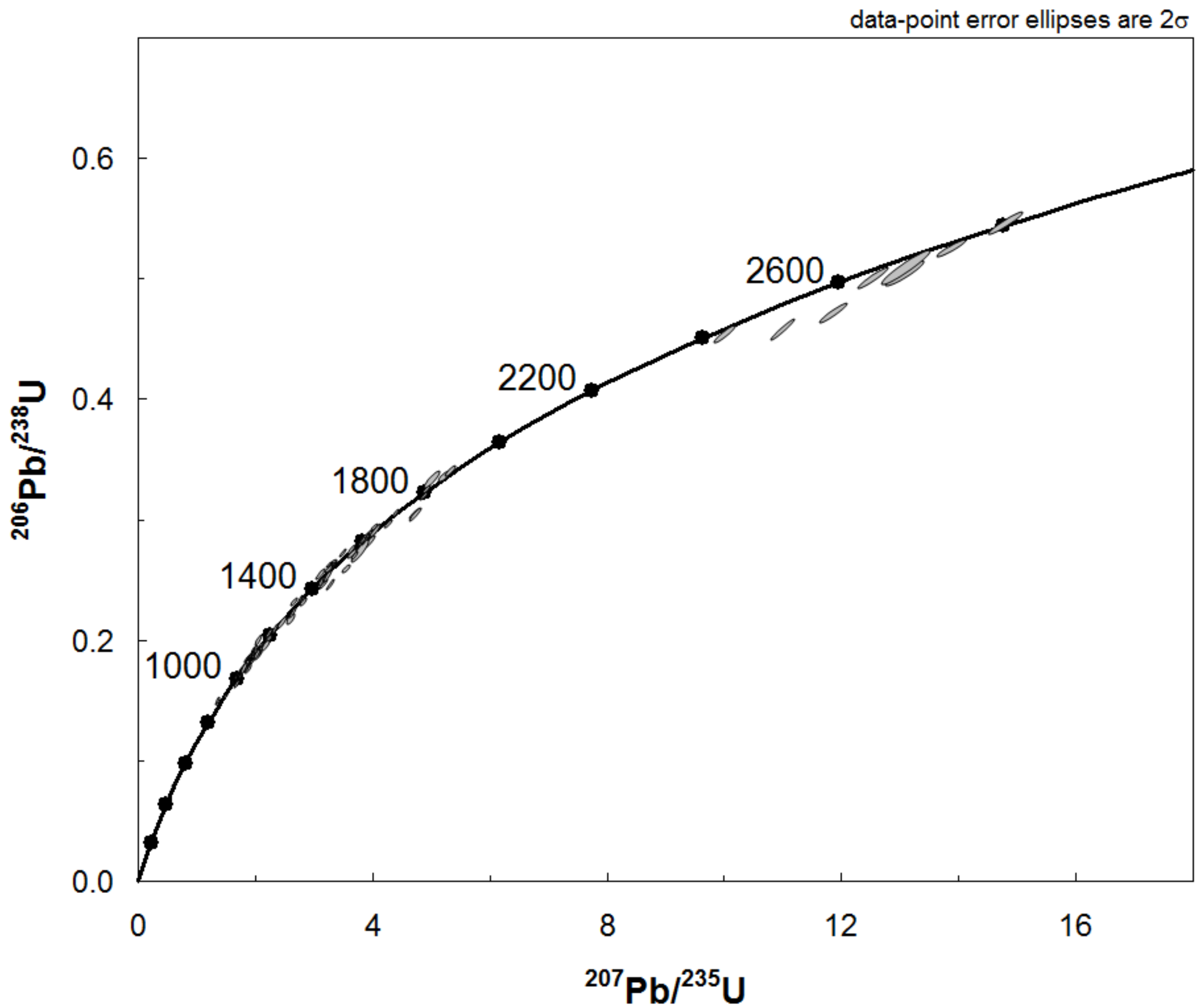


**Figure 5. Concordia Diagram for Sample WD-8. Concordia diagram constructed using Isoplot 3.0 (Ludwig, 2003).**

**Stratigraphy**

The stratigraphic distribution of the sand fraction within a delta is the best indicator of direction of sediment transport. The delta geometry can be used with paleocurrent measurements to place a high degree of constraint on the direction that sediment is being dispersed. For construction of a Wedington Sandstone map, subsurface thicknesses were determined from well logs obtained from the Arkansas Geologic Survey and loaned from Dr. Doy Zachry. Surface thicknesses from Price's thesis (1981) were used with interpreted subsurface thicknesses to make the isopach map.

In subsurface mapping, the most common way to map channel deposits, including those within a delta, is to measure the "net" sand thicknesses, which is the sandstone thickness that has porosity greater than a set amount, usually 8-10%. The Wedington Sandstone is present in both the surface and subsurface. Since there are no porosity values available for surface localities, a "gross" sand map is used to integrate surface thicknesses with subsurface thicknesses. Gross sand thickness is the total amount of sand present, independent of porosity.

Identification of the Wedington in the subsurface is a straightforward procedure. The sandstone of the Wedington has a low gamma ray reading situated between the higher gamma ray emitting upper and lower shales of the Fayetteville Formation. The organic rich lower Fayetteville shale has a "hot shale" signature that causes the gamma ray to be high enough to wrap around the log scale. The Fayetteville is situated between the Pitkin and Boone Formations, which are readily identifiable by their low gamma ray and high resistivity readings. The gamma ray log is used to identify how much sand is present in the Wedington for each log. The sand thickness is then plotted on a basemap and contoured by hand to derive a gross sand isopach map for the Wedington Sandstone.

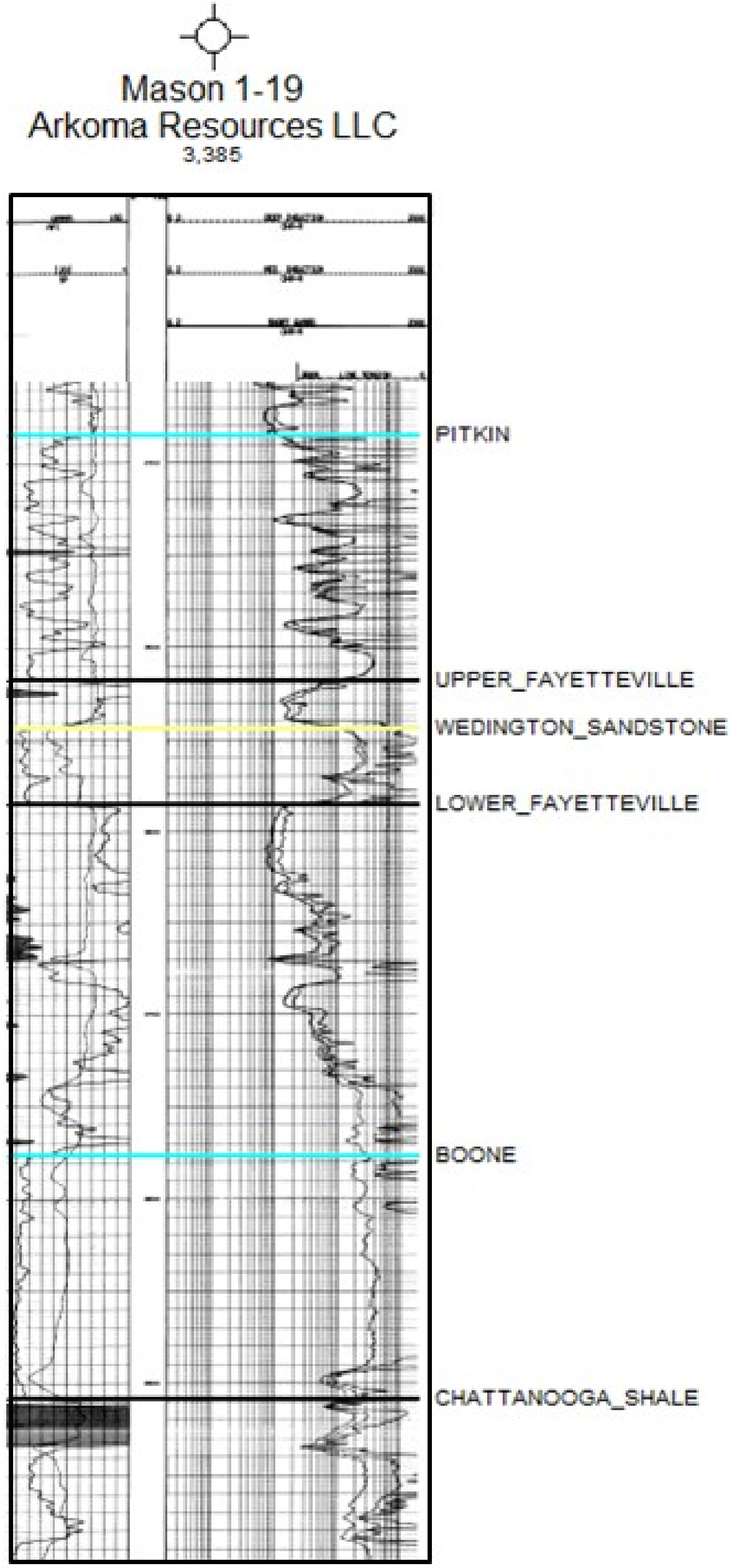


**Figure 6. Type Log for the Wedington Sandstone.**

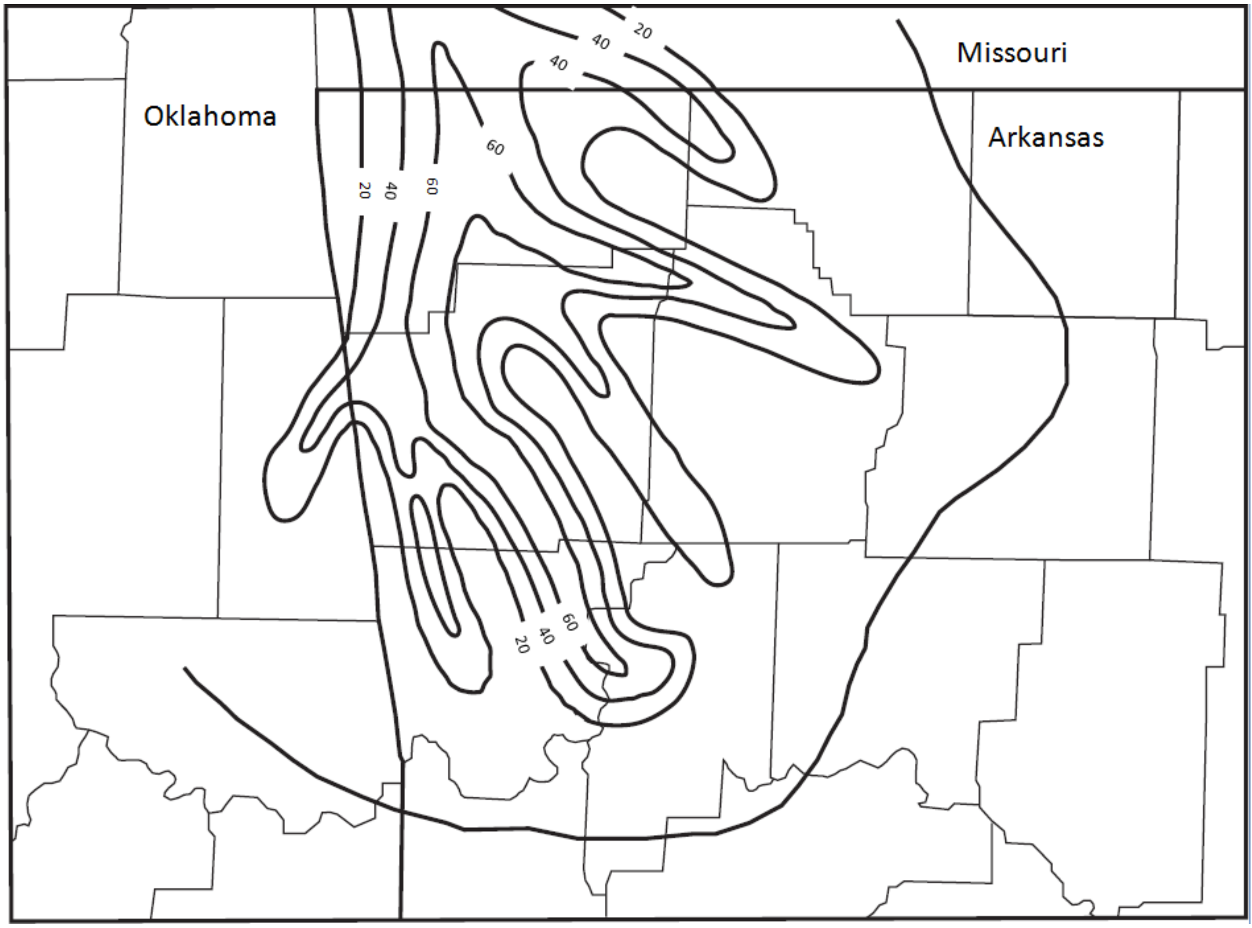


**Figure 7. Gross Sand Isopach Map showing Wedington Sandstone distribution and geometry in surface and subsurface.**

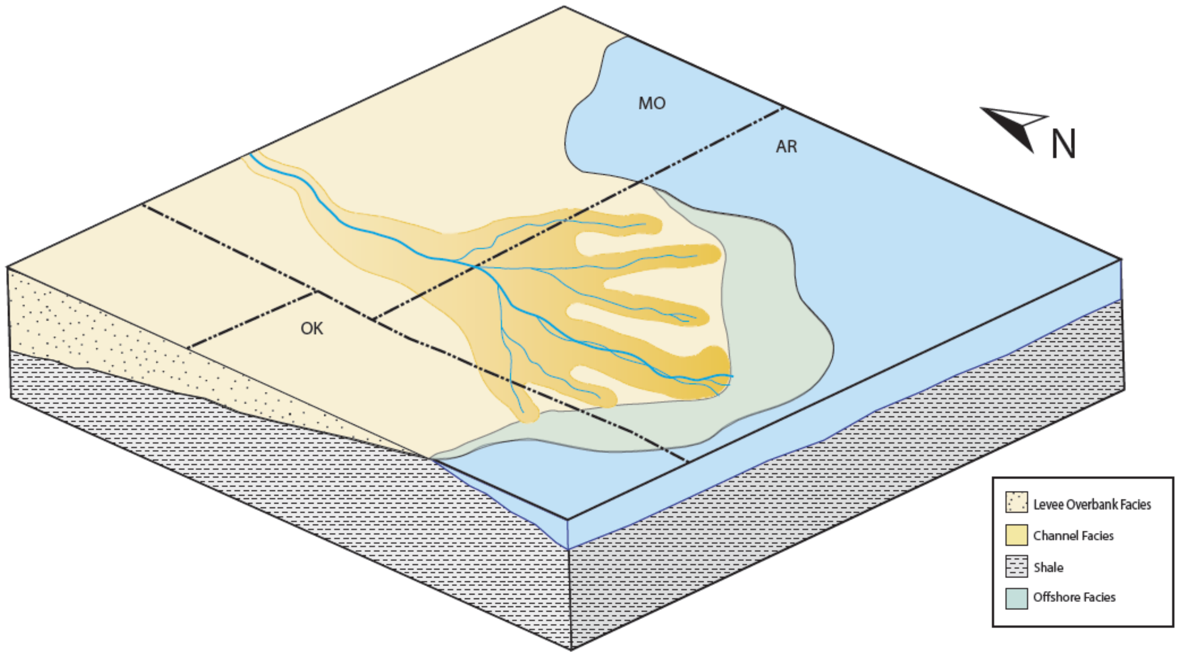


**Figure 8. Depositional Model for the Wedington Delta.**

## D. GEOLOGIC SETTING

Present day Arkansas can be divided into five separate geologic provinces: Ozark Dome, Arkoma Basin, Ouachita Mountains, Mississippi Embayment, and the Gulf Coastal Plain (Figure 9). Each region has a different tectonic history and the modern geology contained within each reflects their evolution. The Ozark Plateau, Arkoma Basin, and Ouachita Mountains consist primarily of Paleozoic sedimentary rocks, while the Mississippi Embayment and Gulf Coastal Plain contain younger Mesozoic and Cenozoic sedimentary rocks.

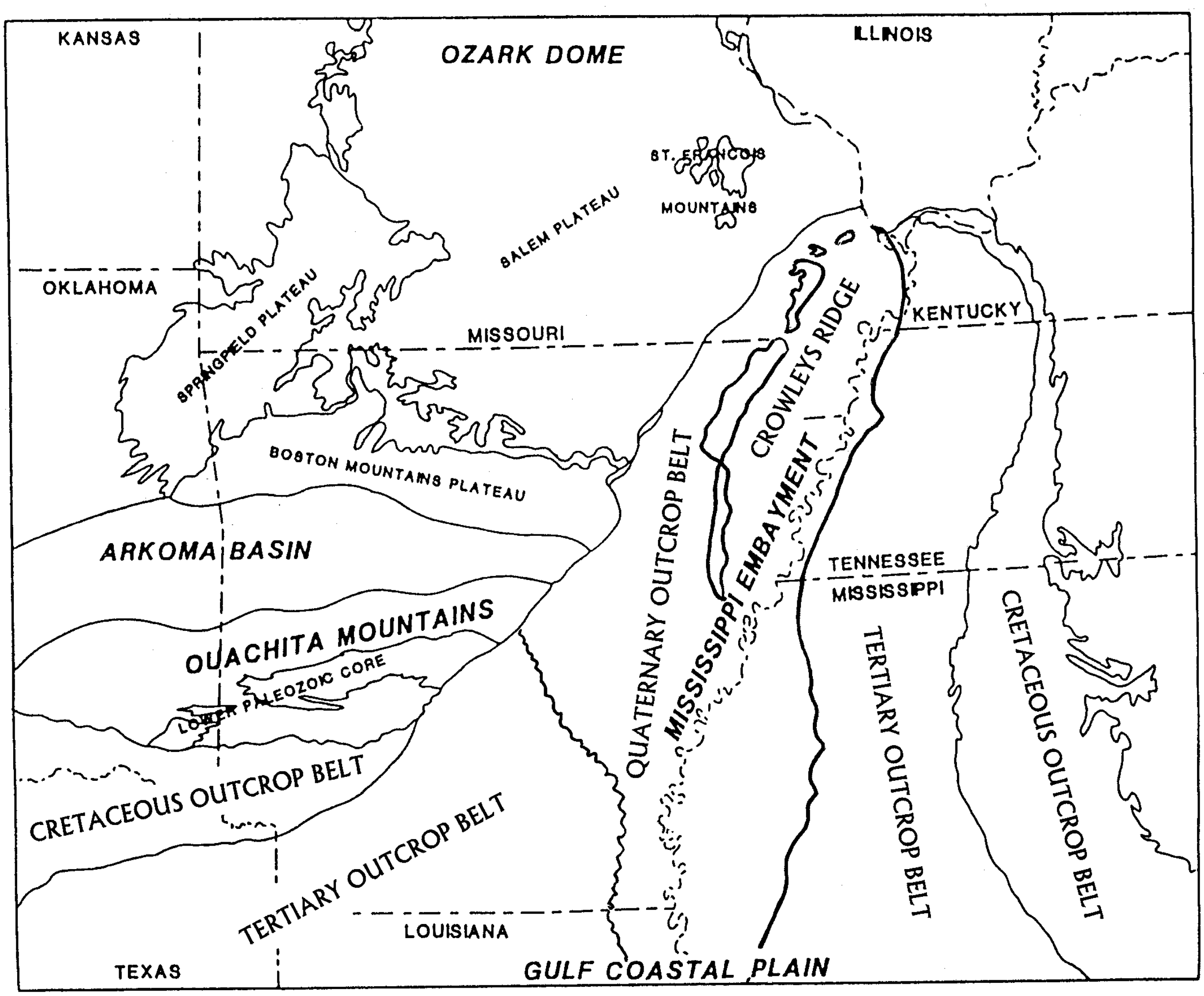


**Figure 9 – Geologic Provinces of Arkansas (Manger, Zachry, and Garrigan, 1988)**

The Ozark Dome region is a broad, asymmetrical, cratonic uplift extending from southeastern Missouri into northern Arkansas and northeast Oklahoma. The Precambrian granitic core of the Ozark Dome uplift is exposed in the St. Francois Mountains of southeastern Missouri. In Arkansas, the Ozark Dome is represented by the Springfield Plateau in the northwestern corner, the Salem Plateau in the north-central part of the state, and the Boston Mountains forming the southern extent of the uplift. The study area lies in this region. The Springfield Plateau is capped by Lower Mississippian carbonates overlying Ordovician dolostones. The Salem Plateau is capped by Lower Ordovician dolostones of the Arbuckle group. The Boston Mountains region is covered by the Middle Pennsylvanian clastic rocks and capped by the Atoka Formation (Moyer and Manger, 2006).

The Arkoma Basin is a foreland basin resulting from the collision of Laurentia with Gondwana along a south dipping subduction zone during the Ouachita orogeny that ended during the late Pennsylvanian. The basin extends from the Arbuckle Mountains in western Oklahoma into central Arkansas (Houseknecht and Kacena, 1983). The present low lying topography can be attributed to erosion by the Arkansas River as it flows eastward to the Mississippi River. The modern asymmetrical trough shape of the basin is a result of the Middle Mississippian-Late Pennsylvanian continent-continent collision. Prior to collision, the region was a passive margin characterized by shelf carbonates, shales, and transported ramp carbonates. Sediment loading began during the Late Mississippian from the formation of an accretionary wedge and caused rapid subsidence and thick sections of Pennsylvanian clastics accumulated in the basin in front of the orogen. A maximum of 35,000 feet of sedimentary rocks can be found in the deepest part of the basin (Moyer and Manger, 2006).

The Ouachita Mountains region contains sedimentary rocks ranging in age from Cambrian through Pennsylvanian. The Cambrian through Lower Mississippian section is comprised of deep water shales and cherts that accumulated very slowly in a starved basin. Beginning during the Late Mississippian and continuing through the Pennsylvanian, the approaching orogen provided large amounts of clastic sediments that accumulated as thick flysch deposits. These strata were intensely deformed into East-West trending synclines and anticlines during the collision of Laurentia with Gondwana to give them their present structural features.

The two regions of Arkansas characterized by Mesozoic and Cenozoic sediments are the Gulf Coastal Plain and the Mississippi Embayment. The Gulf Coastal Plain is an onshore extension of the Gulf of Mexico that began receiving sediments during the Mesozoic and Cenozoic as a passive margin developed following the rifting of Pangea. The Mississippi Embayment is a low-lying topographic region consisting primarily of Tertiary and Quaternary alluvial deposits of the Mississippi River. The region has its roots in the failed arm of the Reelfoot rift following the breaking up of Pangaea.

## E. PREVIOUS INVESTIGATION

The first formal naming of Chesterian strata was published by the Branner for the Arkansas Geological Survey in 1891 (Branner, in Simonds, 1891). He miscorrelated the Wedington Sandstone overlying the lower Fayetteville Shale as the Batesville Sandstone overlying the Moorefield Shale. The correct correlation was established by 1904 and the name Wedington was chosen from outcrops near Wedington Mountain by Adams (1905).

McNully (1966) performed a grain size study of the Wedington Sandstone in an unusual Master's thesis at the University of Arkanasas. He noted a lateral variation in grain size from coarsest in the northwest to progressively finer in the southeast. His conclusions was that the

Wedington Sandstone was deposited as a delta that was moving sediment from northwest to southeast into a marine environment, with a paleoshore trending 70-80° E (McNully, 1966).

In his 1981 Master's thesis titled "Transportational and Depositional History of the Wedington Sandstone (Mississippian), Northwest Arkansas", C. R. Price (1981) mapped the delta geometry of the Wedington Sandstone in outcrop and the subsurface. He identified five different facies within the Wedington Sandstone: channel, interdistributary bay, coastal sand, transitional, and offshore facies. Using paleocurrent measurements and delta geometry, he concluded that the delta prograded from northwest to southeast. Though he did no quantitative petrography, he noted that the Wedington was mostly quartz sand and concluded it was recycled from a cratonic source in the northern midcontinent region (Price, 1981).

T. L. Cochran (1989) performed a detailed petrographic study of the Batesville Sandstone. He believed that the Batesville resembled Chesterian sandstones in the Illinois Basin and proposed a delivery mechanism from the Michigan River delta. Cochran mentions that the Wedington Sandstone may share a common source with the western Batesville Sandstone, but the presence of feldspar in the western Batesville and the lack of feldspar in the Wedington would dispute this suggestion (Cochran, 1989).

D. E. Allen (2010) performed a comparative petrographic study of three Chesterian sandstones: the Batesville, Wyman, and Wedington. Using thin section modal analysis and Folk's Sandstone Classification scheme, he determined the Wedington Sandstone ranges from a lithic wacke to a quartzarenite. He described the Wedington as being mostly angular to subangular quartz, with rare to absent feldspar, and a significant clay component. For provenance, Allen postulated a metamorphic terrane to supply the MRFs, the adjacent Lower Mississippian (Boone) terrane to supply chert, and a third terrane of granitic composition, possibly the Nemaha Ridge (Allen, 2010).

**Figure 10. Contact of Wedington Sandstone with the top of Lower Fayetteville Shale at Outcrop WD-1. Lens cap near contact for scale. Photograph by Will Cains, November 28, 2013.**

## II. SOUTHERN MIDCONTINENT DEPOSITIONAL DYNAMICS

During the late Proterozoic, Laurentia occupied a central position in the supercontinent Rodinia. Late Precambrian rifting of Rodinia allowed a passive margin to develop on the southeast margin of Laurentia (Powell *et al*., 1993). This margin evolved into a south-dipping subduction zone by the Late Mississippian that culminated in a continent-continent collision during the Ouachita Orogeny (Houseknecht and Kacena, 1983). Along the southeast margin of Laurentia, the Southern Midcontinent experienced three broad sedimentologic phases that were heavily influenced by regional tectonics during the Phanerozoic: quiet Late Cambrian through Mississippian epicontinental sea deposition, Pennsylvanian Ouachita orogenic influenced sedimentation, and post-Permian rifting and development of a passive margin along the present continental margin (Johnson *et al*., 1989). Late Cambrian-Mississippian sedimentation directly affected the deposition of the Wedington Sandstone, and more attention will be directed toward strata deposited during this time.

Following development of a passive margin during the Cambrian, sea level transgression of the Sauk Sequence over exposed crystalline basement rocks deposited basal sandstones over a wide area of southeast Laurentia. These basal Cambrian sandstones are difficult to correlate regionally due to the thick sedimentary cover, but they are found over much of the midcontinent and have been termed the Reagan in Oklahoma, the Lamotte in Missouri, and the Hickory Sandstone near the Llano uplift in Texas (Johnson *et al*., 1989). Though this basal sandstone is not exposed in Arkansas, there is a high probability that it underlies the Arbuckle Group in northern Arkansas. The Lamotte Sandstone has been reported above Precambrian granite on well logs in Franklin County, Arkansas.

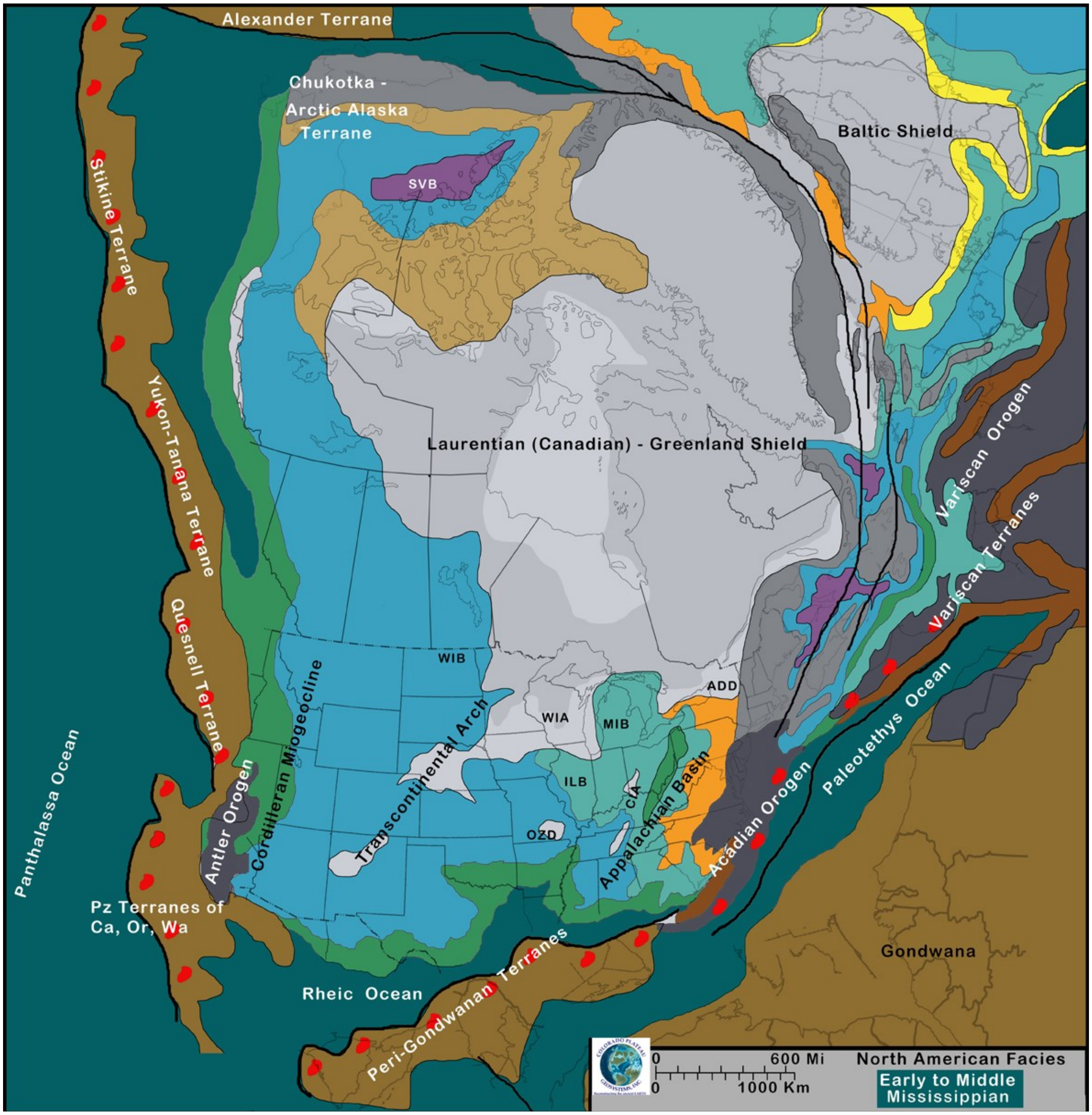


**Figure 11. Early to Middle Mississippian Sed-Tectonic Paleogeographic map showing major tectonic features impacting sediment dispersal patterns. (Blakey, 2013).**

From Middle Cambrian through the Mississippian, the southern midcontinent was covered by a shallow epeiric sea. Widespread carbonate deposition dominated during this time, with lesser amounts of marine sand and shale deposition. The Lower Ordovician of Arkansas is dominated by the limestones and dolomites of the Arbuckle Group, which were deposited on a vast carbonate platform that covered most of the craton interior and stretched along the southeast margin from New Mexico to New York (Johnson *et al*., 1989). In addition to limestones and dolostones, the Middle Ordovician section in Arkansas contains two major sandstone formations: the Everton and the St. Peter. The Everton is limited in lateral extent, ranging from northern Arkansas into southern Missouri (McFarland, 1998). The Everton Formation displays variable lithologies of dolostone, sandstone, and limestone. The St. Peter ranges up to 200 feet in thickness and is widely distributed across the craton interior, stretching north-south from Arkansas into Minnesota, and east-west from Nebraska to Ohio (Giles and Bonewits, 1930). The St. Peter unconformably overlies the Everton, and both are mature, well rounded, frosted, medium grain sized orthoquartzites. The petrographic similarity implies a similar sediment provenance, with the southern Canadian Shield being the likely source of the siliciclastic grains.

The Silurian and Early Devonian strata in northern Arkansas consist of the much less extensive limestones, shales, and cherts of the Cason, St. Clair, Lafferty, and Penters Formations. The Middle Devonian Clifty Formation is a thin unit that was originally designated a limestone, but outside of the type locality consists primarily of sand reworked from underlying Ordovician sandstones (Manger and Zachry, 2009). The Upper Devonian Woodford/Chattanooga Shale extends along the southern margin of Laurentia from Alabama westward to Oklahoma (McFarland, 1998). Initial transgression deposited a basal orthoquartzitic sandstone represented by the Sylamore and Misener Formations that are succeeded by an organic rich black shale

(Johnson *et al*., 1989). The black shales are interpreted to have been deposited in shallow water on a continental shelf. The source of the sediment and the cause of the shallow water anoxia remain unknown (Manger and Zachry, 2009).

During the Early Mississippian, the area from Kansas into Missouri and north Arkansas was dominated by a broad carbonate platform called the Burlington Shelf (Manger and Zachry, 2009). In Arkansas, the Lower Mississippian succession consists of the St. Joe and the overlying Boone Formation (Moyer and Manger, 2006). Reaching thicknesses up to 390 feet, Early Mississippian chert-bearing carbonates represent the thickest lithostratigraphic unit deposited on the southern midcontinent post-Lower Ordovician carbonates and pre-Middle Pennsylvanian clastics (Manger and Zachry, 2009; Johnson *et al*., 1989). They form a blanket over much of southern Laurentia, stretching from northeastern Illinois to southwestern Arizona, and northward into the Canadian Rockies (Manger and Zachry, 2009). This widespread cover would restrict access to clastic sediment sources in the midcontinent for overlying sandstones deposited onto the Arkoma Shelf.

By the Middle Mississippian, tectonic events associated with the approaching orogen from the south began to alter sedimentation in Arkansas. After epeiric seas retreated from the midcontinent during the Meramecan, the Burlington Shelf gave way to a less extensive shelf termed the Arkoma Shelf (Manger and Zachry, 2009). Deposition on the shelf continued in similar fashion to the Lower Mississippian, while thick turbidites of the Stanley Formation began to accumulate in the deepening Ouachita trough to south (Sutherland, 1988).

The Chesterian series of northern Arkansas is a third order depositional sequence bounded by type one unconformities on top and bottom (Moyer and Manger, 2006). Sea level transgression over an eroded Boone Limestone surface deposited the limestones of the Hindsville

Formation in western Arkansas that interfinger with the Batesville Sandstone to the east. The Batesville Sandstone is a probable first-order sandstone derived from sediment supplied by an Appalachian source to the east through the ancestral Mississippi Embayment. Conformably overlying the Hindsville/Batesville interval is the organic rich lower Fayetteville shale. The Wedington Sandstone was deposited during maximum flooding interval following the end of lower Fayetteville deposition. Still-stand conditions allowed the Wedington delta to form as a small constructive delta complex that prograded from the northwest to the southeast. Shale deposition of the organic poor upper Fayetteville member followed delta progradation as the Chesterian cycle entered highstand, and then regressive conditions (Moyer and Manger, 2006). The Pitkin Formation conformably overlies the upper Fayetteville shale and represents a shoaling upward sequence with the Mississippi-Pennsylvanian boundary at the top (Manger and Zachry, 2009).

The Late Mississippian-Early Pennsylvanian Ouachita orogeny drastically changed the depositional environment along the southeast margin of Laurentia. The broad epicontinental carbonate platforms that had dominated since the Cambrian were broken up by the Amarillo, Wichita, Arbuckle, Nemaha, and Muenster Uplifts, among others. Downwarping of the Arkoma, Anadarko, Ardmore, and Fort Worth Basins created new depocenters that began to fill with clastic sediment from the adjacent uplifts. The Anadarko and Arkoma basins each have over 5,000m of sediment deposited during the Pennsylvanian (Johnson *et al*., 1989). Deposition ended with the closure of the Ouachita Mountains during the Middle Pennsylvanian in Arkansas, but continued well into the Permian in basins to the west. The result of this is a thinner sedimentary cover over much of the cratonic interior, with drastic increases in sedimentary rock thickness in the foreland basins formed in front of the Ouachita thrust front.

Late Triassic rifting associated with the breakup of Pangea began to open the modern Gulf of Mexico. Mesozoic synrift sediments were deposited in south Arkansas as marine incursion inundated what is now the Gulf Coastal Plain (Fillon, 2007). Eventually, a passive margin developed and deposits of evaporates, sandstone, limestones, and shales accumulated along the southern margin as North America began to take its present shape.

## III. DETRITAL ZIRCON ANALYSIS

In total, 797 zircons were collected from samples at six outcrops of Wedington Sandstone in northwestern Arkansas. After culling analyses with greater than ten percent discordance, 565 concordant analyses were used for interpretation. Physical characteristics such as size, shape, color, and internal zoning varied greatly within and between samples. Analyzed zircon grains were between 100-200 µm in diameter, and varied from well rounded to euhedral in shape. Internal zoning ranged from un-zoned to minor zoned, and care was taken to place the ablation pit in the core of the oldest zone in the case of zoned zircons. Probability-density plots made using Ludwig's IsoPlot were used to visualize and interpret the data (Ludwig, 2003). Clusters of similarly aged zircons appear as peaks on these plots, and comparison with other samples allows for easy analysis between samples.

### A. WD-1

Sample WD-1 was collected from a road cut near the town of Lincoln. The Wedington Sandstone there forms a large bluff approximately 65 feet high. The contact with the underlying lower Fayetteville shale can be seen in the ditch along the road. The sandstone is fine-medium grained and tan to grey in color. A total of 139 individual zircons were analyzed from sample WD-1. After removing discordant analyses, 119 zircon ages were used for interpretation (<10% discordance). Ages from sample WD-1 ranged from 398 ± 5.2 Ma to 2824 ± 14.3 Ma. Within this age spectra there are several peaks at ~440, ~1000, ~1100, ~1320, ~1640, ~1800, and ~2760 Ma. The largest peak occurs at ~1040 Ma (n = 31) in the 930-1240 Ma range, which encompasses 59% of the zircons in sample WD-1 (n = 70). 10% of the zircons date back to the Archean (n = 12). Both 398-472 Ma and 1614-1810 Ma ranges contain 9% of the ages. 6.7% fall in the 1300-1500 Ma range, and 5.9 % fall in the 1800-2300 Ma range.

**Figure 12. Roadcut along Highway 62 showing Outcrop WD-1. Photograph by Will Cains, November 28, 2013.**

## B. WD-2

111 concordant analyses were used for interpretation from the 145 WD-2 zircons analyzed. Zircons from this sample ranged in age from 436 ± 3.6 Ma to 2818 ± 6.5 Ma. The largest peak occurs at 1080 Ma (n = 20). The 940-1300 Ma range contains 51% of the zircons from the WD-2 sample (n = 57). Smaller peaks occur at ~440, ~1280, ~1640, ~1720, ~1860, and ~2800 Ma. 5.4% of the grains analyzed ranged from 350-500 Ma (n = 6), 12.6% ranged from 1300-1500 Ma (n = 14), 18.9% ranged from 1600-1800 Ma (n = 21), 6.3% fell into the 1800-2300 Ma range (n = 7), and 5.4% were greater than 2500 Ma (n = 6).

| ***Number of Grains*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Acadian - Taconic** | **Iapetan Synrift** | **Grenville** | **Midcontinent** | **Yavapai - Mazatzal** | **Paleo-proterozoic** | **Archean** |
| **Sample** | **Total #** | **350 - 500** | **500-760** | **950-1300** | **1300-1500** | **1600-1800** | **1.8-2.3 Ga** | **>2.5 Ga** |
| WD-1 | 119 | 11 | 0 | 70 | 8 | 11 | 7 | 12 |
| WD-2 | 111 | 6 | 0 | 57 | 14 | 21 | 7 | 6 |
| WD-3 | 48 | 0 | 0 | 18 | 12 | 13 | 4 | 1 |
| WD-5 | 95 | 9 | 1 | 50 | 14 | 14 | 0 | 7 |
| WD-6 | 83 | 2 | 2 | 46 | 8 | 15 | 6 | 4 |
| WD-8 | 109 | 6 | 1 | 49 | 16 | 23 | 6 | 8 |
| TOTAL | 565 | 34 | 4 | 290 | 72 | 97 | 30 | 38 |
| ***Percentage*** | | | | | | | | |
| | | **Acadian - Taconic** | **Iapetan Synrift** | **Grenville** | **Midcontinent** | **Yavapai - Mazatzal** | **Paleo-proterozoic** | **Archean** |
| **Sample** | **Total #** | **350 - 500** | **500-760** | **950-1300** | **1300-1500** | **1600-1800** | **1.8-2.3 Ga** | **>2.5 Ga** |
| WD-1 | 119 | 9.2 | 0.0 | 58.8 | 6.7 | 9.2 | 5.9 | 10.1 |
| WD-2 | 111 | 5.4 | 0.0 | 51.4 | 12.6 | 18.9 | 6.3 | 5.4 |
| WD-3 | 48 | 0.0 | 0.0 | 37.5 | 25.0 | 27.1 | 8.3 | 2.1 |
| WD-5 | 95 | 9.5 | 1.1 | 52.6 | 14.7 | 14.7 | 0.0 | 7.4 |
| WD-6 | 83 | 2.4 | 2.4 | 55.4 | 9.6 | 18.1 | 7.2 | 4.8 |
| WD-8 | 109 | 5.5 | 0.9 | 45.0 | 14.7 | 21.1 | 5.5 | 7.3 |
| Total | 565 | 6.0 | 0.7 | 51.3 | 12.7 | 17.2 | 5.3 | 6.7 |

**Table 1. Distribution of all concordant zircon ages in number and percentage.**

## C. WD-3

Sample WD-3 was collected from an exposure along the side of a creekbed just south of the town of Cane Hill on Arkansas 45. The Wedington here is a tight, fine grained, tan colored sandstone. Of the 110 zircon grains analyzed from sample WD-3, only 48 analyses had a concordance value less than 10%. This is due to the sample having a smaller average grain size than other samples. Zircons analyzed from this sample ranged from 1003 ± 15.2 Ma to 2568 ± 9.2 Ma. Sample WD-3 is the only Wedington sample analyzed that did not contain zircons less than 1000 Ma. Prominent peaks occur at ~1020, ~1375, ~1620, with lesser peaks at ~1150, ~1800, ~2050, and ~2550 Ma. Zircons in this sample were more evenly distributed between the 950-1250, 1300-1500, and 1600-1800 Ma groups.

Most workers try to obtain approximately 100 concordant ages, having fewer concordant analyses increases the chance that an age population may not be recognized in a sample (Gehrels *et al*., 2006). As a result, sample WD-3 is included in this study, but less weight is given to interpretations from this age distribution. The distribution of age peaks on the probability density plot for this sample is significantly different than the distribution in other samples. WD-3 is the only sample with the largest peak occurring in the 1600-1800 Ma range, the rest having the most prominent peak in the 950-1200 Ma range. There are also no peaks below the 1000 Ma peak.

## D. WD-5

Sample WD-5 was collected from near the top of an outcrop of sandstone by Wedington Gap. The Wedington Sandstone here forms a bluff 25 ft. high and consists of fine to medium grained, moderately sorted, subrounded quartz grains. Large scale trough cross bedding with individual beds approximately 12 inches thick indicates channel facies. In total, 135 individual zircons were analyzed from sample WD-5, with 95 zircons being used for final interpretation. Age ranges from sample WD-5 ranged from 420 ± 6.7 Ma and 3590 ± 9.6 Ma. This sample contained the oldest zircon dated from Wedington Sandstone samples. The largest peak occurs at ~1100 Ma, with the age range of 950-1300 Ma making up the most prominent grouping (n = 50). Significant peaks also occur within the ranges 420-500 Ma (n = 9), 1330-1500 Ma (n = 14), 1520-1770 (n = 14), and >2500 Ma (n = 7).

**Figure 13. Outcrop WD-5 (Wedington Gap). Note stacked sets of trough cross beds. Lens cap near middle of picture for scale. Photograph by Will Cains, November 28, 2013.**

## E. WD-6

Sample WD-6 was collected from an exposure just down the hill off of Jackson Highway. WD-6 is a fine-medium grained, mostly grey in color, trough cross bedded sandstone. Exposures down the road along Lincoln Lake show the Wedington is at least 45 ft. thick in the vicinity. Stacked sets of large scale trough cross beds make up the majority of the exposure. A total of 83 concordant analyses were obtained for interpretation from 130 WD-6 zircons. Zircons ranged from 432 ± 3.8 Ma to 3036 ± 6.2 Ma in this sample. The most prominent peak occurs at ~1050 Ma (n = 17), with lesser peaks at ~460, ~1450, ~ 1640, ~1760, ~1980, and ~2400 Ma. An unusual characteristic of the age distribution for sample WD-6 is the presence of two zircons dating in the 500-760 Ma, with only four total zircons from all samples falling in this range.

## F. WD-8

The northernmost sample collected, WD-8 was collected from a 48 foot thick section of Wedington Sandstone that forms the caprock of a bluff near Pea Ridge National Military Park. The Wedington here is a coarse grained sandstone and petrographically comprises a true quartzarenite (Allen, 2010). Sample WD-8 yielded zircon ages between 428 ± 5.6 Ma and 2827 ±11.2 Ma. Several age peaks at ~500, ~1050, ~1500, ~ 1620, ~1850, and ~2700 Ma. About 45% of the ages fall in the 950-1300 Ma range, 21% in the 1600-1800 Ma range, and 15% in the 1300-1500 Ma range. The rest of the age groups make up less than 10% of the age distribution.

**Figure 14. Outcrop of Wedington in Pea Ridge National Military Park (Sample WD-8). Massively bedded sandstone underlying horizontal, thin bedded sandstone. Exposures down hill demonstrate similar thin bedding. Photograph by Will Cains, November 28, 2013.**

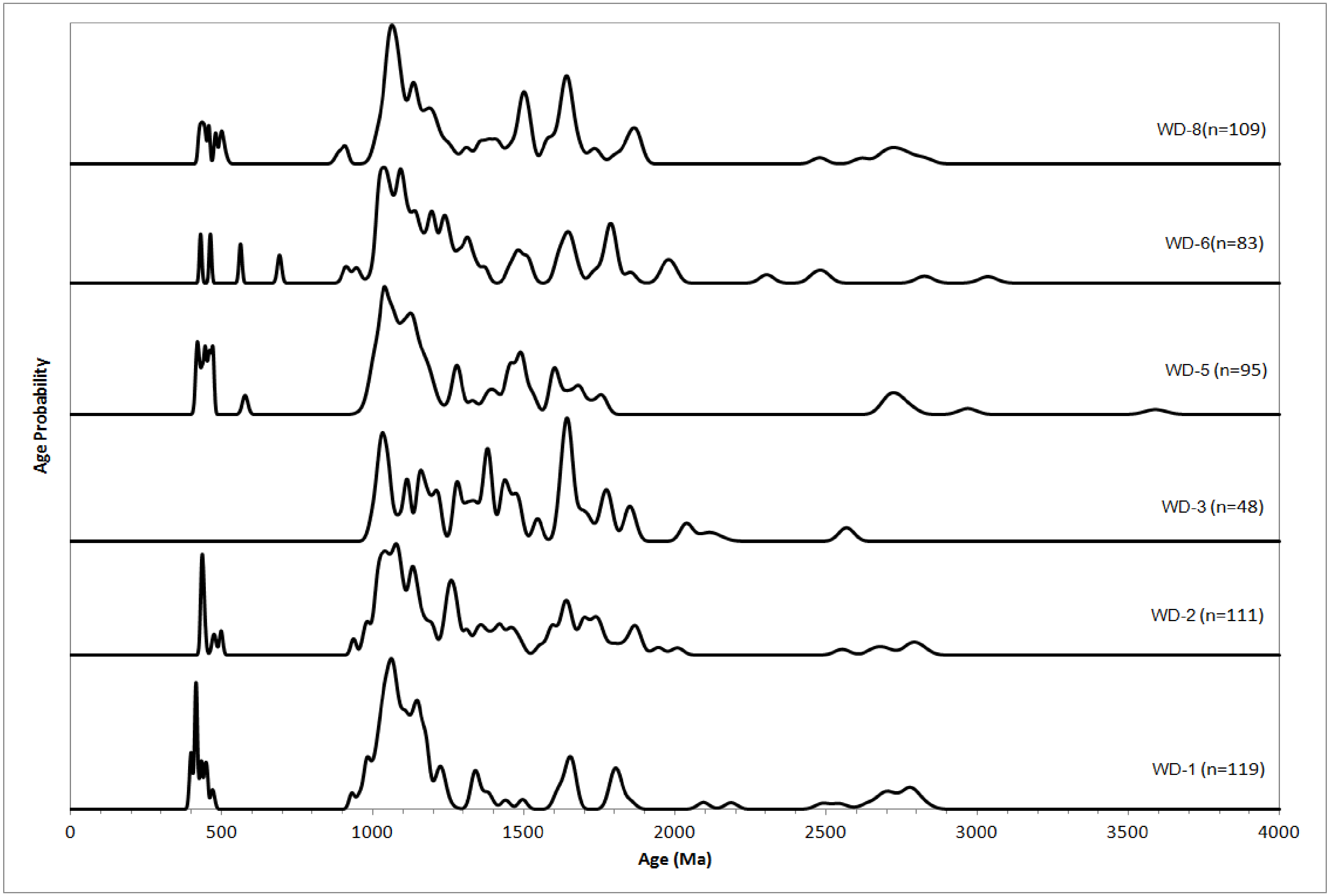


**Figure 15. Probability density plots for detrital zircons analyzed from each sample. Plot constructed using software available from Arizona LaserChron Center Web Site (http://www.laserchron.org).**

## IV. POTENTIAL PROVENANCE TERRANES

The calculated ages of detrital zircons gives the absolute date of the crystalline rock from which the zircon grain originated. The North American craton was assembled over billions of years from plate collisions of microcontinents (Slave, Rae-Hearne, Superior), volcanic arcs, and oceanic terranes along active plate margins (Whitmeyer and Karlstom, 2007). This continual process of collision and accretion has resulted in a multitude of potential zircon source terranes that range from recent to Archean in age. This section focuses on the protosource of the zircons, which are the crystalline basement rocks within the North American craton that are believed to be potential sources for the zircons collected from the Wedington Sandstone. Sediment source from other continental blocks is possible, but unlikely, based on direction of sediment transport interpreted from stratigraphy and paleocurrent measurements from Price (1981).

### A. ARCHEAN (>2.5 Ga)

All samples analyzed contain zircons over 2500 Ma. For a Laurentian protosource, the Archean basement rocks of the Canadian Shield are the most likely candidate. The Canadian Shield forms the core of the Laurentian craton and was assembled in the Paleoproterozoic from collision of Archean microcontinents (Whitmeyer and Karlstom, 2007). These continent-continent collisions took place from 1.96 Ga to 1.80 Ga for the Slave-Rae-Hearne-Superior Provinces and resulted in large scale mountain belts that would supply Archean zircons into adjacent basins. The southernmost provinces of the Canadian Shield, the Superior and Wyoming Provinces, are the most proximal sources of Archean grains. On the southern margin of these two provinces are thick miogeoclinal successions (Huronian and Snowy Pass Supergroups) dating from 2.0 to 2.5 Ga (Whitmeyer and Karlstom, 2007). Petrographic investigation of units containing large percentages of Archean zircons (Bachelor, St. Peter, and Everton) indicates that grains derived from these provinces have undergone multiple cycles of sedimentation.

## B. PALEOPROTEROZOIC (1.8-2.3 Ga)

Every Wedington sample analyzed contained four to seven zircons between 1.8 and 2.3 Ga except WD-5, which contained none. Paleoproterozoic provenance terranes on the Laurentian craton can be found in the Canadian Shield. Within the Laurentian core, the Trans-Hudson Orogen and the Penokean Province stand out as the two most likely protosources of 1.8-2.3 Ga zircons. The Trans-Hudson Orogen resulted from the collision and suturing of the Hearne, Wyoming, and Superior cratons between 1.78 and 1.85 Ga. The Trans-Hudson orogenic belt stretches from the northern United States to Hudson Bay and consists of reworked Archean crust, accreted magmatic arcs, and a small archean crustal fragment called the Sask Craton (Whitmeyer and Karlstom, 2007). Stretching elongate from Minnesota to the Grenville orogen front in Ontario, the Penokean Province is a belt of igneous and metasedimentary rocks that is roughly coeval with the Trans-Hudson Orogen (Whitmeyer and Karlstom, 2007). Archean basement and overlying miogeoclinal sediments were deformed and metamorphosed as the southern margin of the Superior craton collided with oceanic island-arcs (Barovich *et al*., 1989). Both the Trans-Hudson Orogen and Penokean Orogen resulted in uplifted terranes that would be significant sediment sources.

## C. YAVAPAI-MAZATZAL PROVINCES (1.6-1.8 Ga)

Zircons ranging in age from 1.6 to 1.8 Ga constitute a tenth to a quarter of the zircons analyzed from Wedington Sandstone samples. These grains were interpreted to be derived from the Yavapai (1.7-1.8 Ga) and Mazatzal (1.6-1.7 Ga) Provinces. The Yavapai Province stretches in a wide northeast trend that stretches from southwest Arizona, through Colorado, and into the subsurface of the midcontinent (Condie, 1993). The Yavapai basement rocks consist of mostly juvenile arc crust accreted to Laurentia through a series of arc collisions from 1.7 – 1.8 Ga. The collision of ocean arc crust with the Laurentian craton resulted in an orogenic belt from 1.68 –

1.71 Ga that supplied zircons of Yavapai age onto the craton (Whitmeyer and Karlstom, 2007). The Mazatzal Province also extends in a northwest trend from southwestern United States, through the northern midcontinent, and into eastern Canada. Mazatzal basement rocks consist of juvenile arc igneous rocks ranging from 1.6 Ga rhyolites to 1.68 Ga greenstone successions that include oceanic basalt, basaltic andesite, dacitic tuffs, and rhyolites (Whitmeyer and Karlstom, 2007). The province formed as a result of the accretion of several crustal blocks with the Laurentian craton from 1.65 – 1.60 Ga during the Mazatzal Orogeny (Amato *et al*., 2008). The Mazatzal Orogeny reactivated Yavapai thrust faults as well as uplifting Mazatzal age source terranes, supplying zircons of both ages onto the midcontinent. The two provinces are semi-parallel to each other and formed in similar manners. The suture zone between the two provinces been proposed along the Jemez lineament (Whitmeyer and Karlstom, 2007).

## D. MIDCONTINENT GRANITE-RHYOLITE PROVINCE (1350-1550 Ma)

All Wedington samples analyzed contained zircons in the 1300-1500 Ma range. The most obvious source terrane for these zircons is the Midcontinent Granite-Rhyolite Province, which includes the basement rocks underlying northwest Arkansas. 1300-1500 Ma crust lies adjacent to Mazatzal crust and extends along what would have been the southeast margin of Laurentia from northern Mexico into northeast Canada. This crust consists of juvenile crusts ranging from 1550-1400 Ma and intruded granitoids ranging from 1480-1350 Ma (Whitmeyer and Karlstom, 2007). Most of this province is covered by Paleozoic and younger strata, but modern day outcrops can be seen near Spavinaw, Oklahoma (~30 miles west), and the St. Francois Mountains of Missouri (~240 miles northeast).

## E. GRENVILLE PROVINCE (950-1300 Ma)

The largest percentage (~51%) of all zircons analyzed from Wedington samples occurr at 950-1300 Ma. This peak is interpreted to be associated with Grenville orogenic terranes in the Appalachian Mountains Region. The Grenville Province is the exhumed root of a major orogenic belt that resulted from the continent-continent collision that was part of the assembly of the supercontinent Rodinia (Tover *et al*., 2006; Whitmeyer and Karlstom, 2007). The Grenville deformation front on the south and eastern margins of North America is approximately 4,000 km long and stretches from northern Mexico into Labrador, Canada. The Grenville orogeny consisted of multiple stages that included the suturing of continental blocks (Elzeverian Orogeny), the intrusion of anorthositic plutons (Shawingian phase), and collision with other large continental masses (Ottawan Orogeny) (Whitmeyer and Karlstom, 2007). Grenville aged zircons are found in sandstones throughout Laurentia. This is due to a combination of high zircon fertility, widespread distribution of terranes, and repeated uplift resulting from multiple orogenic events associated with the Appalachians.

## F. IAPETAN SYNRIFT (500-760 Ma)

Zircons dating from 500-760 Ma are rare in Wedington samples. Only five total zircons analyzed from three of the samples are in this range. These zircons are interpreted to be derived from rocks related to the late Precambrian-Cambrian rifting of Laurentia that broke up Rodinia. Volcanic activity associated with active rifting supplied the zircons into synrift clastic sedimentary rocks. Individual rifts include the Blue Ridge, Ouachita, and Marathon rifts, which are presently buried beneath younger Appalachian/Ouachita allochthons and sedimentary cover (Thomas, 2011b).

## G. ACADIAN-TACONIC OROGENIC TERRANES (350-500 Ma)

Every sample except for one (WD-3) contained multiple zircons in the 350-500 Ma range. Almost 10% of the zircons analyzed from sample WD-5 fell into this category. These zircons were interpreted to be sourced by terranes associated with the Acadian and Taconic Orogenies. The two terranes lie adjacent to each other along the eastern margin of North America. The Ordovician Taconic Orogeny resulted from the collision of eastern Laurentia with either an island-arc system over an east dipping subduction zone or the western margin of Gondwana between approximately 465-445 Ma (Stanley and Ratcliffe, 1985; McLennan *et al*., 2001). The Devonian Acadian Orogeny resulted from a collision between approximately 400-350 Ma of the Avalon terrane with the eastern margin of Laurentia following the Taconic Orogeny. The Acadian and Taconic Orogenies are often listed together, due to volcanism and metamorphism occurring almost continuously between them (McLennan *et al*., 2001).

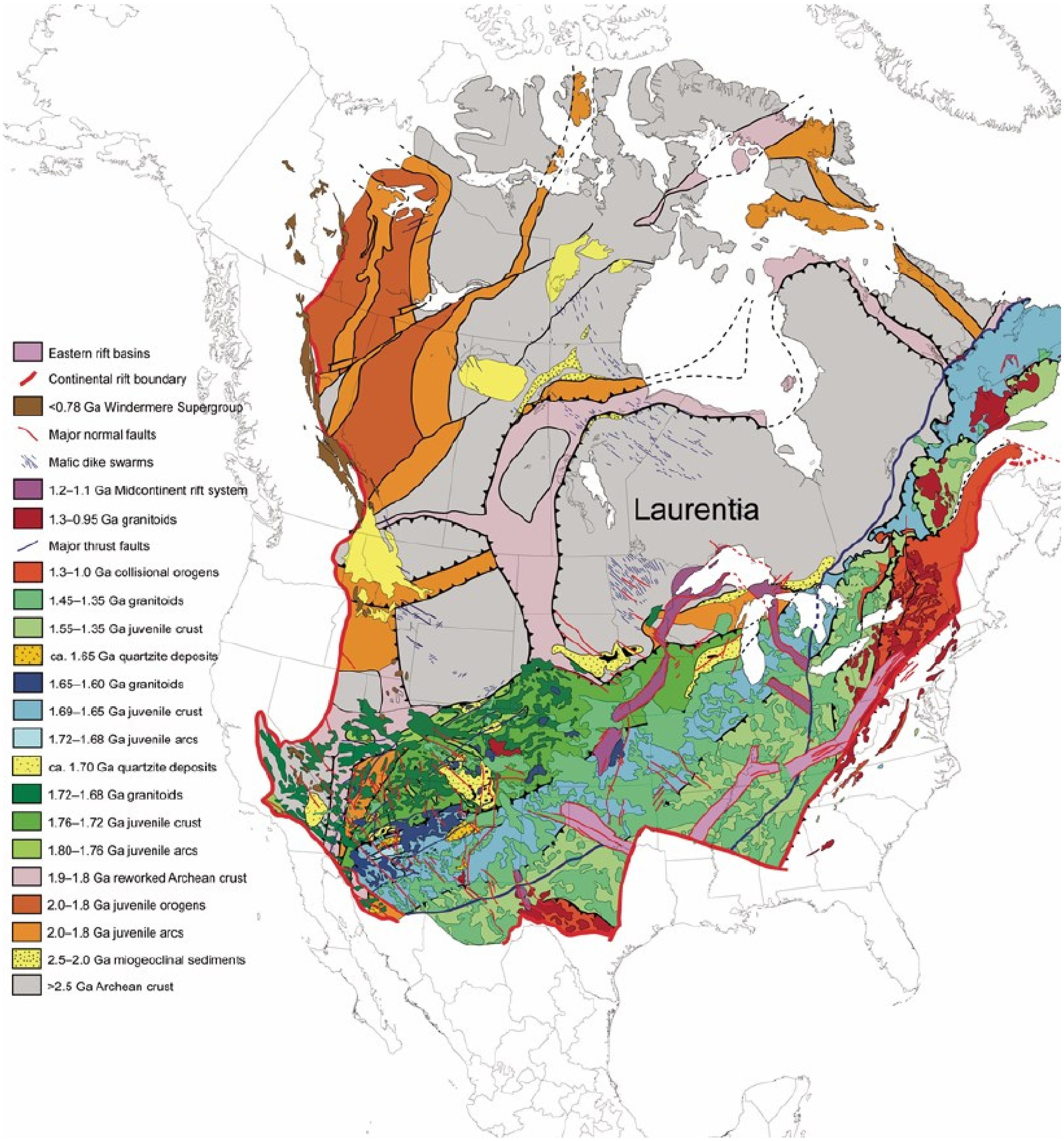


**Figure 16. Precambrian Basement Features of North American terranes (Whitmeyer and Karlstom, 2007).**

## V. PROVENANCE DISCUSSION

Evaluating provenance for clastic sedimentary rocks is a difficult process that involves many variables. Sandstones will commonly contain sediment from multiple crystalline sources. The broad range of detrital zircon ages present within the Wedington Sandstone demonstrates this complexity. Virtually all of the major potential basement sources within the Laurentian craton are present within the Wedington. Sediment dispersal pathways must be able to link the potential source areas with the location of deposition.

The potential source areas must also satisfy petrographic requirements. Most of the petrographic data for the Wedington Sandstone comes from Allen (2010). His modal analyses indicated two source terranes were required to supply the sediment. The first source is a metamorphic terrane to supply the metamorphic rock fragments and polycrystalline quartz. A metamorphic terrane could also supply the extremely small amount of plagioclase feldspar. The second terrane required is a chert-bearing terrane, with the adjacent Lower Mississippian chert bearing carbonates the definitive source. The amount of chert found in the Wedington is suprisingly low, indicating that sediment moved over the Lower Mississippian carbonates that cover most of the midcontinent with minimal erosion (Allen, 2010). This is probably due to the fact that sea level was at a maximum flooding interval during the deposition of the Wedington Sandstone, resulting in an increased base level and diminished ability for streams to erode downward.

Allen's modal analysis of Wedington thin sections never counted any feldspar grains. Plagioclase grains were noted in very rare abundance, as well as a single grain of potassium feldspar. Clay matrix, on the other hand, was abundant in Wedington samples (up to 32%). Hjulstrom's diagram would indicate that clay should not be deposited together with coarser quartz grains, especially in the channel deposits where most samples were collected. Allen concluded that the clay formed from weathering of claystone clasts deposited with the sand grains (Allen, 2010). Feldspar deposited with the quartz grains in the Wedington would have been heavily weathered from transportation, and may have been further altered to clay during diagenesis. As a result, feldspar bearing source terranes, including crystalline rocks and first cycle sediments, are not discounted as potential sources for Wedington sediment.

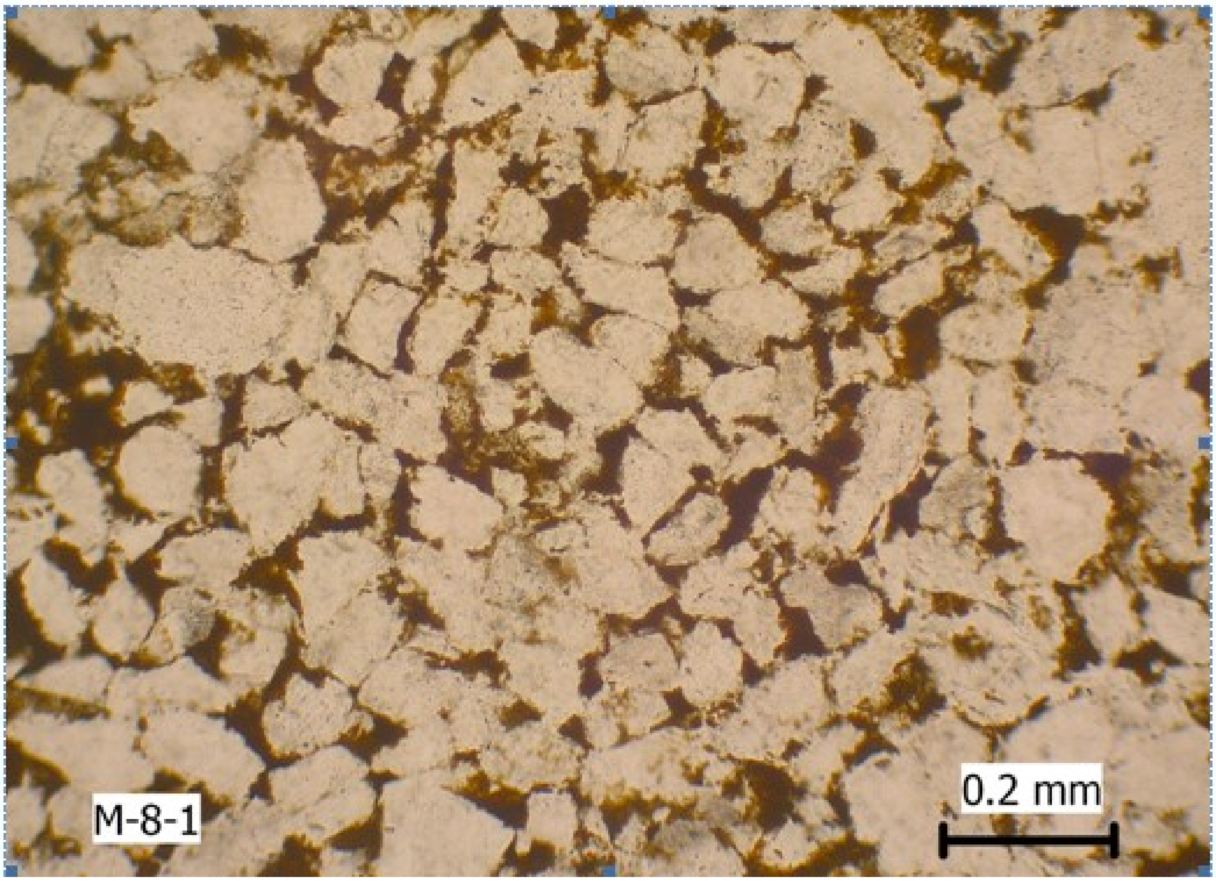


**Figure 17. Wedington Sandstone photomicrograph showing pervasive clay matrix. (Allen, 2010).**

Methods for interpreting the tectonic setting from which sandstone grains are derived have been outlined by Dickinson *et al*. (1983). Composition of framework grains plotted on triangular Quartz-Feldspar-Lithic (QFL) diagrams divides sandstones into continental block, magmatic arc, or recycled orogen derived (Dickinson *et al*., 1983). A provenance triangle utilizing point count data from Allen's thesis is shown in Figure 18. For this diagram, the Q pole contains only monocrystalline quartz, the F pole was monocrystalline feldspar, and the L pole contained both metamorphic and sedimentary rock fragments, as well as polycrystalline quartz. Most of the lithic grains counted were claystone clasts. Six Wedington Samples in total were plotted according to their composition, with samples M-8-1 and PR-2 (Using Allen's nomenclature) overlapping (Allen, 2010). Half of the samples indicate the Wedington Sandstone was sourced by a cratonic source. The other three samples indicate derivation from a recycled orogenic source. All six samples plotted relatively close to each other, No feldspars were counted, meaning all six samples plotted along the Q-L axis. The range in lithic composition varied from 4-20%.

| Sample Number | Quartz | Feldspar | Lithics | Folk/Dott Name |
|---|---|---|---|---|
| M-7-1* | 85 | 0 | 15 | Sublithic wacke |
| M-8-1* | 96 | 0 | 4 | Quartzwacke |
| M-10-5* | 80 | 0 | 20 | Sublithic wacke |
| M-13-1 | 94 | 0 | 6 | Sublitharenite |
| PR2 | 96 | 0 | 4 | Quartzarenite |
| PG23 | 87 | 0 | 13 | Sublitharenite |

**Table 2. Normalized modal data for plot in Figure 13 (Allen 2010).**

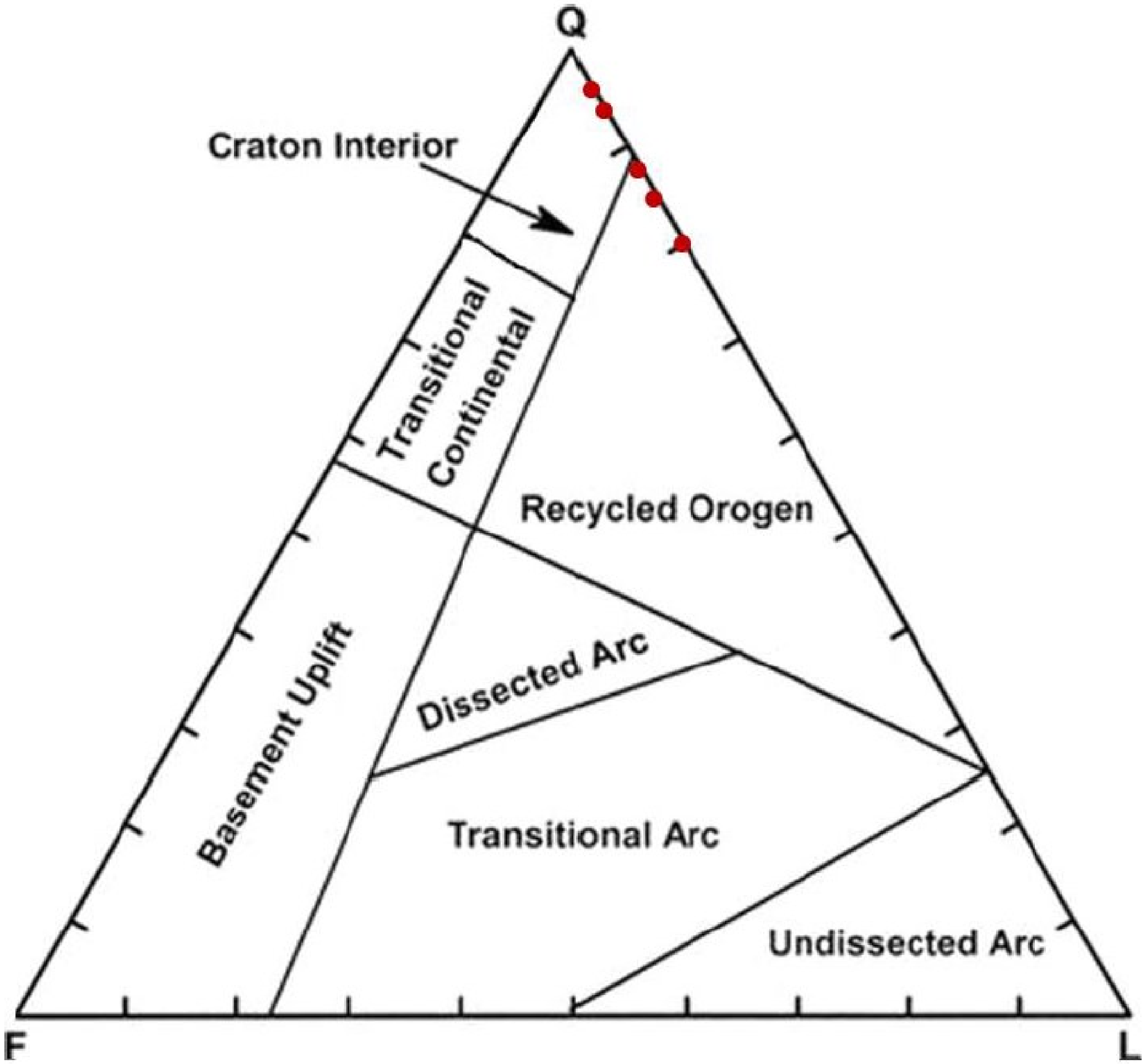


**Figure 18. Dickson Provenance Triangle for Wedington Sandstone predicting tectonic source from sandstone composition. Composition data from Allen, 2010.**

## A. ARCHEAN AND PALEOPROTEROZOIC PROVENANCE

Sandstones underlying the Wedington in Arkansas are significantly different in composition from Wedington and younger sandstones. Ordovician – Lower Mississippian sandstones in northwestern Arkansas are mostly clean, mature orthoquartzites. The Everton, St. Peter, Clifty, and Bachelor formations are all mature, frosted, well rounded, fine-medium grain sized orthoquartzites. Detrital zircon analyses of these units indicate that the vast majority of the sediment was ultimately derived from the Canadian Shield, with smaller contributions from the Grenville, Midcontinent Granite-Rhyolite, and Yavapai-Mazatzal basement terranes (Xie and Cains, 2014, in prep). The limited aerial extent of the Bachelor and Clifty formations indicates that they were probably derived from recycling of underlying St. Peter or Everton Formations. The Everton is confined to northern Arkansas and southern Missouri. This area is almost completely covered by thick Lower Mississippian carbonates, making these sediments inaccessible as a source for sediment in the Wedington.

The St. Peter Formation likely contributed a small amount of sediment to the Wedington Sandstone. The Middle Ordovician St. Peter Sandstone is a classic example of a cratonic sheet sand deposited on a shallow shelf. The widespread distribution of the St. Peter, stretching north-south from Arkansas into Minnesota, and east-west from Nebraska to Ohio, extends beyond the cover of Lower Mississippian carbonates (Giles, 1930; Shell, 1975). With its high quartz content and thicknesses up to 200 feet, the St. Peter could supply a large amount of quartz sand from exposures of limited lateral extent. Detrital zircons analysis of the St. Peter indicates that the bulk of the sediment (~85%) was derived from Archean and Paleoproterozoic terranes of the Canadian Shield, with the remaining portion derived from the Grenville Province (Xie and Cains, 2014, in prep). The Grenville aged zircons present in the St. Peter were probably sourced by Grenville basement rocks uplifted during the Ordovician Taconic Orogeny. These sediments were then transported into Arkansas by the epicontinental depositional systems of the St. Peter. The St. Peter contains a bimodal grain shape distribution, with one population being smooth and well rounded, while the other population is irregular and angular (Mazullo and Ehrlich, 1983). The detrital zircon analyses would indicate that the well rounded population of grains would correspond with the Archean and Paleoproterozoic sources and the angular population would correspond with the younger Grenville age population. A small amount of sediment derived from the St. Peter could account for the small percentage (10-15%) of the Archean and Paleoproterozoic zircons found in Wedington Sandstone samples. The St. Peter cannot be the source for the vast majority of the Grenville zircons found in the Wedington. The Everton shares the same source and composition as the St. Peter, but its limited extent makes the St. Peter the more likely candidate as a source for Wedington Sandstone grains.

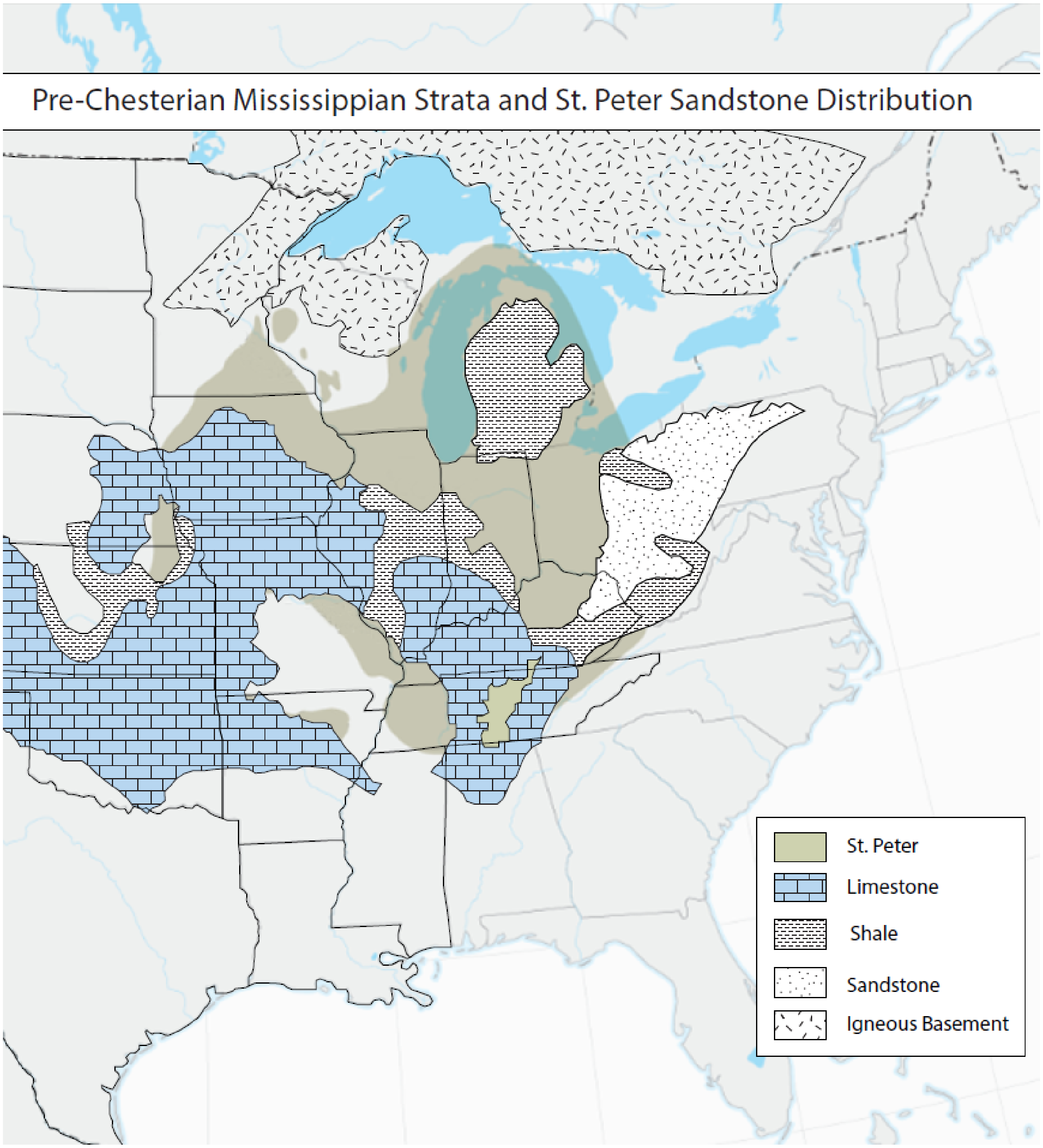


**Figure 19. Map showing distribution of Pre-Chesterian Mississippian Strata and St. Peter Sandstone Distribution. Areas covered by Mississippian Limestone would be unable to supply sediments. St. Peter distribution from Dake, 1921. Pre-Chesterian Mississippian distribution from Shell Oil Company, 1975.**

## B. MIDCONTINENT AND YAVAPAI-MAZATZAL PROVENANCE

Midcontinent and Yavapai-Mazatzal zircons were likely derived from a similar source area. The combined abundance of zircons of these ages ranges from 16-35% in Wedington samples. The Midcontinent Granite-Rhyolite Province underlies the Wedington and extends both east and west of the study area. The Yavapai-Mazatzal Province is west of the study area, indicating an eastward sediment delivery system. Two sources for Midcontinent and Yavapai-Mazatzal grains are possible: the Nemaha Ridge and the Illinois Basin.

The Nemaha Ridge in northeast Kansas and Nebraska contains exposed basement rocks dating between 1350 Ma and 1950 Ma that could supply both Midcontinent and Yavapai-Mazatzal aged zircons (Goebel, 1968). The division between the Midcontinent Granite-Rhyolite Province and the Yavapai-Mazatzal Province runs in an east-west line through southern Kansas over the Nemaha Ridge (Figure 20). Uplift of the north-south trending Nemaha Anticline could expose basement rocks of both provinces. The Cambrian Lamotte/Reagan Sandstone deposited in this locality would contain abundant sediment derived from underlying crystalline rocks of the Midcontinent and Yavapai-Mazatzal. Recycling of this sediment following uplift of the Nemaha Ridge would be able to supply zircons of the same ages as the granite. The Forest City Basin, located in between the Nemaha Ridge and the study area, poses a potential barrier to sediment transportation. However, Forest City Basin does not contain any Chesterian strata, suggesting that sediment could have been transported through this area over Lower Mississippian carbonates into northwest Arkansas. This interpretation indicates that the Nemaha ridge was uplifted by late Mississippian time, most likely as a result of compressional stresses associated with the Alleghanian Orogeny on the eastern margin of Laurentia.

The sandstones within the Illinois Basin are another potential source of Midcontinent and Yavapai-Mazatzal grains. Midcontinent and Yavapai-Mazatzal grains are likely to be found in abundance in Illinois Basin sandstones due the basin's proximity to these basement provinces. Detrital zircon analyses from these sandstones could confirm or refute this assertion. Sediment recycled from the Illinois Basin could also supply a large amount of the Grenville zircons analyzed from Wedington samples. The Illinois Basin was actively receiving sediment and subsiding during the Chesterian, making recycling older sandstones difficult, if not impossible (Swann, 1968).

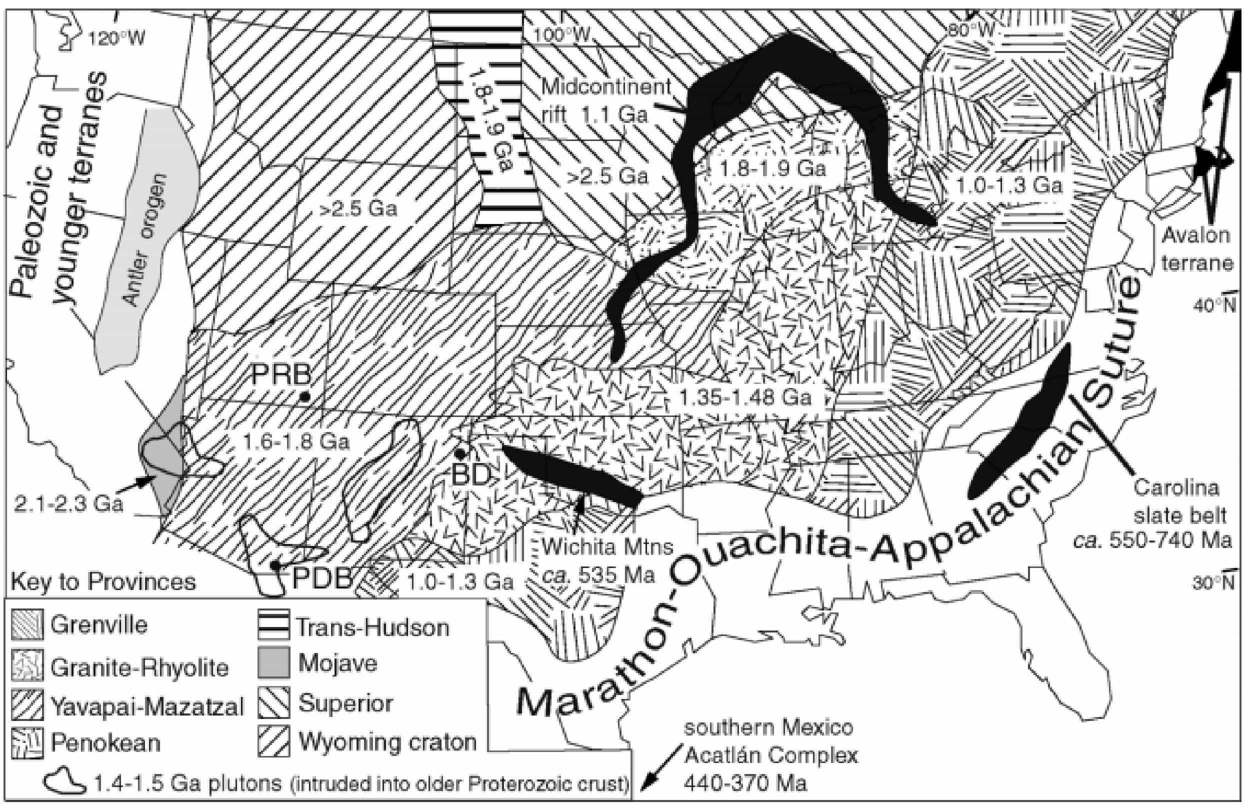


**Figure 20. Map showing prominent basement provinces and associated ages. Note the boundry between Yavapai-Mazatzal and Granite-Rhyolite Provinces in southern Kansas. (Soreghan et al., 2002).**

## C. APPALACHIAN PROVENANCE

The Batesville Sandstone, deposited to the east of the Wedington during early Chesterian time, is the first sandstone to differ from the orthoquartzites that dominated sandstone deposition from the Lower Ordovician through Lower Mississippian. The Batesville contains significant potassium feldspar grains and metamorphic rock fragments, indicating that it is a first cycle sandstone (Allen, 2010). This sandstone has been interpreted as being deposited by a deltaic system and then reworked by east-west longshore currents to form a shoreface deposit (Handford, 1995). This unit likely represents the first influx of sediment from the actively uplifting Appalachians to the east.

The high abundance of zircons ranging from 950-1250 Ma indicates that the majority of sediment for the Wedington Sandstone was derived from the Grenville Province in the Appalachians. Grenville aged zircons were being transported into northern Arkansas at least by the Early Ordovician (Xie and Cains, 2014, in prep). The amount of Grenville aged zircons present in Ordovician sandstones is not sufficient to supply the large volume present in Wedington Sandstone samples. The abundance of Grenville zircons indicates large amounts sediment must have been transported from Appalachian sources into Arkansas. Moving sediment from the eastern Appalachian sources into Arkansas raises some issues, as the direction of sediment transport during deposition of the Wedington Sandstone is firmly constrained by delta geometry and paleocurrent measurements as northwest to southeast. Three different sediment sources are possible. 1.) First cycle sediment, eroded from Grenville crustal rocks following onset of the Alleghanian orogeny, which was transported westward once an overfilled Appalachian Basin topped the Cincinnati forebulge, and then south into northwest Arkansas. 2.) Recycling of sandstones deposited during Acadian/Taconic uplifts. This model requires that sand derived from Appalachian Basin sandstones be eroded, transported over the Cincinnati arch, westward across the Illinois basin, then south into northwest Arkansas. 3.) Recycling of Illinois Basin sandstones of Cambrian–Mississippian age, that were eroded and transported south into Arkansas.

Mid- Late Mississippian Alleghanian uplift would have enabled Grenville basement rocks as an active sediment source. A Grenville crystalline source would satisfy the requirement of a metamorphic source terrane necessitated by Allen's modal analysis. The long transport distance required to move first cycle sediment from the Grenville Province to Arkansas would be sufficient to weather out the vast majority of feldspars, leaving the very minor amount found in Wedington Sandstone thin sections (Allen, 2010). A Grenville crystalline source on its own would not be able to satisfy all the Appalachian sediment requirements, as a significant percentage (2-10%) of Wedington zircons were derived from Acadian/Taconic terranes.

Sandstones deposited in the Acadian and Taconic foreland basins are composed mainly of grains derived from the Grenville Province, with smaller inputs from the active orogenic and rift related terranes. Cambrian-Ordovician sandstones deposited on the passive margin and early in the foreland are devoid of Taconic aged zircons, probably due to sediment trapping by the accretionary wedge. Devonian synorogenic and postorogenic sediments contain Taconic zircons in an abundance of about 40% (McLennan *et al*., 2001). Analyzed Wedington Sandstone samples contain zircons of both Taconic and Acadian ages, as well as a few individual grains that fit rift related magmatism ages. The sandstones from the Taconic and Acadian foreland basins are a good match as a source for these Wedington sediments. Later uplift of these Cambrian-Devonian sandstones during onset of the Alleghanian Orogeny in the Late Mississippian would allow access to these sediments (Steltenpohl and Kunk, 1993).

The third model for Appalachian sediment transport into northwest Arkansas requires recycling of Cambrian-Mississippian sandstones in the Illinois Basin. At least twice, during the Upper Ordovician and Upper Devonian, sediment derived from Acadian and Taconic uplifts overfilled the Appalachian Basin. Sediment of Grenville, Taconic, and Acadian ages would have spilled over the Cincinnati Arch and been deposited in the Illinois Basin (Swann, 1968). Recycling of these sandstones could supply the Appalachian sediment found in Wedington Samples. The problem with recycling Illinois Basin sandstones for sediment deposited in the Wedington Sandstone is the presence of Chesterian sandstones in the Illinois Basin (Swann, 1968). It is impossible to erode older formations while deposition is actively occurring.

It seems more likely that west-moving sediment from Appalachian sources was transported through or around the Illinois Basin. One possibility is that the supply of sediments flowing into the Illinois Basin from the rising Appalachian Mountains to the east exceeded the accommodation space of the basin. Sediments could then be transported to the west to be deposited in northwest Arkansas. This explanation would eliminate the Illinois Basin as a barrier for a westward transportation of Appalachian sediments. If sediment did not move through the Illinois Basin, the only other possible routes westward to northwest Arkansas would be south of the Illinois Basin or north of the Michigan Basin. Fluvial systems transporting sediment south of the Illinois Basin would have to make a nearly 180° bend to deposit the Wedington in the orientation we see today. Sediment transported north of the Michigan Basin would be very unlikely to make it south to Arkansas. A third method of transporting sediment past the Illinois Basins involves an eolian system similar to one proposed for Grand Canyon sediments by Gehrels *et al*. (2011). Trade winds from the northeast during the late Paleozoic would be consistent with the southwest transport of sediment from the Appalachian Mountains into the continent interior (Peterson, 1988). However, quartz grains within the Wedington Sandstone do not demonstrate evidence of eolian transport, such as grain frosting. The possibility of an eolian system is retained, due to the fact that the fine grained size quartz may not have sufficient impact to frost, or fluvial processes following eolian deposition could remove signs of frosting.

It is the author's opinion that the most likely scenario involves a combination of eroded Acadian/Taconic Paleozoic sandstones and Grenville crystalline rocks overfilling the Appalachian foreland basin westward and feeding into the interior lowlands, entering a southward drainage system that emptied into the Rheic Ocean in northwest Arkansas. A Grenville crystalline source is suggested in addition to recycled Taconic/Acadian foreland sandstones due to the ratio of Grenville:Taconic/Acadian zircons in Wedington samples being higher than those ratios found in Acadian/Taconic foreland sandstones (McLennan *et al*., 2001). In this scenario, the Alleghanian Orogeny is the most significant factor impacting depositional patterns in northern Arkansas. The timing of collision onset coincides well with the drastic change in sand composition deposited in Arkansas during the Chesterian.

**Future Study**

Sandstone provenance is difficult to establish with complete certainty. Assigning zircon ages to specific source terranes can be nearly impossible for ages that match multiple terranes. Further study utilizing Nd isotope analysis could add further constraint on Wedington Sandstone provenance by identifying the type of crystalline terrane from which a zircon is derived. Knowledge of the age spectra of zircons in sandstones throughout the craton would allow interpretation of potential recycled sources. Specifically, detrital zircon analysis of Upper Mississippian sandstones could provide an essential link for sediment transport from Appalachian sources into Arkansas.

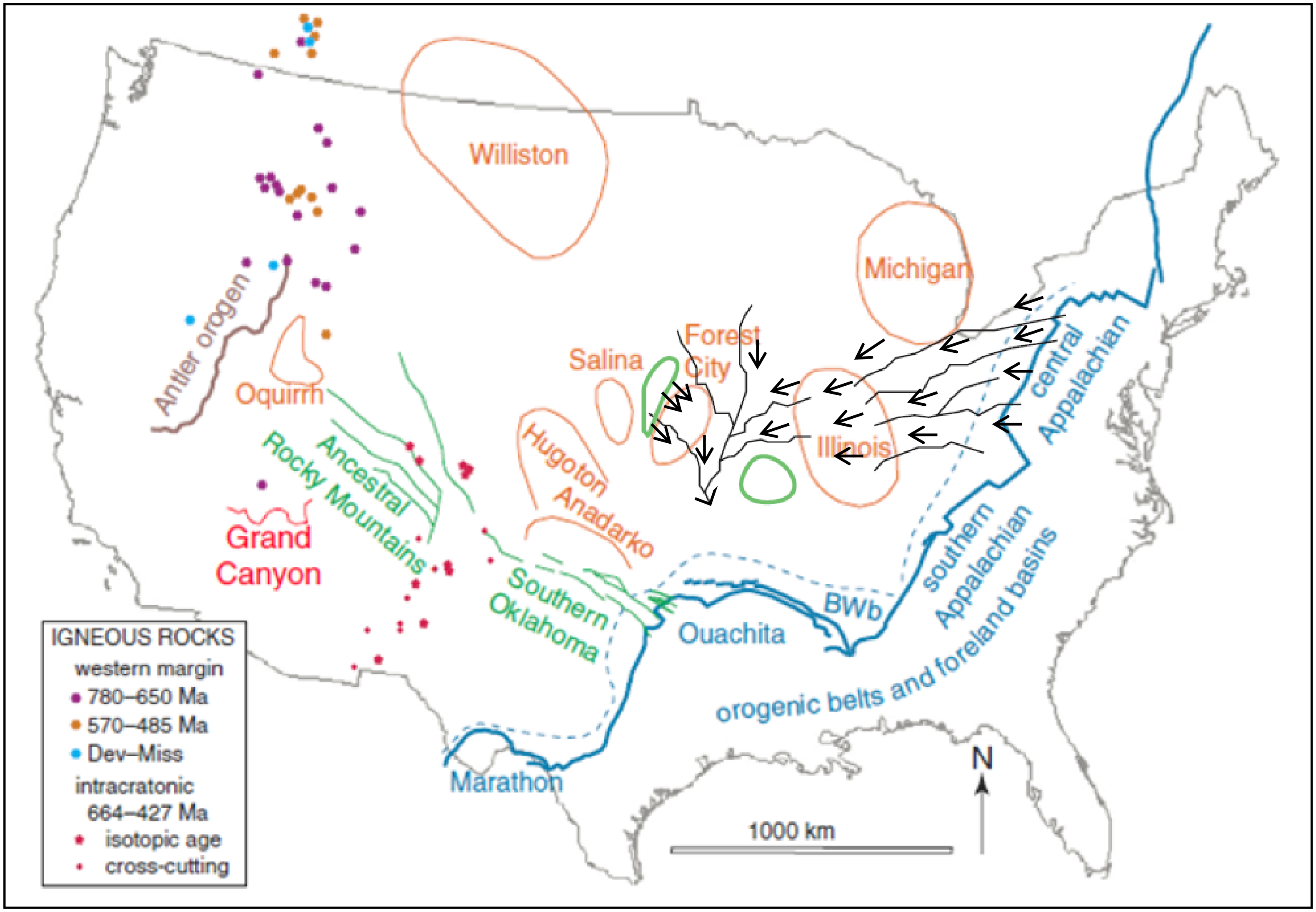


**Figure 21. Late Paleozozoic Structural features map with interpreted transport pathways for Wedington sediment into northwest Arkansas. Modified from Thomas, 2011a.**

## CONCLUSIONS

1. The Wedington Sandstone contains sediment supplied by two main regions: the Appalachian Mountains and the Nemaha Ridge
2. Archean and Paleoproterozoic zircons are derived from recycled sandstones exposed along the Nemaha Ridge and the Great Lakes region.
3. Midcontinent and Yavapai-Mazatzal zircons are derived from Nemaha Ridge granite and the basal Cambrian sandstone overlying the crystalline rocks.
4. Grenville, Taconic, and Acadian zircons are derived from Appalachian sandstones and crystalline rocks uplifted during the Alleghanian Orogeny.
5. The Nemaha Ridge and Appalachian features were uplifted and supplying sediment by the Chesterian.

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**APPENDIX**

**Appendix A - Sample Locations**

| <u>Samples</u> | <u>Names</u> | <u>Notes</u> | <u>GPS Location</u> |
|---|---|---|---|
| Sandstone Stop 1 | WD-1 | | N 35°57′23.2′′, W 094°22′21.0′′ |
| Wedington Stop 2 | WD-2 | | N 35°51′11.7′′, W 094°22′31.8′′ |
| Dutch Mill Stop 3B | WD-3 | * small sample size, send out | N 35°53′54.7′′, W 094°24′06.3′′ |
| Wedington Gap (top) Stop 5 | WD-5 | * extra, repeat with WD-4, no picking | N 36°06′58′′, W 094°23′09.4′′ |
| Wedington (Bottom) Stop 6 | WD-6 | * send out | N 36°03′45.7′′, W 094°25′35.6′′ |
| Pea Ridge Stop 8 | WD-8 | * send out | N 36°26′39.5′′, W 093°58′19.0′′ |

**Appendix B - WD-1**

Sample WD-1 (Wedington Stop 1) U–Pb detrital zircon LA-ICP-MS analysis results

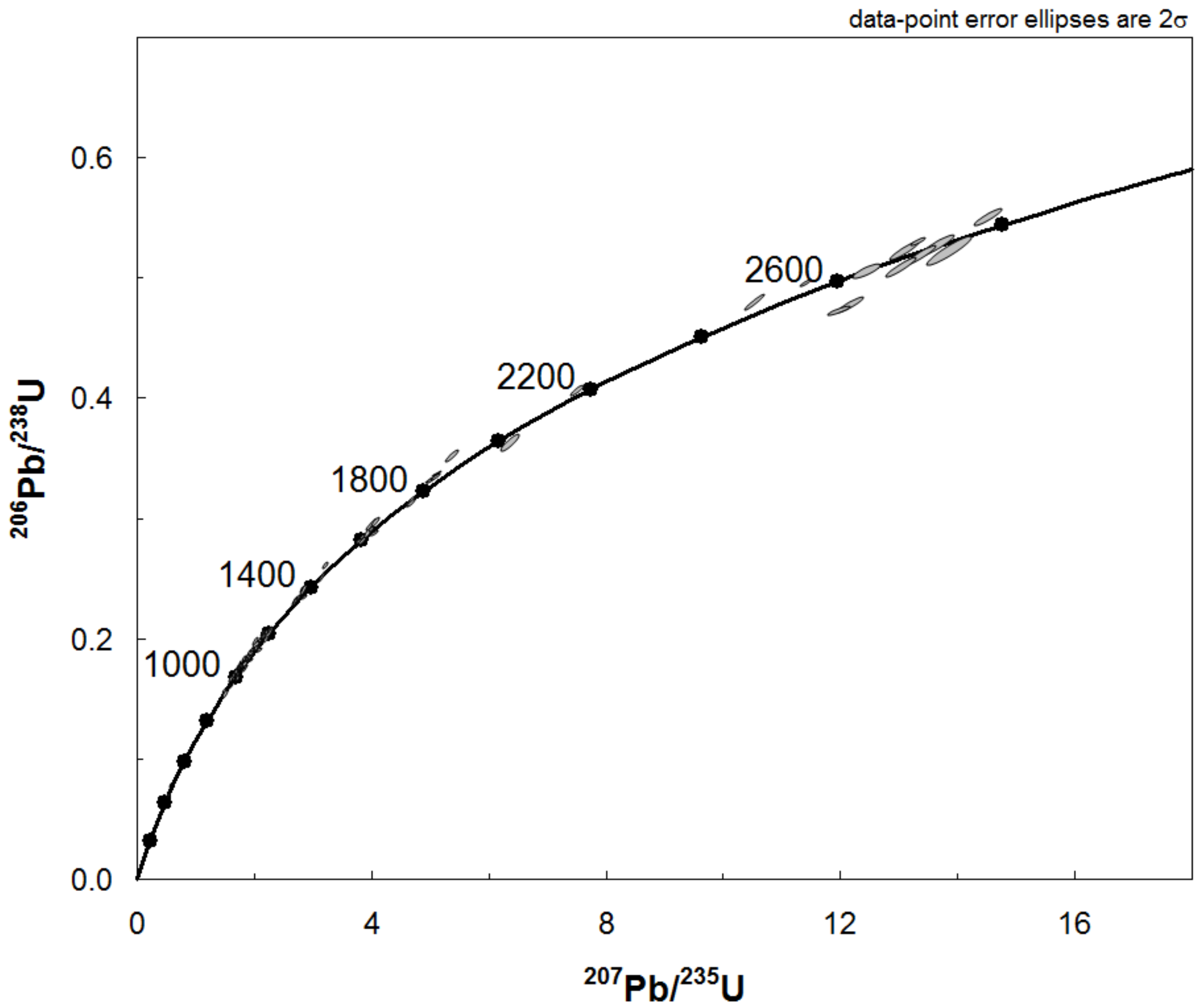
| | Isotopic Ratio | | Apperant Ages | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sample | 206/238 | ±1σ | 206/238 | ±1σ (Ma) | 207/206 | ±1σ (Ma) | Best Age | ±1σ (Ma) |
| WD1_139 | 0.5217 | 0.0062 | 2706.26 | 26.2091 | 2700.95 | 10.4374 | 2700.95 | 10.4374 |
| WD1_137 | 0.1996 | 0.0032 | 1173.30 | 16.9437 | 1237.09 | 18.9491 | 1237.09 | 18.9491 |
| WD1_136 | 0.2393 | 0.0031 | 1383.19 | 15.8696 | 1378.03 | 15.7013 | 1378.03 | 15.7013 |
| WD1_135 | 0.1973 | 0.0025 | 1160.62 | 13.5390 | 1167.10 | 17.8918 | 1167.10 | 17.8918 |
| WD1_134 | 0.1676 | 0.0021 | 998.95 | 11.8022 | 986.63 | 16.7032 | 998.95 | 11.8022 |
| WD1_133 | 0.1776 | 0.0024 | 1053.93 | 12.9643 | 1060.38 | 19.8014 | 1060.38 | 19.8014 |
| WD1_132 | 0.1977 | 0.0027 | 1162.87 | 14.3631 | 1167.35 | 18.7765 | 1167.35 | 18.7765 |
| WD1_131 | 0.4761 | 0.0057 | 2510.12 | 25.0489 | 2730.90 | 10.1395 | 2730.90 | 10.1395 |
| WD1_130 | 0.2038 | 0.0035 | 1195.93 | 18.4921 | 1224.18 | 36.2190 | 1224.18 | 36.2190 |
| WD1_129 | 0.1908 | 0.0025 | 1125.67 | 13.3717 | 1128.72 | 16.9385 | 1128.72 | 16.9385 |
| WD1_127 | 0.3505 | 0.0044 | 1936.77 | 20.7653 | 1853.52 | 12.3958 | 1853.52 | 12.3958 |
| WD1_126 | 0.3621 | 0.0061 | 1992.07 | 28.7661 | 2095.62 | 17.2943 | 2095.62 | 17.2943 |
| WD1_125 | 0.1526 | 0.0025 | 915.55 | 14.1359 | 1006.93 | 27.4781 | 1006.93 | 27.4781 |
| WD1_122 | 0.1773 | 0.0025 | 1052.27 | 13.7478 | 1104.09 | 21.2366 | 1104.09 | 21.2366 |
| WD1_121 | 0.0759 | 0.0013 | 471.52 | 7.6567 | 446.24 | 39.2299 | 471.52 | 7.6567 |
| WD1_120 | 0.1743 | 0.0026 | 1035.52 | 14.4313 | 1061.59 | 28.8519 | 1061.59 | 28.8519 |
| WD1_119 | 0.2026 | 0.0029 | 1189.30 | 15.3648 | 1223.34 | 16.5871 | 1223.34 | 16.5871 |
| WD1_118 | 0.5210 | 0.0097 | 2703.22 | 40.8737 | 2824.47 | 14.2942 | 2824.47 | 14.2942 |
| WD1_117 | 0.1706 | 0.0024 | 1015.63 | 13.4727 | 1046.33 | 19.8350 | 1046.33 | 19.8350 |
| WD1_116 | 0.0665 | 0.0008 | 414.92 | 5.1097 | 427.36 | 16.8318 | 414.92 | 5.1097 |
| WD1_115 | 0.2932 | 0.0040 | 1657.28 | 19.9658 | 1664.57 | 15.3945 | 1664.57 | 15.3945 |
| WD1_114 | 0.5257 | 0.0070 | 2723.44 | 29.3909 | 2785.92 | 11.4639 | 2785.92 | 11.4639 |
| WD1_113 | 0.1667 | 0.0025 | 994.14 | 13.8842 | 1038.90 | 25.5923 | 1038.90 | 25.5923 |
| WD1_112 | 0.5176 | 0.0067 | 2689.01 | 28.5380 | 2775.60 | 11.0108 | 2775.60 | 11.0108 |
| WD1_111 | 0.1794 | 0.0030 | 1063.63 | 16.6144 | 1170.18 | 24.7702 | 1170.18 | 24.7702 |
| WD1_110 | 0.5074 | 0.0065 | 2645.44 | 27.5992 | 2768.65 | 10.6162 | 2768.65 | 10.6162 |
| WD1_109 | 0.2501 | 0.0033 | 1438.99 | 16.9418 | 1497.54 | 10.7454 | 1497.54 | 10.7454 |
| WD1_108 | 0.0638 | 0.0009 | 398.50 | 5.2480 | 441.06 | 19.7686 | 398.50 | 5.2480 |
| WD1_106 | 0.2864 | 0.0040 | 1623.56 | 20.2387 | 1662.69 | 15.7931 | 1662.69 | 15.7931 |
| WD1_104 | 0.1776 | 0.0023 | 1053.69 | 12.6272 | 1070.77 | 13.8278 | 1070.77 | 13.8278 |
| WD1_103 | 0.4785 | 0.0059 | 2520.52 | 25.8061 | 2488.51 | 6.6095 | 2488.51 | 6.6095 |
| WD1_102 | 0.1738 | 0.0026 | 1032.85 | 14.0501 | 1078.19 | 21.4886 | 1078.19 | 21.4886 |
| WD1_101 | 0.2059 | 0.0027 | 1206.92 | 14.3294 | 1228.96 | 14.1728 | 1228.96 | 14.1728 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD1_100 | 0.1966 | 0.0024 | 1156.83 | 12.9894 | 1179.48 | 9.6106 | 1179.48 | 9.6106 |
| WD1_99 | 0.1926 | 0.0024 | 1135.65 | 13.1043 | 1149.18 | 10.8747 | 1149.18 | 10.8747 |
| WD1_98 | 0.1702 | 0.0023 | 1013.22 | 12.4176 | 1076.92 | 15.5315 | 1076.92 | 15.5315 |
| WD1_97 | 0.1767 | 0.0023 | 1048.84 | 12.4236 | 1015.29 | 11.2435 | 1015.29 | 11.2435 |
| WD1_95 | 0.1603 | 0.0021 | 958.27 | 11.5405 | 997.26 | 15.0941 | 958.27 | 11.5405 |
| WD1_94 | 0.1858 | 0.0027 | 1098.69 | 14.5951 | 1130.96 | 22.1899 | 1130.96 | 22.1899 |
| WD1_92 | 0.0688 | 0.0012 | 429.13 | 7.4350 | 474.07 | 51.8793 | 429.13 | 7.4350 |
| WD1_91 | 0.1737 | 0.0021 | 1032.24 | 11.2851 | 1052.94 | 13.8919 | 1052.94 | 13.8919 |
| WD1_90 | 0.1800 | 0.0020 | 1067.19 | 10.8374 | 1108.64 | 11.6940 | 1108.64 | 11.6940 |
| WD1_89 | 0.2316 | 0.0028 | 1342.70 | 14.4963 | 1349.83 | 13.4272 | 1349.83 | 13.4272 |
| WD1_88 | 0.1648 | 0.0018 | 983.54 | 10.2010 | 996.38 | 11.9284 | 983.54 | 10.2010 |
| WD1_87 | 0.1841 | 0.0027 | 1089.32 | 14.6791 | 1094.37 | 19.1108 | 1094.37 | 19.1108 |
| WD1_85 | 0.1596 | 0.0019 | 954.81 | 10.3483 | 1023.54 | 12.4683 | 1023.54 | 12.4683 |
| WD1_84 | 0.2311 | 0.0025 | 1340.09 | 13.3225 | 1333.38 | 9.8213 | 1333.38 | 9.8213 |
| WD1_83 | 0.1994 | 0.0022 | 1172.14 | 11.8007 | 1175.48 | 10.4406 | 1175.48 | 10.4406 |
| WD1_82 | 0.3121 | 0.0035 | 1751.18 | 17.2053 | 1790.44 | 8.9460 | 1790.44 | 8.9460 |
| WD1_81 | 0.2293 | 0.0027 | 1330.87 | 13.8827 | 1338.49 | 11.9369 | 1338.49 | 11.9369 |
| WD1_78 | 0.1887 | 0.0014 | 1114.10 | 7.7295 | 1221.45 | 16.1031 | 1221.45 | 16.1031 |
| WD1_76 | 0.1731 | 0.0015 | 1029.26 | 7.9810 | 1127.47 | 20.4230 | 1127.47 | 20.4230 |
| WD1_75 | 0.1640 | 0.0011 | 979.21 | 6.0542 | 974.28 | 15.8679 | 979.21 | 6.0542 |
| WD1_74 | 0.1808 | 0.0010 | 1071.54 | 5.5574 | 1056.22 | 12.6085 | 1056.22 | 12.6085 |
| WD1_73 | 0.1806 | 0.0018 | 1070.44 | 10.0829 | 1057.80 | 23.4084 | 1057.80 | 23.4084 |
| WD1_72 | 0.1758 | 0.0013 | 1043.84 | 7.2549 | 1074.62 | 16.4407 | 1074.62 | 16.4407 |
| WD1_71 | 0.3118 | 0.0021 | 1749.39 | 10.1239 | 1808.17 | 12.6595 | 1808.17 | 12.6595 |
| WD1_70 | 0.1691 | 0.0018 | 1007.09 | 10.0748 | 1052.13 | 24.3330 | 1052.13 | 24.3330 |
| WD1_69 | 0.1655 | 0.0016 | 987.00 | 8.6838 | 1097.72 | 20.9915 | 1097.72 | 20.9915 |
| WD1_68 | 0.1961 | 0.0016 | 1154.26 | 8.5566 | 1155.92 | 18.4776 | 1155.92 | 18.4776 |
| WD1_67 | 0.1748 | 0.0016 | 1038.62 | 8.7658 | 1134.93 | 17.9376 | 1134.93 | 17.9376 |
| WD1_66 | 0.2801 | 0.0019 | 1591.88 | 9.4574 | 1616.74 | 13.7839 | 1616.74 | 13.7839 |
| WD1_65 | 0.3306 | 0.0020 | 1841.49 | 9.7462 | 1819.85 | 11.5530 | 1819.85 | 11.5530 |
| WD1_63 | 0.5490 | 0.0058 | 2821.15 | 24.2775 | 2786.97 | 9.0295 | 2786.97 | 9.0295 |
| WD1_62 | 0.4053 | 0.0037 | 2193.24 | 17.1553 | 2186.32 | 9.1708 | 2186.32 | 9.1708 |
| WD1_60 | 0.0699 | 0.0007 | 435.65 | 4.1414 | 447.88 | 16.9168 | 435.65 | 4.1414 |
| WD1_59 | 0.2035 | 0.0022 | 1193.92 | 11.8201 | 1148.81 | 13.1632 | 1148.81 | 13.1632 |
| WD1_58 | 0.1968 | 0.0025 | 1157.87 | 13.7122 | 1083.40 | 22.6014 | 1083.40 | 22.6014 |
| WD1_57 | 0.1795 | 0.0018 | 1063.99 | 9.8037 | 1054.98 | 15.0158 | 1054.98 | 15.0158 |
| WD1_56 | 0.1653 | 0.0024 | 986.29 | 13.2818 | 973.81 | 27.5626 | 986.29 | 13.2818 |
| WD1_55 | 0.2952 | 0.0030 | 1667.53 | 15.0922 | 1656.34 | 12.6690 | 1656.34 | 12.6690 |
| WD1_54 | 0.2802 | 0.0027 | 1592.17 | 13.5225 | 1643.31 | 10.1202 | 1643.31 | 10.1202 |

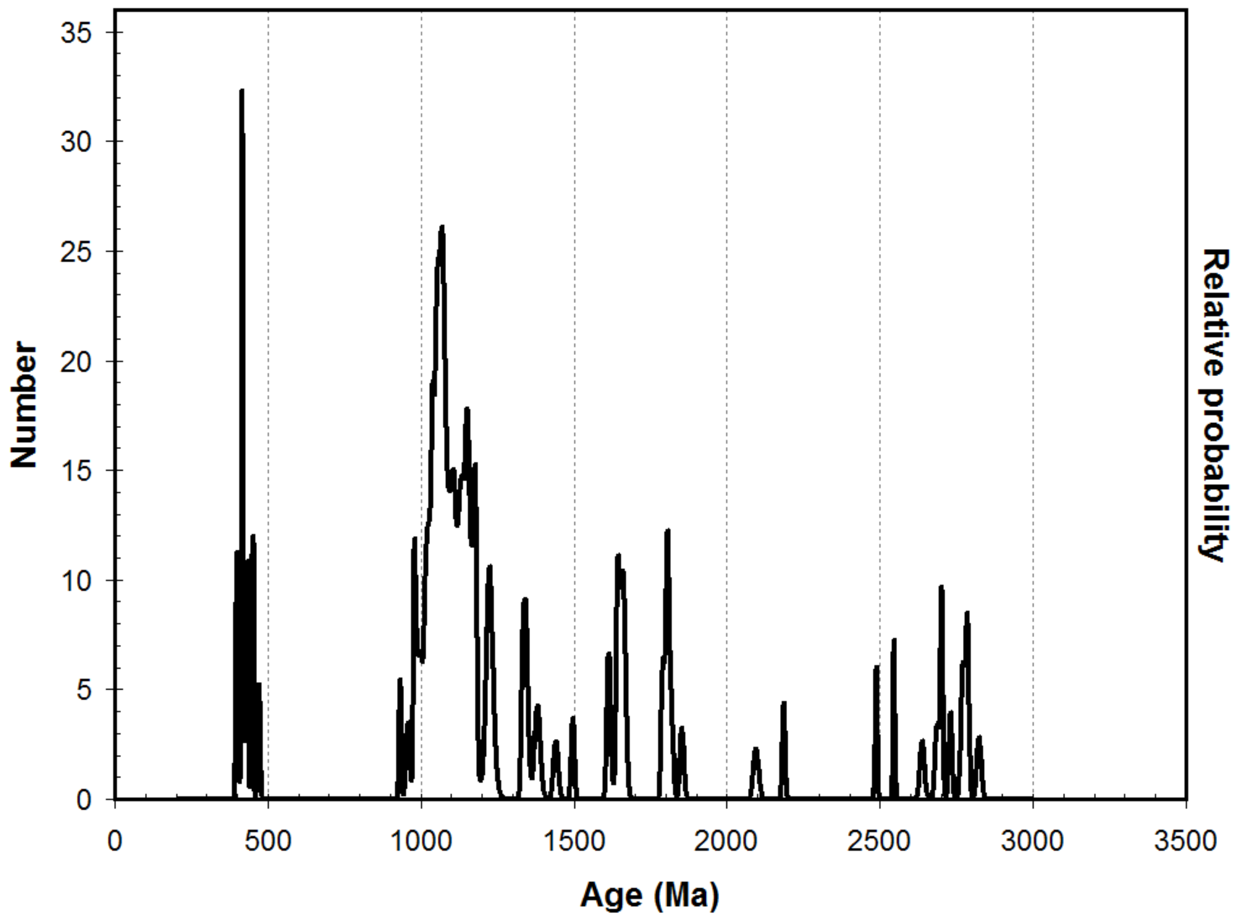
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD1_53 | 0.0645 | 0.0008 | 402.66 | 4.8891 | 447.69 | 30.2329 | 402.66 | 4.8891 |
| WD1_52 | 0.1761 | 0.0018 | 1045.77 | 10.0553 | 1032.36 | 15.9024 | 1032.36 | 15.9024 |
| WD1_51 | 0.1875 | 0.0031 | 1107.62 | 16.5626 | 1098.72 | 31.0471 | 1098.72 | 31.0471 |
| WD1_50 | 0.1651 | 0.0017 | 985.02 | 9.1813 | 1030.29 | 13.7917 | 1030.29 | 13.7917 |
| WD1_48 | 0.2890 | 0.0018 | 1636.72 | 9.0503 | 1644.27 | 10.0390 | 1644.27 | 10.0390 |
| WD1_47 | 0.4943 | 0.0023 | 2589.11 | 9.7860 | 2546.80 | 5.4750 | 2546.80 | 5.4750 |
| WD1_46 | 0.1952 | 0.0012 | 1149.65 | 6.4376 | 1138.11 | 13.0458 | 1138.11 | 13.0458 |
| WD1_45 | 0.3307 | 0.0019 | 1841.62 | 9.3642 | 1806.73 | 8.5506 | 1806.73 | 8.5506 |
| WD1_44 | 0.1823 | 0.0022 | 1079.67 | 11.7506 | 1077.42 | 21.7779 | 1077.42 | 21.7779 |
| WD1_43 | 0.1919 | 0.0023 | 1131.51 | 12.4803 | 1162.54 | 19.3100 | 1162.54 | 19.3100 |
| WD1_42 | 0.2592 | 0.0024 | 1485.56 | 12.2595 | 1441.80 | 15.1279 | 1441.80 | 15.1279 |
| WD1_41 | 0.1774 | 0.0012 | 1052.64 | 6.3383 | 1067.49 | 12.8690 | 1067.49 | 12.8690 |
| WD1_40 | 0.0671 | 0.0007 | 418.74 | 4.1721 | 434.30 | 31.5431 | 418.74 | 4.1721 |
| WD1_39 | 0.1842 | 0.0012 | 1089.87 | 6.4080 | 1069.32 | 15.3272 | 1069.32 | 15.3272 |
| WD1_38 | 0.1754 | 0.0021 | 1041.72 | 11.5033 | 1003.85 | 26.2996 | 1003.85 | 26.2996 |
| WD1_36 | 0.1918 | 0.0012 | 1131.17 | 6.4602 | 1155.89 | 11.4346 | 1155.89 | 11.4346 |
| WD1_35 | 0.1830 | 0.0018 | 1083.39 | 9.6524 | 1112.03 | 20.9120 | 1112.03 | 20.9120 |
| WD1_34 | 0.1760 | 0.0012 | 1044.90 | 6.7904 | 1041.14 | 15.5978 | 1041.14 | 15.5978 |
| WD1_33 | 0.1823 | 0.0014 | 1079.43 | 7.8161 | 1020.53 | 16.9472 | 1020.53 | 16.9472 |
| WD1_32 | 0.1892 | 0.0016 | 1116.82 | 8.4281 | 1080.59 | 21.1359 | 1080.59 | 21.1359 |
| WD1_30 | 0.4713 | 0.0031 | 2489.27 | 13.5295 | 2686.86 | 12.3668 | 2686.86 | 12.3668 |
| WD1_29 | 0.2011 | 0.0015 | 1181.07 | 7.8904 | 1138.02 | 18.7904 | 1138.02 | 18.7904 |
| WD1_28 | 0.3361 | 0.0017 | 1867.81 | 8.2193 | 1798.51 | 14.2067 | 1798.51 | 14.2067 |
| WD1_27 | 0.3331 | 0.0019 | 1853.54 | 8.9676 | 1807.37 | 14.4486 | 1807.37 | 14.4486 |
| WD1_26 | 0.2921 | 0.0013 | 1651.88 | 6.2639 | 1649.50 | 14.0433 | 1649.50 | 14.0433 |
| WD1_25 | 0.0670 | 0.0006 | 418.28 | 3.8472 | 364.64 | 35.6287 | 418.28 | 3.8472 |
| WD1_24 | 0.2862 | 0.0021 | 1622.69 | 10.2907 | 1664.81 | 15.2809 | 1664.81 | 15.2809 |
| WD1_23 | 0.5043 | 0.0043 | 2632.37 | 18.4947 | 2638.63 | 15.2008 | 2638.63 | 15.2008 |
| WD1_22 | 0.2332 | 0.0016 | 1351.23 | 8.4119 | 1385.97 | 17.7925 | 1385.97 | 17.7925 |
| WD1_21 | 0.1778 | 0.0016 | 1055.04 | 8.8290 | 1061.85 | 25.3358 | 1061.85 | 25.3358 |
| WD1_20 | 0.1893 | 0.0014 | 1117.41 | 7.5120 | 1099.40 | 17.3929 | 1099.40 | 17.3929 |
| WD1_19 | 0.1832 | 0.0016 | 1084.56 | 8.4959 | 1064.38 | 22.3797 | 1064.38 | 22.3797 |
| WD1_18 | 0.1937 | 0.0023 | 1141.33 | 12.1862 | 1090.56 | 31.1182 | 1090.56 | 31.1182 |
| WD1_17 | 0.1749 | 0.0014 | 1039.04 | 7.5657 | 979.27 | 19.6537 | 1039.04 | 7.5657 |
| WD1_16 | 0.1916 | 0.0014 | 1130.22 | 7.8205 | 1126.51 | 18.7187 | 1126.51 | 18.7187 |
| WD1_15 | 0.0717 | 0.0006 | 446.51 | 3.6003 | 479.79 | 25.0769 | 446.51 | 3.6003 |
| WD1_14 | 0.1557 | 0.0013 | 932.91 | 7.2531 | 937.17 | 20.1447 | 932.91 | 7.2531 |
| WD1_13 | 0.0729 | 0.0005 | 453.89 | 3.2095 | 467.99 | 18.8769 | 453.89 | 3.2095 |
| WD1_11 | 0.5288 | 0.0027 | 2736.30 | 11.2612 | 2702.32 | 6.9802 | 2702.32 | 6.9802 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD1_9 | 0.1905 | 0.0014 | 1124.28 | 7.7965 | 1154.24 | 16.4765 | 1154.24 | 16.4765 |
| WD1_7 | 0.0667 | 0.0005 | 416.07 | 2.8154 | 388.03 | 20.0207 | 416.07 | 2.8154 |
| WD1_6 | 0.1695 | 0.0013 | 1009.38 | 7.3102 | 1048.82 | 17.8110 | 1048.82 | 17.8110 |
| WD1_5 | 0.1897 | 0.0017 | 1119.54 | 9.0573 | 1217.71 | 20.8062 | 1217.71 | 20.8062 |
| WD1_4 | 0.1810 | 0.0011 | 1072.55 | 6.0746 | 1180.40 | 10.5183 | 1180.40 | 10.5183 |
| WD1_3 | 0.2394 | 0.0013 | 1383.52 | 6.8785 | 1343.42 | 9.9527 | 1343.42 | 9.9527 |
| WD1_2 | 0.1887 | 0.0014 | 1114.23 | 7.5443 | 1115.51 | 16.5487 | 1115.51 | 16.5487 |
| WD1_1 | 0.2833 | 0.0017 | 1608.11 | 8.5355 | 1613.71 | 10.0810 | 1613.71 | 10.0810 |
| | | | | | | | | |
| Discordance >10% | | | | | | | | |
| WD1_138 | 0.1866 | 0.0024 | 1284.16 | 13.3189 | 1284.16 | 13.3189 | | |
| WD1_128 | 0.1289 | 0.0018 | 1070.10 | 18.1790 | 1070.10 | 18.1790 | | |
| WD1_124 | 0.0683 | 0.0009 | 512.51 | 16.6662 | 425.80 | 5.2756 | | |
| WD1_123 | 0.0633 | 0.0008 | 489.32 | 16.5441 | 395.50 | 5.0841 | | |
| WD1_107 | 0.0681 | 0.0009 | 487.98 | 21.6886 | 424.85 | 5.3890 | | |
| WD1_105 | 0.0687 | 0.0011 | 351.05 | 38.2924 | 428.51 | 6.4622 | | |
| WD1_96 | 0.1760 | 0.0022 | 1192.91 | 14.5060 | 1192.91 | 14.5060 | | |
| WD1_93 | 0.2364 | 0.0032 | 1622.67 | 16.0289 | 1622.67 | 16.0289 | | |
| WD1_86 | 0.2288 | 0.0032 | 2487.09 | 9.1376 | 2487.09 | 9.1376 | | |
| WD1_80 | 0.0674 | 0.0009 | 486.25 | 27.3394 | 420.55 | 5.5982 | | |
| WD1_61 | 0.4668 | 0.0045 | 2805.65 | 8.4102 | 2805.65 | 8.4102 | | |
| WD1_31 | 0.0670 | 0.0009 | 342.71 | 47.1556 | 417.97 | 5.4310 | | |
| WD1_10 | 0.1943 | 0.0026 | 1001.27 | 26.5224 | 1001.27 | 26.5224 | | |

**WD-1 Concordia Diagram**



**WD-1 Probability Density Plot**



**Appendix C - WD-2**

Sample WD-2 (Wedington Stop 2) U–Pb detrital zircon LA-ICP-MS analysis results

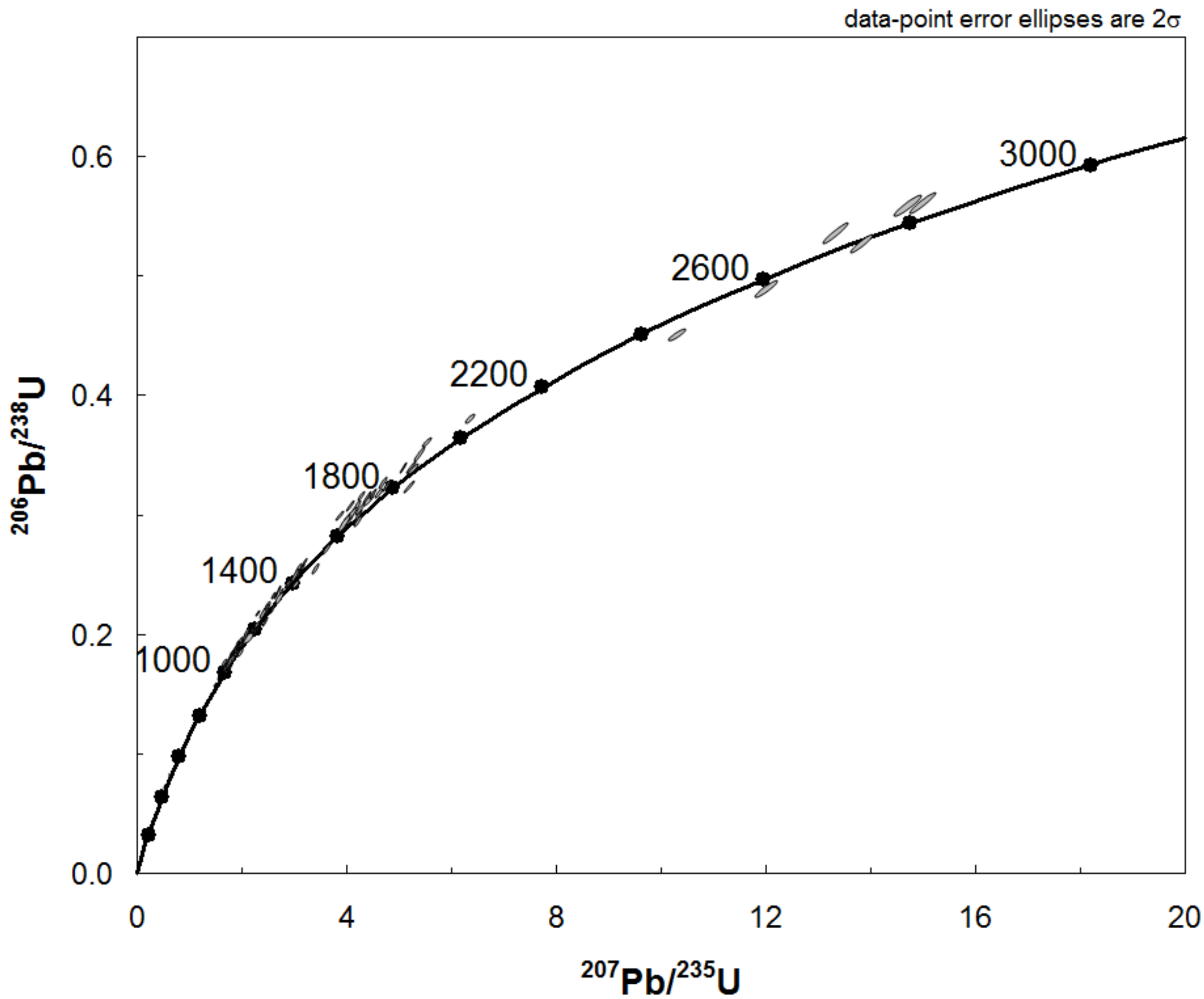
| | Isotopic Ratio | | Apperant Ages | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sample | 206/238 | ±1σ | 206/238 | ±1σ (Ma) | 207/206 | ±1σ (Ma) | Best Age | ±1σ (Ma) |
| WD2_145 | 0.1712 | 0.0014 | 1018.73 | 7.6335 | 1035.00 | 14.2034 | 1035.00 | 14.2034 |
| WD2_144 | 0.1911 | 0.0019 | 1127.60 | 10.2860 | 1066.93 | 15.3709 | 1066.93 | 15.3709 |
| WD2_143 | 0.2162 | 0.0015 | 1261.71 | 8.0293 | 1176.04 | 8.7196 | 1176.04 | 8.7196 |
| WD2_142 | 0.2420 | 0.0032 | 1397.17 | 16.8233 | 1420.56 | 21.5035 | 1420.56 | 21.5035 |
| WD2_140 | 0.3126 | 0.0023 | 1753.53 | 11.1463 | 1729.49 | 7.7943 | 1729.49 | 7.7943 |
| WD2_139 | 0.2537 | 0.0025 | 1457.74 | 12.6998 | 1473.92 | 11.5038 | 1473.92 | 11.5038 |
| WD2_138 | 0.1630 | 0.0019 | 973.16 | 10.3093 | 972.47 | 13.8649 | 973.16 | 10.3093 |
| WD2_137 | 0.1566 | 0.0012 | 938.11 | 6.8966 | 964.29 | 13.6140 | 938.11 | 6.8966 |
| WD2_136 | 0.2179 | 0.0027 | 1270.62 | 14.4874 | 1277.55 | 16.8115 | 1277.55 | 16.8115 |
| WD2_134 | 0.0807 | 0.0011 | 500.15 | 6.4230 | 478.16 | 33.9884 | 500.15 | 6.4230 |
| WD2_132 | 0.2406 | 0.0027 | 1390.07 | 14.2377 | 1491.68 | 15.5516 | 1491.68 | 15.5516 |
| WD2_131 | 0.2038 | 0.0020 | 1195.44 | 10.5683 | 1274.50 | 12.4316 | 1274.50 | 12.4316 |
| WD2_130 | 0.1679 | 0.0018 | 1000.78 | 9.8238 | 1065.93 | 14.1256 | 1065.93 | 14.1256 |
| WD2_129 | 0.1894 | 0.0031 | 1117.93 | 16.9777 | 1120.51 | 25.3341 | 1120.51 | 25.3341 |
| WD2_128 | 0.2889 | 0.0027 | 1635.90 | 13.7362 | 1641.71 | 10.2256 | 1641.71 | 10.2256 |
| WD2_125 | 0.1706 | 0.0016 | 1015.28 | 9.0468 | 1041.35 | 13.8042 | 1041.35 | 13.8042 |
| WD2_124 | 0.4492 | 0.0041 | 2391.86 | 18.3429 | 2554.81 | 10.1959 | 2554.81 | 10.1959 |
| WD2_122 | 0.3163 | 0.0030 | 1771.65 | 14.6885 | 1760.12 | 10.5210 | 1760.12 | 10.5210 |
| WD2_121 | 0.2313 | 0.0021 | 1341.45 | 11.0744 | 1279.14 | 12.3384 | 1279.14 | 12.3384 |
| WD2_120 | 0.1752 | 0.0024 | 1040.71 | 13.3143 | 1034.44 | 20.5537 | 1034.44 | 20.5537 |
| WD2_118 | 0.2702 | 0.0036 | 1541.70 | 18.0086 | 1591.33 | 12.3266 | 1591.33 | 12.3266 |
| WD2_115 | 0.3112 | 0.0043 | 1746.58 | 20.8945 | 1698.16 | 16.5349 | 1698.16 | 16.5349 |
| WD2_114 | 0.1928 | 0.0024 | 1136.73 | 12.8447 | 1069.93 | 17.6299 | 1069.93 | 17.6299 |
| WD2_111 | 0.1780 | 0.0021 | 1056.12 | 11.6683 | 1088.75 | 16.1073 | 1088.75 | 16.1073 |
| WD2_110 | 0.1830 | 0.0026 | 1083.12 | 14.0288 | 1168.23 | 21.9331 | 1168.23 | 21.9331 |
| WD2_109 | 0.3373 | 0.0040 | 1873.63 | 19.2993 | 1878.18 | 12.5343 | 1878.18 | 12.5343 |
| WD2_108 | 0.4875 | 0.0058 | 2559.69 | 25.1683 | 2660.67 | 10.2812 | 2660.67 | 10.2812 |
| WD2_107 | 0.2940 | 0.0039 | 1661.60 | 19.1624 | 1633.44 | 14.8260 | 1633.44 | 14.8260 |
| WD2_106 | 0.1841 | 0.0022 | 1089.32 | 12.0752 | 1096.82 | 17.5847 | 1096.82 | 17.5847 |
| WD2_105 | 0.3048 | 0.0048 | 1715.29 | 23.5005 | 1656.71 | 13.1792 | 1656.71 | 13.1792 |
| WD2_104 | 0.5574 | 0.0071 | 2855.96 | 29.2762 | 2793.13 | 8.3592 | 2793.13 | 8.3592 |
| WD2_103 | 0.1890 | 0.0024 | 1115.68 | 12.9001 | 1140.69 | 13.0920 | 1140.69 | 13.0920 |
| WD2_102 | 0.5597 | 0.0068 | 2865.29 | 28.1995 | 2818.38 | 6.5164 | 2818.38 | 6.5164 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD2_101 | 0.0711 | 0.0008 | 442.54 | 5.1062 | 407.88 | 17.0886 | 442.54 | 5.1062 |
| WD2_98 | 0.2535 | 0.0033 | 1456.72 | 16.7535 | 1419.54 | 14.1313 | 1419.54 | 14.1313 |
| WD2_97 | 0.1903 | 0.0022 | 1123.07 | 12.0367 | 1127.97 | 8.9760 | 1127.97 | 8.9760 |
| WD2_96 | 0.3391 | 0.0042 | 1882.30 | 20.1673 | 1875.47 | 7.7215 | 1875.47 | 7.7215 |
| WD2_94 | 0.2184 | 0.0027 | 1273.41 | 14.2902 | 1256.35 | 10.0890 | 1256.35 | 10.0890 |
| WD2_94 | 0.2184 | 0.0027 | 1273.41 | 14.2902 | 1256.35 | 10.0890 | 1256.35 | 10.0890 |
| WD2_93 | 0.2503 | 0.0029 | 1440.22 | 15.1602 | 1449.53 | 7.8338 | 1449.53 | 7.8338 |
| WD2_92 | 0.1717 | 0.0025 | 1021.71 | 13.6735 | 1122.66 | 17.4155 | 1122.66 | 17.4155 |
| WD2_91 | 0.0701 | 0.0009 | 436.54 | 5.4894 | 421.97 | 21.9744 | 436.54 | 5.4894 |
| WD2_90 | 0.2539 | 0.0034 | 1458.32 | 17.2694 | 1600.99 | 13.9124 | 1600.99 | 13.9124 |
| WD2_89 | 0.1899 | 0.0022 | 1120.57 | 12.0542 | 1099.07 | 17.5148 | 1099.07 | 17.5148 |
| WD2_88 | 0.2019 | 0.0023 | 1185.64 | 12.3008 | 1244.03 | 14.8268 | 1244.03 | 14.8268 |
| WD2_86 | 0.1708 | 0.0020 | 1016.44 | 11.2647 | 1006.72 | 18.5319 | 1006.72 | 18.5319 |
| WD2_84 | 0.5257 | 0.0058 | 2723.47 | 24.6096 | 2772.38 | 7.6174 | 2772.38 | 7.6174 |
| WD2_82 | 0.1727 | 0.0020 | 1026.91 | 10.9893 | 1035.80 | 17.7456 | 1035.80 | 17.7456 |
| WD2_81 | 0.2024 | 0.0021 | 1187.99 | 11.2190 | 1199.03 | 12.9735 | 1199.03 | 12.9735 |
| WD2_80 | 0.1837 | 0.0019 | 1087.38 | 10.3026 | 1083.82 | 15.5621 | 1083.82 | 15.5621 |
| WD2_78 | 0.1838 | 0.0018 | 1087.74 | 9.7786 | 1016.80 | 12.9273 | 1016.80 | 12.9273 |
| WD2_77 | 0.1793 | 0.0018 | 1062.98 | 9.8465 | 1036.88 | 13.0164 | 1036.88 | 13.0164 |
| WD2_76 | 0.2347 | 0.0024 | 1359.11 | 12.7460 | 1343.44 | 13.1228 | 1343.44 | 13.1228 |
| WD2_75 | 0.1814 | 0.0018 | 1074.67 | 9.5732 | 1096.33 | 16.4112 | 1096.33 | 16.4112 |
| WD2_74 | 0.3590 | 0.0032 | 1977.36 | 15.0289 | 1856.81 | 8.2901 | 1856.81 | 8.2901 |
| WD2_72 | 0.2061 | 0.0020 | 1207.81 | 10.5653 | 1196.09 | 13.7768 | 1196.09 | 13.7768 |
| WD2_71 | 0.2287 | 0.0037 | 1327.90 | 19.2047 | 1375.25 | 17.2619 | 1375.25 | 17.2619 |
| WD2_70 | 0.2204 | 0.0043 | 1283.82 | 22.6125 | 1264.22 | 26.5350 | 1264.22 | 26.5350 |
| WD2_69 | 0.0700 | 0.0006 | 436.27 | 3.6451 | 426.05 | 11.2594 | 436.27 | 3.6451 |
| WD2_68 | 0.0767 | 0.0012 | 476.57 | 7.0733 | 508.72 | 28.1446 | 476.57 | 7.0733 |
| WD2_67 | 0.1947 | 0.0020 | 1146.78 | 10.6686 | 1144.57 | 14.2311 | 1144.57 | 14.2311 |
| WD2_65 | 0.1712 | 0.0031 | 1018.47 | 17.0433 | 1089.79 | 16.2263 | 1089.79 | 16.2263 |
| WD2_63 | 0.1832 | 0.0018 | 1084.49 | 9.8869 | 1049.44 | 15.0909 | 1049.44 | 15.0909 |
| WD2_62 | 0.3791 | 0.0032 | 2071.95 | 14.9522 | 2009.51 | 11.8053 | 2009.51 | 11.8053 |
| WD2_61 | 0.1778 | 0.0021 | 1054.81 | 11.4149 | 1008.61 | 17.3238 | 1008.61 | 17.3238 |
| WD2_60 | 0.2938 | 0.0040 | 1660.48 | 20.0345 | 1741.34 | 11.7702 | 1741.34 | 11.7702 |
| WD2_59 | 0.3385 | 0.0036 | 1879.23 | 17.3120 | 1825.86 | 5.3850 | 1825.86 | 5.3850 |
| WD2_58 | 0.3157 | 0.0034 | 1768.80 | 16.5786 | 1738.13 | 5.1215 | 1738.13 | 5.1215 |
| WD2_56 | 0.1767 | 0.0032 | 1048.92 | 17.4491 | 1097.33 | 31.3320 | 1097.33 | 31.3320 |
| WD2_55 | 0.2318 | 0.0025 | 1344.08 | 13.2664 | 1312.45 | 8.0226 | 1312.45 | 8.0226 |
| WD2_54 | 0.2962 | 0.0034 | 1672.51 | 17.0642 | 1642.12 | 8.7010 | 1642.12 | 8.7010 |
| WD2_52 | 0.2997 | 0.0048 | 1689.78 | 23.7039 | 1658.55 | 13.2309 | 1658.55 | 13.2309 |

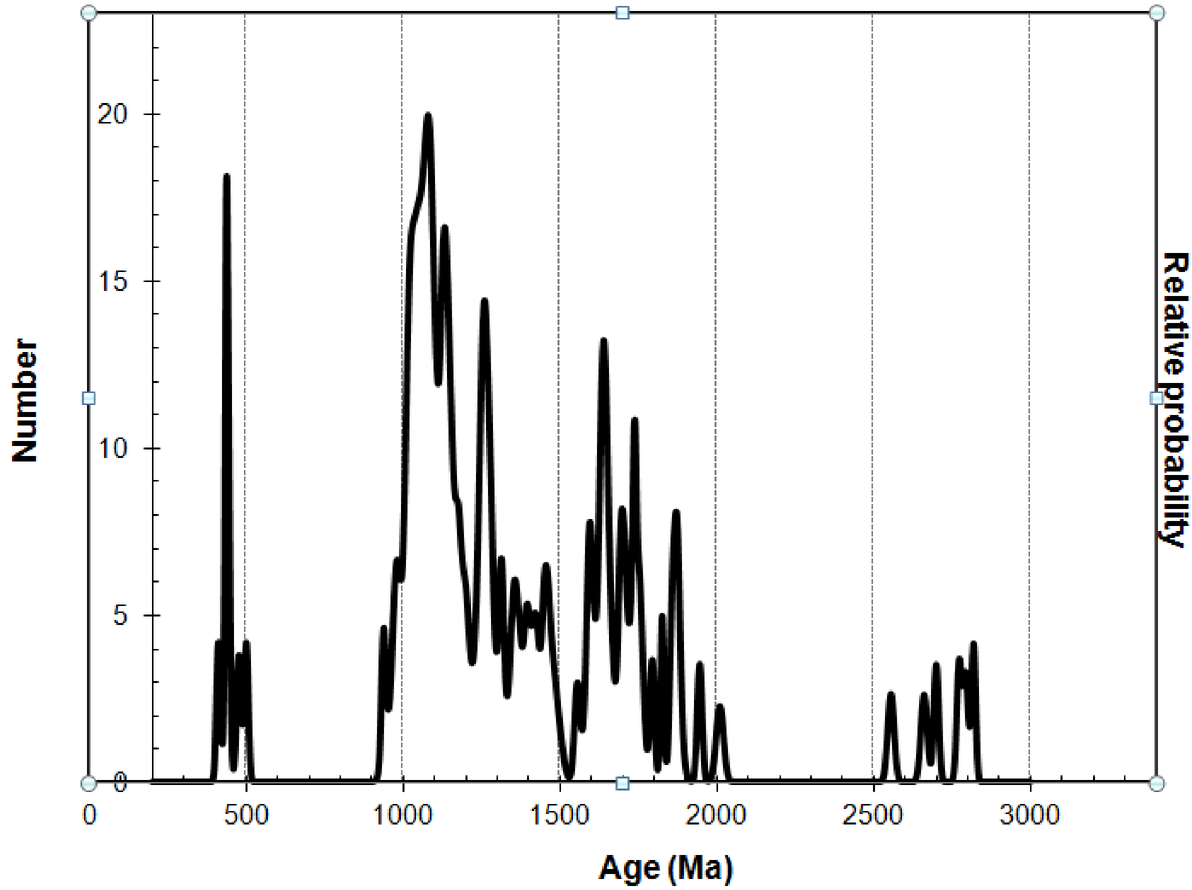
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD2_51 | 0.1857 | 0.0028 | 1097.81 | 15.1596 | 1057.60 | 23.9522 | 1057.60 | 23.9522 |
| WD2_50 | 0.3259 | 0.0039 | 1818.72 | 19.1254 | 1750.49 | 9.2098 | 1750.49 | 9.2098 |
| WD2_49 | 0.2414 | 0.0030 | 1393.71 | 15.4968 | 1394.40 | 8.7694 | 1394.40 | 8.7694 |
| WD2_48 | 0.2980 | 0.0034 | 1681.22 | 16.7705 | 1555.29 | 9.1571 | 1555.29 | 9.1571 |
| WD2_47 | 0.1857 | 0.0023 | 1098.06 | 12.4606 | 1081.53 | 11.8681 | 1081.53 | 11.8681 |
| WD2_46 | 0.3232 | 0.0037 | 1805.52 | 17.9760 | 1794.19 | 7.3426 | 1794.19 | 7.3426 |
| WD2_45 | 0.5341 | 0.0072 | 2758.51 | 30.2539 | 2699.36 | 7.6426 | 2699.36 | 7.6426 |
| WD2_43 | 0.1748 | 0.0026 | 1038.53 | 14.0058 | 960.65 | 18.7034 | 1038.53 | 14.0058 |
| WD2_42 | 0.3225 | 0.0042 | 1801.79 | 20.2868 | 1945.34 | 7.6003 | 1945.34 | 7.6003 |
| WD2_41 | 0.2163 | 0.0036 | 1262.20 | 18.8155 | 1255.64 | 22.1629 | 1255.64 | 22.1629 |
| WD2_40 | 0.3032 | 0.0040 | 1706.92 | 19.6916 | 1698.60 | 10.5290 | 1698.60 | 10.5290 |
| WD2_39 | 0.3132 | 0.0039 | 1756.49 | 19.3287 | 1693.67 | 8.2247 | 1693.67 | 8.2247 |
| WD2_38 | 0.2092 | 0.0029 | 1224.35 | 15.4118 | 1353.37 | 10.0851 | 1353.37 | 10.0851 |
| WD2_37 | 0.3497 | 0.0046 | 1933.14 | 21.7119 | 1865.76 | 8.6668 | 1865.76 | 8.6668 |
| WD2_36 | 0.3065 | 0.0039 | 1723.47 | 19.2706 | 1594.91 | 8.4266 | 1594.91 | 8.4266 |
| WD2_34 | 0.1748 | 0.0039 | 1038.48 | 21.1544 | 1036.97 | 35.3697 | 1036.97 | 35.3697 |
| WD2_33 | 0.2061 | 0.0029 | 1207.91 | 15.6376 | 1245.29 | 13.6383 | 1245.29 | 13.6383 |
| WD2_32 | 0.2583 | 0.0033 | 1481.16 | 16.8216 | 1460.84 | 8.3279 | 1460.84 | 8.3279 |
| WD2_31 | 0.2914 | 0.0059 | 1648.37 | 29.1541 | 1639.10 | 16.7841 | 1639.10 | 16.7841 |
| WD2_29 | 0.1877 | 0.0018 | 1108.99 | 9.8698 | 1052.57 | 15.1235 | 1052.57 | 15.1235 |
| WD2_28 | 0.1923 | 0.0024 | 1134.05 | 12.6981 | 1147.49 | 16.3673 | 1147.49 | 16.3673 |
| WD2_27 | 0.2202 | 0.0036 | 1282.80 | 18.9760 | 1368.17 | 11.5279 | 1368.17 | 11.5279 |
| WD2_25 | 0.2213 | 0.0019 | 1288.81 | 9.7738 | 1265.68 | 11.8673 | 1265.68 | 11.8673 |
| WD2_24 | 0.2005 | 0.0015 | 1177.86 | 7.9005 | 1131.15 | 11.8814 | 1131.15 | 11.8814 |
| WD2_23 | 0.2372 | 0.0015 | 1371.87 | 7.7194 | 1314.70 | 9.7872 | 1314.70 | 9.7872 |
| WD2_21 | 0.3144 | 0.0031 | 1762.31 | 15.3308 | 1631.37 | 8.5884 | 1631.37 | 8.5884 |
| WD2_20 | 0.1950 | 0.0037 | 1148.34 | 19.9424 | 1206.44 | 45.1554 | 1206.44 | 45.1554 |
| WD2_18 | 0.1735 | 0.0010 | 1031.49 | 5.5665 | 984.05 | 9.9384 | 984.05 | 9.9384 |
| WD2_16 | 0.2001 | 0.0021 | 1176.07 | 11.4251 | 1157.76 | 13.9928 | 1157.76 | 13.9928 |
| WD2_15 | 0.0709 | 0.0012 | 441.70 | 7.0480 | 462.25 | 20.8321 | 441.70 | 7.0480 |
| WD2_14 | 0.1802 | 0.0028 | 1068.32 | 15.2909 | 1020.44 | 11.6044 | 1020.44 | 11.6044 |
| WD2_11 | 0.1923 | 0.0032 | 1133.71 | 17.1916 | 1078.47 | 19.2423 | 1078.47 | 19.2423 |
| WD2_10 | 0.1959 | 0.0032 | 1153.23 | 17.4115 | 1132.34 | 14.3930 | 1132.34 | 14.3930 |
| WD2_7 | 0.1874 | 0.0031 | 1107.51 | 16.9125 | 1059.09 | 15.1240 | 1059.09 | 15.1240 |
| WD2_5 | 0.2001 | 0.0034 | 1175.76 | 18.3312 | 1142.31 | 19.4460 | 1142.31 | 19.4460 |
| WD2_4 | 0.2978 | 0.0046 | 1680.55 | 22.6479 | 1710.23 | 8.5979 | 1710.23 | 8.5979 |
| WD2_3 | 0.1890 | 0.0031 | 1115.95 | 16.5416 | 1083.55 | 15.9438 | 1083.55 | 15.9438 |
| WD2_2 | 0.1745 | 0.0027 | 1036.96 | 14.7263 | 1017.76 | 11.1160 | 1017.76 | 11.1160 |
| WD2_1 | 0.2480 | 0.0041 | 1428.34 | 21.0640 | 1422.94 | 14.4105 | 1422.94 | 14.4105 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Discordance >10% | | | | | | | | |
| WD2_141 | 0.2122 | 0.0026 | 1240.38 | 13.7760 | 1712.22 | 7.6461 | | |
| WD2_135 | 0.1793 | 0.0048 | 1063.29 | 26.1426 | 1189.55 | 41.6049 | | |
| WD2_133 | 0.0488 | 0.0005 | 307.24 | 2.8744 | 400.00 | 14.9324 | | |
| WD2_127 | 0.0748 | 0.0010 | 464.86 | 5.8068 | 1066.11 | 14.6330 | | |
| WD2_126 | 0.0363 | 0.0005 | 230.09 | 3.1282 | 544.61 | 32.3625 | | |
| WD2_123 | 0.1693 | 0.0026 | 1008.27 | 14.4474 | 1452.85 | 32.3464 | | |
| WD2_119 | 0.2010 | 0.0033 | 1180.92 | 17.4457 | 1575.52 | 23.1143 | | |
| WD2_117 | 0.1387 | 0.0018 | 837.25 | 9.9263 | 1185.22 | 13.3591 | | |
| WD2_116 | 0.1851 | 0.0027 | 1094.67 | 14.6974 | 1510.85 | 26.5998 | | |
| WD2_113 | 0.1538 | 0.0021 | 921.96 | 11.7074 | 1193.82 | 16.6268 | | |
| WD2_112 | 0.1879 | 0.0023 | 1109.84 | 12.2564 | 1498.45 | 16.6156 | | |
| WD2_100 | 0.1767 | 0.0025 | 1049.18 | 13.7678 | 1200.34 | 17.7734 | | |
| WD2_99 | 0.1589 | 0.0021 | 950.65 | 11.8868 | 1106.49 | 10.1117 | | |
| WD2_95 | 0.1453 | 0.0018 | 874.79 | 10.0672 | 1048.25 | 7.1407 | | |
| WD2_87 | 0.4086 | 0.0048 | 2208.37 | 21.7513 | 2702.80 | 8.1968 | | |
| WD2_85 | 0.2083 | 0.0024 | 1219.60 | 12.9785 | 1813.93 | 8.8472 | | |
| WD2_83 | 0.6652 | 0.0062 | 3287.15 | 24.0998 | 2800.39 | 7.4842 | | |
| WD2_79 | 0.2436 | 0.0032 | 1405.34 | 16.4234 | 1921.22 | 41.4745 | | |
| WD2_73 | 0.0697 | 0.0008 | 434.38 | 4.9607 | 643.85 | 25.1299 | | |
| WD2_66 | 0.2519 | 0.0066 | 1448.15 | 34.1134 | 1620.22 | 20.9205 | | |
| WD2_64 | 0.0401 | 0.0006 | 253.72 | 3.8110 | 617.05 | 20.7825 | | |
| WD2_57 | 0.1215 | 0.0017 | 739.32 | 9.7248 | 1121.15 | 10.2220 | | |
| WD2_53 | 0.0916 | 0.0025 | 564.90 | 14.5269 | 1141.88 | 57.4074 | | |
| WD2_44 | 0.1806 | 0.0031 | 1070.27 | 16.8543 | 1379.51 | 10.5587 | | |
| WD2_35 | 0.1546 | 0.0039 | 926.80 | 21.5440 | 1265.21 | 25.6493 | | |
| WD2_26 | 0.0503 | 0.0012 | 316.31 | 7.2181 | 475.00 | 42.7849 | | |
| WD2_22 | 0.2267 | 0.0027 | 1317.38 | 14.0039 | 1528.44 | 22.2314 | | |
| WD2_19 | 0.2012 | 0.0077 | 1181.97 | 41.3873 | 3637.77 | 58.2155 | | |
| WD2_17 | 0.0518 | 0.0012 | 325.76 | 7.4830 | 871.83 | 36.9136 | | |
| WD2_13 | 0.0659 | 0.0011 | 411.29 | 6.4127 | 457.82 | 25.0304 | | |
| WD2_12 | 0.1205 | 0.0031 | 733.32 | 17.6296 | 1625.19 | 15.4984 | | |
| WD2_9 | 0.1710 | 0.0054 | 1017.37 | 29.4837 | 1147.83 | 77.3405 | | |
| WD2_8 | 0.0271 | 0.0029 | 172.08 | 17.9596 | 8095.52 | 26.4839 | | |
| WD2_6 | 0.0686 | 0.0014 | 427.66 | 8.5723 | 873.40 | 40.0135 | | |

**WD-2 Concordia Diagram**



**WD-2 Probability Density Plot**



**Appendix D - WD-3**

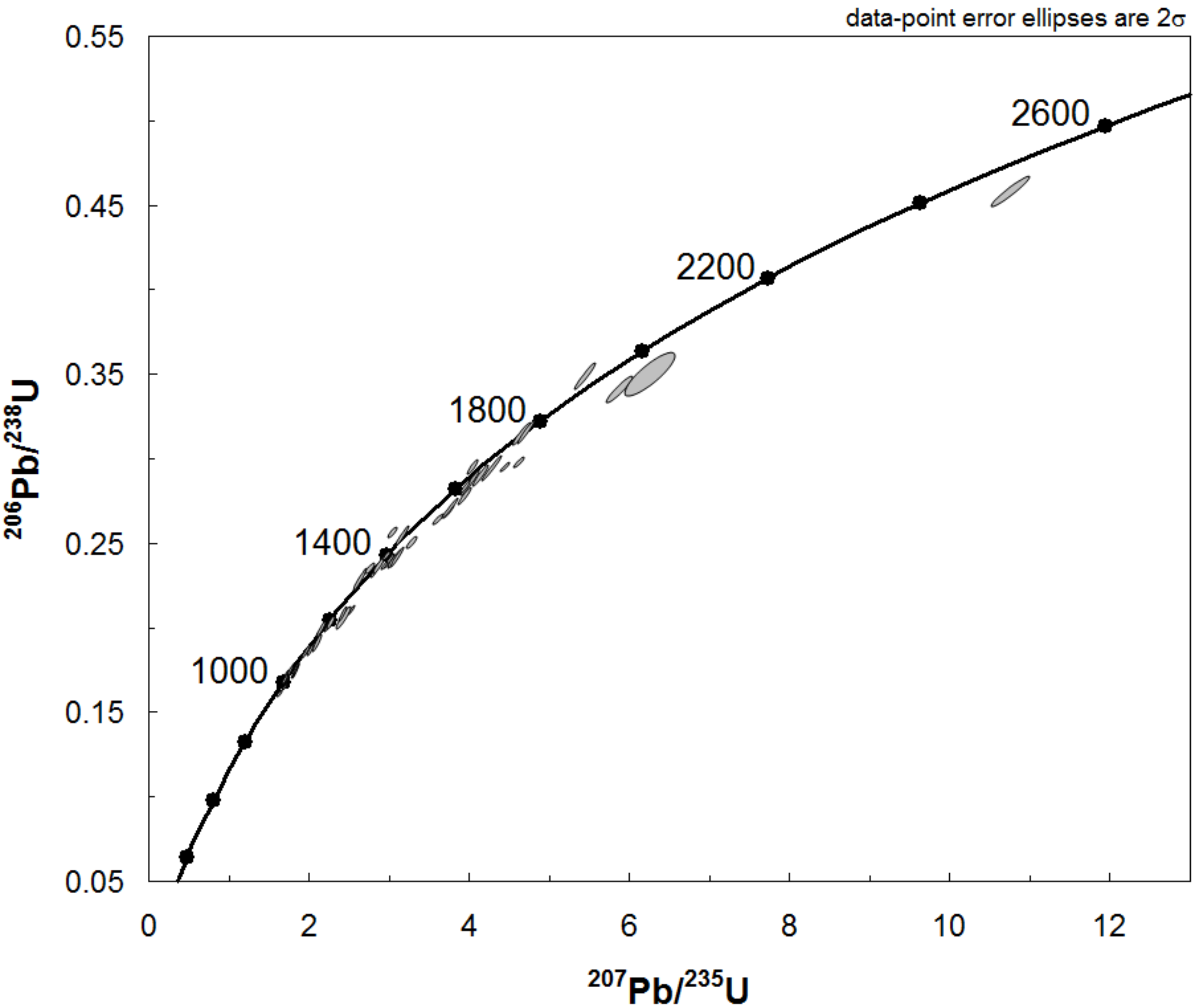
Sample WD-3 (Dutch Mill) U–Pb detrital zircon LA-ICP-MS analysis results

| | Isotopic Ratio | | Apparent Ages | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sample | 206/238 | ±1σ | 206/238 | ±1σ (Ma) | 207/206 | ±1σ (Ma) | Best Age | ±1σ (Ma) |
| WD3_110r | 0.2314 | 0.0023 | 1341.81 | 12.1527 | 1377.40 | 12.45 | 1377.40 | 12.45 |
| WD3_105 | 0.3137 | 0.0053 | 1758.72 | 25.7706 | 1761.75 | 10.41 | 1761.75 | 10.41 |
| WD3_103 | 0.2387 | 0.0036 | 1379.96 | 18.9387 | 1451.61 | 9.39 | 1451.61 | 9.39 |
| Wd3_101 | 0.3402 | 0.0066 | 1887.83 | 31.7287 | 2038.18 | 14.56 | 2038.18 | 14.56 |
| WD3_97 | 0.4573 | 0.0075 | 2427.57 | 33.1465 | 2568.60 | 9.28 | 2568.60 | 9.28 |
| WD3_95 | 0.1902 | 0.0041 | 1122.38 | 21.9575 | 1205.62 | 19.18 | 1205.62 | 19.18 |
| WD3_87 | 0.1861 | 0.0030 | 1100.23 | 16.4200 | 1164.87 | 16.95 | 1164.87 | 16.95 |
| WD3_85 | 0.1682 | 0.0018 | 1002.35 | 9.9633 | 1051.75 | 10.09 | 1051.75 | 10.09 |
| WD3_83 | 0.2094 | 0.0022 | 1225.77 | 11.6843 | 1373.38 | 10.18 | 1373.38 | 10.18 |
| WD3_80 | 0.1998 | 0.0025 | 1174.09 | 13.3645 | 1218.19 | 12.08 | 1218.19 | 12.08 |
| Wd3_79 | 0.2679 | 0.0036 | 1530.01 | 18.3485 | 1651.76 | 10.42 | 1651.76 | 10.42 |
| WD3_76 | 0.2490 | 0.0029 | 1433.55 | 14.8369 | 1546.13 | 15.51 | 1546.13 | 15.51 |
| WD3_73 | 0.2934 | 0.0065 | 1658.31 | 32.0771 | 1715.63 | 8.48 | 1715.63 | 8.48 |
| WD3_72 | 0.2048 | 0.0054 | 1201.29 | 28.8888 | 1323.78 | 20.26 | 1323.78 | 20.26 |
| WD3_71 | 0.2276 | 0.0052 | 1321.77 | 27.4062 | 1282.37 | 12.51 | 1282.37 | 12.51 |
| WD3_68 | 0.1740 | 0.0041 | 1034.25 | 22.2292 | 1086.14 | 15.21 | 1086.14 | 15.21 |
| WD3_66 | 0.2848 | 0.0064 | 1615.33 | 32.1129 | 1653.57 | 9.92 | 1653.57 | 9.92 |
| WD3_64 | 0.2397 | 0.0045 | 1384.96 | 23.1953 | 1473.56 | 12.59 | 1473.56 | 12.59 |
| WD3_63 | 0.2410 | 0.0048 | 1391.76 | 24.8246 | 1486.88 | 10.24 | 1486.88 | 10.24 |
| WD3_62 | 0.2893 | 0.0052 | 1637.79 | 26.0376 | 1689.16 | 11.11 | 1689.16 | 11.11 |
| WD3_61 | 0.2359 | 0.0043 | 1365.42 | 22.3338 | 1385.09 | 12.85 | 1385.09 | 12.85 |
| WD3_59 | 0.2631 | 0.0026 | 1505.80 | 13.3750 | 1627.84 | 12.35 | 1627.84 | 12.35 |
| WD3_57 | 0.2946 | 0.0035 | 1664.65 | 17.3831 | 1627.32 | 12.44 | 1627.32 | 12.44 |
| WD3_56 | 0.3487 | 0.0105 | 1928.26 | 49.9473 | 2115.26 | 38.48 | 2115.26 | 38.48 |
| WD3_52 | 0.2765 | 0.0041 | 1573.79 | 20.6091 | 1651.04 | 9.89 | 1651.04 | 9.89 |
| WD3_48 | 0.2071 | 0.0034 | 1213.55 | 18.2678 | 1275.93 | 12.38 | 1275.93 | 12.38 |
| WD3_47 | 0.2021 | 0.0034 | 1186.84 | 18.4692 | 1190.87 | 18.64 | 1190.87 | 18.64 |
| WD3_45 | 0.2944 | 0.0024 | 1663.71 | 11.9259 | 1784.96 | 8.61 | 1784.96 | 8.61 |
| WD3_44 | 0.1641 | 0.0017 | 979.28 | 9.3678 | 1058.54 | 12.08 | 1058.54 | 12.08 |
| WD3_37 | 0.2346 | 0.0027 | 1358.36 | 14.2817 | 1309.29 | 16.93 | 1309.29 | 16.93 |
| WD3_36 | 0.2417 | 0.0022 | 1395.72 | 11.6192 | 1390.40 | 10.82 | 1390.40 | 10.82 |
| WD3_34 | 0.2824 | 0.0025 | 1603.45 | 12.7173 | 1641.05 | 10.73 | 1641.05 | 10.73 |
| WD3_24 | 0.2970 | 0.0024 | 1676.63 | 11.7059 | 1845.13 | 9.58 | 1845.13 | 9.58 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD3_22 | 0.2359 | 0.0020 | 1365.55 | 10.5876 | 1430.05 | 8.88 | 1430.05 | 8.88 |
| WD3_21 | 0.1957 | 0.0015 | 1151.99 | 8.1596 | 1153.61 | 11.98 | 1153.61 | 11.98 |
| WD3_20 | 0.1719 | 0.0015 | 1022.81 | 8.0192 | 1003.35 | 15.28 | 1003.35 | 15.28 |
| WD3_17 | 0.2556 | 0.0026 | 1467.35 | 13.1818 | 1343.16 | 14.09 | 1343.16 | 14.09 |
| WD3_15 | 0.1601 | 0.0016 | 957.48 | 8.6370 | 1024.66 | 17.43 | 1024.66 | 17.43 |
| WD3_14 | 0.1703 | 0.0032 | 1013.52 | 17.6647 | 1029.99 | 12.72 | 1029.99 | 12.72 |
| WD3_13 | 0.1697 | 0.0033 | 1010.32 | 17.9736 | 1024.65 | 12.88 | 1024.65 | 12.88 |
| WD3_11 | 0.1979 | 0.0040 | 1163.81 | 21.2998 | 1168.15 | 15.03 | 1168.15 | 15.03 |
| WD3_9 | 0.1735 | 0.0033 | 1031.15 | 18.1387 | 1114.61 | 10.39 | 1114.61 | 10.39 |
| WD3_8 | 0.3150 | 0.0059 | 1765.34 | 28.8405 | 1775.35 | 8.98 | 1775.35 | 8.98 |
| WD3_7 | 0.3480 | 0.0064 | 1925.27 | 30.3902 | 1859.43 | 9.85 | 1859.43 | 9.85 |
| WD3_5 | 0.2698 | 0.0050 | 1539.77 | 25.4597 | 1644.47 | 9.60 | 1644.47 | 9.60 |
| WD3_3 | 0.1855 | 0.0035 | 1096.72 | 18.8056 | 1117.57 | 12.43 | 1117.57 | 12.43 |
| WD3_2 | 0.2536 | 0.0047 | 1457.11 | 24.3524 | 1436.67 | 10.04 | 1436.67 | 10.04 |
| WD3_1 | 0.1741 | 0.0032 | 1034.80 | 17.5570 | 1038.78 | 10.79 | 1038.78 | 10.79 |
| | | | | | | | | |
| Discordance >10% | | | | | | | | |
| WD3_107 | 0.3654 | 0.0058 | 2007.72 | 27.1663 | 2723.77 | 9.66 | | |
| WD3_106 | 0.2818 | 0.0032 | 1600.39 | 16.1679 | 2671.61 | 7.72 | | |
| WD3_104 | 0.2193 | 0.0156 | 1278.37 | 81.7607 | 1903.08 | 62.58 | | |
| WD3_102 | 0.1880 | 0.0029 | 1110.58 | 15.9315 | 1668.55 | 11.96 | | |
| WD3_100 | 0.1836 | 0.0034 | 1086.78 | 18.3019 | 1440.07 | 10.16 | | |
| WD3_99 | 0.0764 | 0.0014 | 474.76 | 8.3482 | 636.72 | 20.57 | | |
| WD3_98 | 0.1974 | 0.0031 | 1161.41 | 16.7832 | 1482.19 | 11.18 | | |
| WD3_96 | 0.0789 | 0.0017 | 489.42 | 10.0933 | 838.82 | 32.71 | | |
| WD3_94 | 0.2334 | 0.0043 | 1352.51 | 22.5999 | 1525.88 | 12.61 | | |
| WD3_93 | 0.1710 | 0.0028 | 1017.37 | 15.1225 | 1281.15 | 10.48 | | |
| WD3_92 | 0.2429 | 0.0039 | 1401.57 | 20.0150 | 1692.34 | 9.46 | | |
| WD3_91 | 0.0787 | 0.0013 | 488.22 | 7.5205 | 1287.88 | 10.26 | | |
| Wd3_90 | 0.1680 | 0.0021 | 1000.96 | 11.4951 | 1199.32 | 18.47 | | |
| WD3_88 | 0.0919 | 0.0018 | 566.67 | 10.7720 | 1155.31 | 20.08 | | |
| WD3_86 | 0.2342 | 0.0025 | 1356.66 | 13.1839 | 1577.66 | 10.85 | | |
| WD3_84 | 0.1232 | 0.0018 | 748.71 | 10.2345 | 1264.82 | 16.23 | | |
| WD3_82 | 0.1686 | 0.0021 | 1004.54 | 11.4600 | 1162.52 | 16.65 | | |
| WD3_81 | 0.0375 | 0.0005 | 237.38 | 2.9251 | 1986.85 | 17.48 | | |
| WD3_78 | 0.1491 | 0.0018 | 895.71 | 10.2239 | 1137.39 | 10.75 | | |
| WD3_77 | 0.2361 | 0.0032 | 1366.20 | 16.8108 | 1614.73 | 16.27 | | |
| WD3_75 | 0.1631 | 0.0039 | 974.05 | 21.5245 | 1100.47 | 18.42 | | |
| WD3_74 | 0.0595 | 0.0016 | 372.87 | 10.0278 | 678.49 | 31.32 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD3_70 | 0.0663 | 0.0018 | 413.90 | 11.0309 | 546.17 | 35.90 | | |
| WD3_69 | 0.1670 | 0.0039 | 995.74 | 21.5601 | 1533.49 | 11.78 | | |
| Wd3_67 | 0.1102 | 0.0026 | 674.15 | 14.8043 | 1473.62 | 11.60 | | |
| WD3_65 | 0.0395 | 0.0017 | 249.45 | 10.7247 | 1230.37 | 17.08 | | |
| WD3_55 | 0.1678 | 0.0045 | 1000.16 | 24.8565 | 1302.48 | 26.59 | | |
| WD3_54 | 0.1860 | 0.0030 | 1099.71 | 16.3215 | 1265.68 | 12.09 | | |
| WD3_51 | 0.2127 | 0.0031 | 1243.27 | 16.7183 | 2179.80 | 10.80 | | |
| WD3_50 | 0.0689 | 0.0016 | 429.79 | 9.4391 | 556.70 | 52.35 | | |
| WD3_49 | 0.1504 | 0.0032 | 903.41 | 17.9927 | 1274.76 | 22.52 | | |
| WD3_46 | 0.1602 | 0.0068 | 957.63 | 37.6712 | 2146.04 | 54.61 | | |
| WD3_41r | 0.1586 | 0.0048 | 948.98 | 26.6100 | 1331.17 | 24.84 | | |
| WD3_43 | 0.0682 | 0.0006 | 425.20 | 3.5092 | 540.32 | 12.73 | | |
| WD3_42 | 0.4469 | 0.0038 | 2381.41 | 17.0779 | 2710.12 | 7.49 | | |
| WD3_41 | 0.1405 | 0.0033 | 847.24 | 18.8583 | 1221.21 | 24.34 | | |
| WD3_39 | 0.0660 | 0.0006 | 412.02 | 3.6131 | 653.56 | 16.99 | | |
| WD3_38 | 0.0671 | 0.0010 | 418.81 | 6.1650 | 661.29 | 17.42 | | |
| WD3_35 | 0.2200 | 0.0066 | 1282.13 | 34.9708 | 1537.48 | 34.94 | | |
| WD3_33 | 0.0661 | 0.0010 | 412.55 | 6.0658 | 700.85 | 26.47 | | |
| Wd3_32r | 0.1670 | 0.0027 | 995.35 | 15.0822 | 1147.37 | 21.94 | | |
| WD3_31 | 0.0685 | 0.0009 | 427.06 | 5.2264 | 695.60 | 21.57 | | |
| WD3_30 | 0.2519 | 0.0028 | 1448.07 | 14.5532 | 1856.35 | 10.22 | | |
| WD3_29 | 0.1724 | 0.0025 | 1025.16 | 13.5273 | 1208.51 | 22.04 | | |
| WD3_28 | 0.4053 | 0.0045 | 2193.49 | 20.7151 | 2667.57 | 9.67 | | |
| WD3_27 | 0.1655 | 0.0015 | 987.27 | 8.4294 | 1200.28 | 15.05 | | |
| WD3_25 | 0.3036 | 0.0024 | 1709.26 | 11.8291 | 1485.30 | 9.78 | | |
| WD3_23 | 0.2553 | 0.0021 | 1465.78 | 11.0123 | 1653.94 | 9.54 | | |
| WD3_19 | 0.0722 | 0.0014 | 449.62 | 8.5844 | 994.14 | 31.60 | | |
| WD3_18 | 0.1365 | 0.0013 | 824.89 | 7.2114 | 1128.14 | 11.94 | | |
| WD3_16 | 0.2095 | 0.0017 | 1226.32 | 9.0156 | 1430.74 | 11.12 | | |
| WD3_12 | 0.2183 | 0.0041 | 1272.71 | 21.7967 | 1476.39 | 10.06 | | |
| WD3_10 | 0.0573 | 0.0012 | 359.06 | 7.3302 | 1502.29 | 36.08 | | |
| WD3_6 | 0.2165 | 0.0047 | 1263.19 | 24.5947 | 2245.05 | 27.00 | | |
| WD3_4 | 0.1227 | 0.0031 | 746.32 | 17.7026 | 1760.00 | 14.26 | | |

**WD-3 Concordia Diagram**



**WD-3 Probability Density Plot**

**Appendix E - WD-5**

Sample WD-5 (Wedington Gap) U–Pb detrital zircon LA-ICP-MS analysis results

| | Isotopic Ratio | | Apparent Ages | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sample | 206/238 | ±1σ | 206/238 | ±1σ (Ma) | 207/206 | ±1σ (Ma) | Best Age | ±1σ (Ma) |
| WD5_134 | 0.0731 | 0.0010 | 454.60 | 6.2170 | 483.62 | 23.9419 | 454.60 | 6.2170 |
| WD5_133 | 0.2624 | 0.0032 | 1502.19 | 16.5485 | 1604.94 | 12.3764 | 1604.94 | 12.3764 |
| WD5_132 | 0.2004 | 0.0031 | 1177.34 | 16.4754 | 1281.54 | 21.1562 | 1281.54 | 21.1562 |
| WD5_131 | 0.2402 | 0.0032 | 1387.52 | 16.5121 | 1386.68 | 15.6870 | 1386.68 | 15.6870 |
| WD5_130 | 0.1680 | 0.0027 | 1000.84 | 14.7182 | 1062.11 | 31.4462 | 1062.11 | 31.4462 |
| WD5_129 | 0.0705 | 0.0009 | 439.10 | 5.5608 | 471.40 | 21.0664 | 439.10 | 5.5608 |
| WD5_128 | 0.2515 | 0.0033 | 1446.24 | 17.0702 | 1455.38 | 14.6332 | 1455.38 | 14.6332 |
| WD5_126 | 0.5794 | 0.0073 | 2946.35 | 29.8632 | 2969.85 | 10.3181 | 2969.85 | 10.3181 |
| WD5_125 | 0.1790 | 0.0033 | 1061.67 | 18.0417 | 1127.44 | 24.8504 | 1127.44 | 24.8504 |
| WD5_124 | 0.1728 | 0.0026 | 1027.70 | 14.3164 | 1052.06 | 14.0851 | 1052.06 | 14.0851 |
| WD5_122 | 0.1773 | 0.0027 | 1052.43 | 14.7571 | 1078.61 | 16.6322 | 1078.61 | 16.6322 |
| WD5_121 | 0.1911 | 0.0030 | 1127.48 | 16.0107 | 1161.23 | 16.0491 | 1161.23 | 16.0491 |
| WD5_120 | 0.1791 | 0.0036 | 1062.09 | 19.3967 | 1011.10 | 29.1764 | 1011.10 | 29.1764 |
| WD5_119 | 0.0674 | 0.0011 | 420.17 | 6.6599 | 463.70 | 25.9193 | 420.17 | 6.6599 |
| WD5_118 | 0.2314 | 0.0037 | 1342.01 | 19.5006 | 1372.17 | 18.8509 | 1372.17 | 18.8509 |
| WD5_117 | 0.4973 | 0.0076 | 2602.34 | 32.6642 | 2698.44 | 11.2028 | 2698.44 | 11.2028 |
| WD5_114 | 0.1793 | 0.0032 | 1063.10 | 17.5366 | 1097.31 | 27.3415 | 1097.31 | 27.3415 |
| WD5_111 | 0.1954 | 0.0021 | 1150.36 | 11.3929 | 1188.91 | 17.0127 | 1188.91 | 17.0127 |
| WD5_110 | 0.0742 | 0.0009 | 461.57 | 5.4985 | 485.39 | 27.2481 | 461.57 | 5.4985 |
| WD5_109 | 0.1753 | 0.0019 | 1041.45 | 10.5961 | 1069.85 | 16.5907 | 1069.85 | 16.5907 |
| WD5_105 | 0.5074 | 0.0054 | 2645.55 | 23.2004 | 2736.17 | 10.8640 | 2736.17 | 10.8640 |
| WD5_104 | 0.1808 | 0.0020 | 1071.10 | 10.9133 | 1044.97 | 17.2712 | 1044.97 | 17.2712 |
| WD5_103 | 0.1794 | 0.0021 | 1063.93 | 11.5330 | 1084.21 | 18.3133 | 1084.21 | 18.3133 |
| WD5_101 | 0.2646 | 0.0032 | 1513.20 | 16.0509 | 1478.92 | 16.3956 | 1478.92 | 16.3956 |
| WD5_100 | 0.2246 | 0.0023 | 1305.93 | 12.2034 | 1332.92 | 14.6328 | 1332.92 | 14.6328 |
| WD5_99 | 0.2951 | 0.0032 | 1666.89 | 15.8016 | 1688.27 | 13.0610 | 1688.27 | 13.0610 |
| WD5_98 | 0.2966 | 0.0030 | 1674.35 | 14.6827 | 1720.75 | 12.8541 | 1720.75 | 12.8541 |
| WD5_96 | 0.1703 | 0.0018 | 1013.67 | 9.6813 | 1102.69 | 19.8603 | 1102.69 | 19.8603 |
| WD5_95 | 0.2165 | 0.0025 | 1263.16 | 13.1935 | 1287.56 | 18.9469 | 1287.56 | 18.9469 |
| WD5_94 | 0.1754 | 0.0021 | 1041.97 | 11.6376 | 1121.84 | 25.1310 | 1121.84 | 25.1310 |
| WD5_93 | 0.2897 | 0.0033 | 1639.79 | 16.4204 | 1646.14 | 14.4439 | 1646.14 | 14.4439 |
| WD5_92 | 0.0753 | 0.0010 | 468.27 | 6.0271 | 468.42 | 29.2454 | 468.27 | 6.0271 |
| WD5_91 | 0.1838 | 0.0018 | 1087.62 | 9.7217 | 1125.68 | 16.2039 | 1125.68 | 16.2039 |

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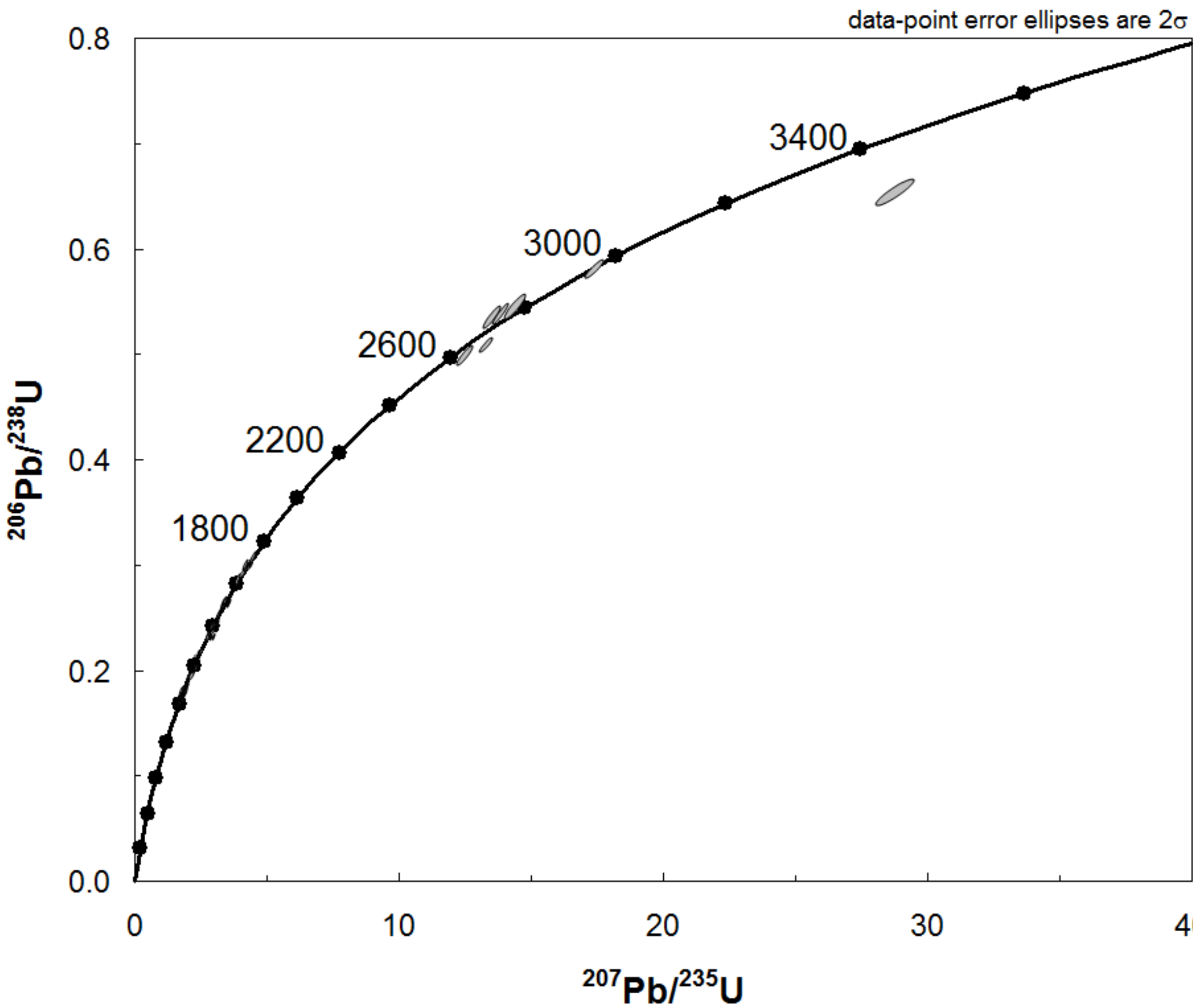
|---|---|---|---|---|---|---|---|---|
| WD5_88 | 0.2353 | 0.0029 | 1362.09 | 15.2339 | 1424.73 | 20.3210 | 1424.73 | 20.3210 |
| WD5_85 | 0.1634 | 0.0015 | 975.49 | 8.4160 | 1058.69 | 14.0591 | 1058.69 | 14.0591 |
| WD5_84 | 0.1731 | 0.0016 | 1029.21 | 8.7151 | 1036.72 | 14.2329 | 1036.72 | 14.2329 |
| WD5_83 | 0.1783 | 0.0020 | 1057.61 | 10.7497 | 1031.02 | 22.6192 | 1031.02 | 22.6192 |
| WD5_82 | 0.1987 | 0.0036 | 1168.49 | 19.3260 | 1267.02 | 21.4827 | 1267.02 | 21.4827 |
| WD5_81 | 0.5442 | 0.0095 | 2800.84 | 39.4939 | 2779.21 | 12.4330 | 2779.21 | 12.4330 |
| WD5_80 | 0.6521 | 0.0104 | 3236.57 | 40.4810 | 3590.28 | 9.6354 | 3590.28 | 9.6354 |
| WD5_79 | 0.1691 | 0.0028 | 1006.96 | 15.2980 | 1025.41 | 16.5954 | 1025.41 | 16.5954 |
| WD5_78 | 0.1767 | 0.0029 | 1049.11 | 15.6807 | 1038.46 | 14.5950 | 1038.46 | 14.5950 |
| WD5_77 | 0.3053 | 0.0050 | 1717.68 | 24.4242 | 1752.93 | 12.9782 | 1752.93 | 12.9782 |
| WD5_76 | 0.1830 | 0.0034 | 1083.33 | 18.2504 | 1152.68 | 21.2922 | 1152.68 | 21.2922 |
| WD5_74 | 0.1891 | 0.0035 | 1116.41 | 19.0296 | 1142.89 | 25.0785 | 1142.89 | 25.0785 |
| WD5_73 | 0.5334 | 0.0086 | 2755.72 | 36.2419 | 2710.35 | 10.3428 | 2710.35 | 10.3428 |
| WD5_71 | 0.2986 | 0.0049 | 1684.42 | 24.2148 | 1685.24 | 12.9360 | 1685.24 | 12.9360 |
| WD5_70 | 0.0940 | 0.0017 | 579.30 | 9.7556 | 602.60 | 27.4790 | 579.30 | 9.7556 |
| WD5_69 | 0.2129 | 0.0034 | 1244.37 | 18.1597 | 1277.22 | 13.2884 | 1277.22 | 13.2884 |
| WD5_68 | 0.2301 | 0.0040 | 1335.14 | 20.8268 | 1407.38 | 15.8746 | 1407.38 | 15.8746 |
| WD5_66 | 0.0690 | 0.0010 | 430.38 | 6.3070 | 452.69 | 20.1880 | 430.38 | 6.3070 |
| WD5_64 | 0.0676 | 0.0010 | 421.73 | 5.9347 | 442.91 | 16.8873 | 421.73 | 5.9347 |
| WD5_63 | 0.2610 | 0.0038 | 1495.20 | 19.2803 | 1494.06 | 12.2159 | 1494.06 | 12.2159 |
| WD5_62 | 0.1662 | 0.0031 | 990.95 | 16.9652 | 1071.83 | 24.2236 | 1071.83 | 24.2236 |
| WD5_61 | 0.1764 | 0.0028 | 1047.54 | 15.3956 | 1150.56 | 17.1999 | 1150.56 | 17.1999 |
| WD5_60 | 0.5365 | 0.0083 | 2768.87 | 34.5648 | 2737.32 | 10.4891 | 2737.32 | 10.4891 |
| WD5_57 | 0.2846 | 0.0047 | 1614.25 | 23.7401 | 1630.97 | 18.2241 | 1630.97 | 18.2241 |
| WD5_56 | 0.2416 | 0.0037 | 1394.86 | 18.9590 | 1495.38 | 14.9293 | 1495.38 | 14.9293 |
| WD5_55 | 0.2805 | 0.0044 | 1593.78 | 22.2065 | 1666.37 | 13.1550 | 1666.37 | 13.1550 |
| WD5_51 | 0.2983 | 0.0025 | 1683.07 | 12.2497 | 1765.45 | 13.3833 | 1765.45 | 13.3833 |
| WD5_49 | 0.1976 | 0.0018 | 1162.26 | 9.5467 | 1189.86 | 17.6068 | 1189.86 | 17.6068 |
| WD5_48 | 0.2412 | 0.0025 | 1393.15 | 13.0607 | 1457.18 | 14.3383 | 1457.18 | 14.3383 |
| WD5_46 | 0.2646 | 0.0035 | 1513.22 | 17.6478 | 1532.04 | 18.4191 | 1532.04 | 18.4191 |
| WD5_44 | 0.2622 | 0.0032 | 1501.27 | 16.3916 | 1606.23 | 14.5215 | 1606.23 | 14.5215 |
| WD5_43 | 0.1868 | 0.0014 | 1103.84 | 7.6532 | 1138.45 | 14.6305 | 1138.45 | 14.6305 |
| WD5_41 | 0.1763 | 0.0014 | 1046.60 | 7.4084 | 1068.76 | 14.4840 | 1068.76 | 14.4840 |
| WD5_40 | 0.1716 | 0.0014 | 1020.79 | 7.4791 | 1004.15 | 15.4400 | 1004.15 | 15.4400 |
| WD5_39 | 0.2292 | 0.0020 | 1330.39 | 10.4385 | 1469.14 | 16.4515 | 1469.14 | 16.4515 |
| WD5_38 | 0.2617 | 0.0024 | 1498.37 | 12.1388 | 1598.83 | 13.5428 | 1598.83 | 13.5428 |
| WD5_37 | 0.1823 | 0.0011 | 1079.68 | 6.1384 | 1099.11 | 13.9074 | 1099.11 | 13.9074 |
| WD5_33 | 0.2480 | 0.0018 | 1428.25 | 9.0726 | 1448.35 | 14.2420 | 1448.35 | 14.2420 |
| WD5_31 | 0.2692 | 0.0021 | 1536.65 | 10.8823 | 1599.45 | 15.4811 | 1599.45 | 15.4811 |

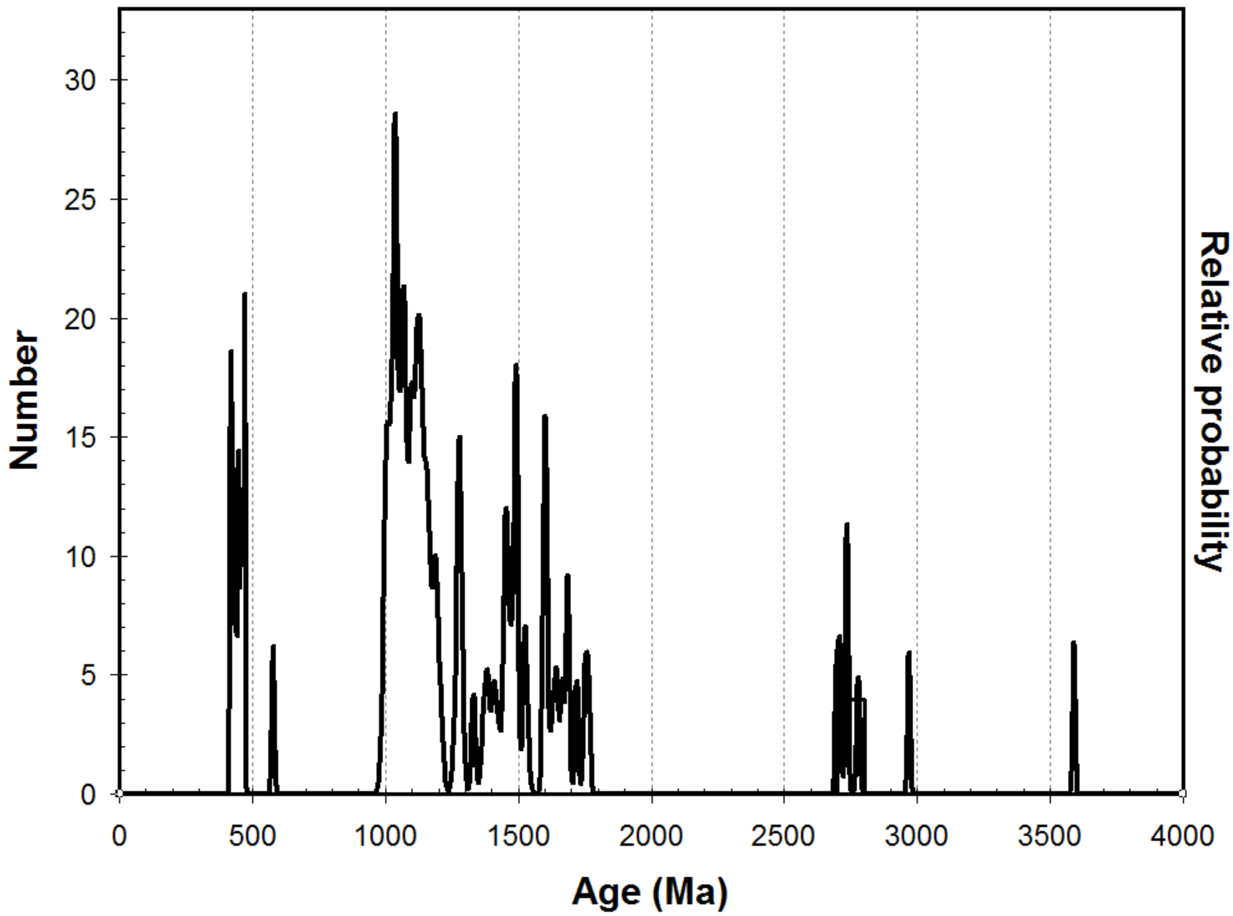
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| WD5_30 | 0.2103 | 0.0020 | 1230.51 | 10.7658 | 1171.62 | 16.8496 | 1171.62 | 16.8496 |
| WD5_29 | 0.0763 | 0.0005 | 473.89 | 3.1914 | 522.46 | 17.9202 | 473.89 | 3.1914 |
| WD5_28 | 0.1965 | 0.0017 | 1156.49 | 8.9002 | 1208.70 | 20.0592 | 1208.70 | 20.0592 |
| WD5_24 | 0.1917 | 0.0014 | 1130.37 | 7.7335 | 1116.62 | 15.2039 | 1116.62 | 15.2039 |
| WD5_23 | 0.1986 | 0.0013 | 1167.95 | 6.7762 | 1132.06 | 13.9383 | 1132.06 | 13.9383 |
| WD5_21 | 0.1669 | 0.0025 | 995.27 | 13.6130 | 1032.72 | 25.1106 | 1032.72 | 25.1106 |
| WD5_20 | 0.1820 | 0.0022 | 1077.93 | 11.8759 | 1120.80 | 17.5446 | 1120.80 | 17.5446 |
| WD5_19 | 0.1624 | 0.0021 | 969.93 | 11.5258 | 1004.31 | 20.7270 | 1004.31 | 20.7270 |
| WD5_18 | 0.1855 | 0.0023 | 1097.03 | 12.3112 | 1096.97 | 18.4094 | 1096.97 | 18.4094 |
| WD5_17 | 0.2111 | 0.0023 | 1234.49 | 12.3680 | 1281.54 | 14.4838 | 1281.54 | 14.4838 |
| WD5_15 | 0.1761 | 0.0029 | 1045.78 | 15.8465 | 1011.94 | 26.3671 | 1011.94 | 26.3671 |
| WD5_13 | 0.2302 | 0.0028 | 1335.29 | 14.8029 | 1493.76 | 15.0840 | 1493.76 | 15.0840 |
| WD5_12 | 0.2428 | 0.0030 | 1401.14 | 15.6264 | 1492.02 | 14.3405 | 1492.02 | 14.3405 |
| WD5_11 | 0.1720 | 0.0024 | 1023.30 | 13.1182 | 1002.31 | 27.7860 | 1002.31 | 27.7860 |
| WD5_10 | 0.1929 | 0.0030 | 1137.16 | 16.3646 | 1190.30 | 32.8668 | 1190.30 | 32.8668 |
| WD5_9 | 0.1749 | 0.0022 | 1039.15 | 12.2436 | 1018.50 | 20.6045 | 1018.50 | 20.6045 |
| WD5_8 | 0.1783 | 0.0020 | 1057.92 | 10.7442 | 1042.12 | 15.9860 | 1042.12 | 15.9860 |
| WD5_7 | 0.1748 | 0.0019 | 1038.73 | 10.3667 | 989.35 | 16.8368 | 1038.73 | 10.3667 |
| WD5_6 | 0.1720 | 0.0024 | 1023.24 | 13.2856 | 1109.11 | 22.5086 | 1109.11 | 22.5086 |
| WD5_5 | 0.1605 | 0.0015 | 959.29 | 8.1842 | 1069.71 | 14.6710 | 1069.71 | 14.6710 |
| WD5_3 | 0.0719 | 0.0007 | 447.41 | 4.4756 | 500.90 | 21.9791 | 447.41 | 4.4756 |
| WD5_2 | 0.2598 | 0.0025 | 1489.02 | 12.5658 | 1524.55 | 13.7866 | 1524.55 | 13.7866 |
| WD5_1 | 0.1791 | 0.0025 | 1061.80 | 13.3897 | 1158.32 | 27.9320 | 1158.32 | 27.9320 |
| | | | | | | | | |
| Discordance >10% | | | | | | | | |
| WD5_135 | 0.4384 | 0.0062 | 2343.26 | 27.9224 | 2814.55 | 11.1438 | | |
| WD5_127 | 0.1796 | 0.0028 | 1064.61 | 15.3497 | 1203.96 | 26.2875 | | |
| WD5_123 | 0.1929 | 0.0029 | 1137.10 | 15.3942 | 1326.55 | 13.2028 | | |
| WD5_116 | 0.2148 | 0.0035 | 1254.48 | 18.3707 | 1691.00 | 12.9180 | | |
| WD5_115 | 0.1674 | 0.0026 | 997.97 | 14.3208 | 1232.70 | 20.3506 | | |
| WD5_112 | 0.2179 | 0.0025 | 1270.82 | 12.9761 | 1490.17 | 13.5831 | | |
| WD5_108 | 0.1666 | 0.0026 | 993.33 | 14.1619 | 1132.39 | 26.8114 | | |
| WD5_107 | 0.1811 | 0.0030 | 1073.03 | 16.5023 | 1363.58 | 19.2515 | | |
| WD5_106 | 0.3989 | 0.0047 | 2163.90 | 21.7739 | 2678.58 | 11.1157 | | |
| WD5_97 | 0.0694 | 0.0007 | 432.29 | 4.1838 | 558.24 | 18.3823 | | |
| WD5_90 | 0.0625 | 0.0011 | 390.96 | 6.5784 | 540.83 | 54.3691 | | |
| WD5_89 | 0.0659 | 0.0006 | 411.27 | 3.8940 | 532.13 | 21.3690 | | |
| WD5_87 | 0.0661 | 0.0007 | 412.47 | 4.4108 | 468.52 | 18.0435 | | |
| WD5_86 | 0.0908 | 0.0010 | 560.31 | 5.8465 | 645.47 | 22.0800 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD5_75 | 0.1869 | 0.0060 | 1104.44 | 32.3184 | 1354.95 | 43.0516 | | |
| WD5_72 | 0.0700 | 0.0013 | 436.10 | 7.9369 | 568.36 | 24.2041 | | |
| WD5_65 | 0.2491 | 0.0042 | 1433.88 | 21.7841 | 1611.13 | 17.3903 | | |
| WD5_59 | 0.2033 | 0.0031 | 1193.07 | 16.8530 | 1381.82 | 23.0770 | | |
| WD5_58 | 0.0956 | 0.0017 | 588.40 | 10.0748 | 690.59 | 30.9296 | | |
| WD5_54 | 0.4335 | 0.0063 | 2321.59 | 28.1565 | 2655.74 | 10.3822 | | |
| WD5_53 | 0.2637 | 0.0042 | 1508.90 | 21.3429 | 1913.84 | 14.4669 | | |
| WD5_52 | 0.0691 | 0.0007 | 430.74 | 4.0844 | 524.62 | 18.5643 | | |
| WD5_50 | 0.0650 | 0.0007 | 405.77 | 4.0719 | 484.49 | 26.6326 | | |
| WD5_47 | 0.1862 | 0.0026 | 1100.91 | 14.1424 | 1294.82 | 19.9733 | | |
| WD5_45 | 0.3725 | 0.0034 | 2041.04 | 15.8055 | 2341.66 | 11.5109 | | |
| WD5_42 | 0.0496 | 0.0006 | 312.25 | 3.7388 | 612.99 | 20.7574 | | |
| WD5_36 | 0.1317 | 0.0009 | 797.40 | 4.9546 | 1071.73 | 13.2894 | | |
| WD5_35 | 0.0642 | 0.0006 | 401.18 | 3.6603 | 479.90 | 23.4320 | | |
| WD5_34 | 0.0493 | 0.0008 | 310.22 | 5.1174 | 596.30 | 18.0272 | | |
| WD5_32 | 0.2032 | 0.0018 | 1192.66 | 9.8748 | 1497.90 | 15.4800 | | |
| WD5_27 | 0.1792 | 0.0027 | 1062.86 | 14.7994 | 1264.32 | 26.6254 | | |
| WD5_26 | 0.0776 | 0.0040 | 481.59 | 24.0017 | 1583.52 | 68.5766 | | |
| WD5_25 | 0.4529 | 0.0052 | 2408.01 | 23.1659 | 2795.18 | 10.7365 | | |
| WD5_16 | 0.1984 | 0.0030 | 1166.70 | 16.1578 | 1532.04 | 20.7068 | | |
| WD5_14 | 0.1754 | 0.0025 | 1041.97 | 13.6364 | 1300.71 | 22.6270 | | |
| WD5_4 | 0.0695 | 0.0012 | 432.91 | 7.2703 | 498.69 | 52.1456 | | |

**WD-5 Concordia Diagram**



**WD-5 Probability Density Plot**



**Appendix F - WD-6**

Sample WD-6 (Wedington Stop 6) U–Pb detrital zircon LA-ICP-MS analysis results.

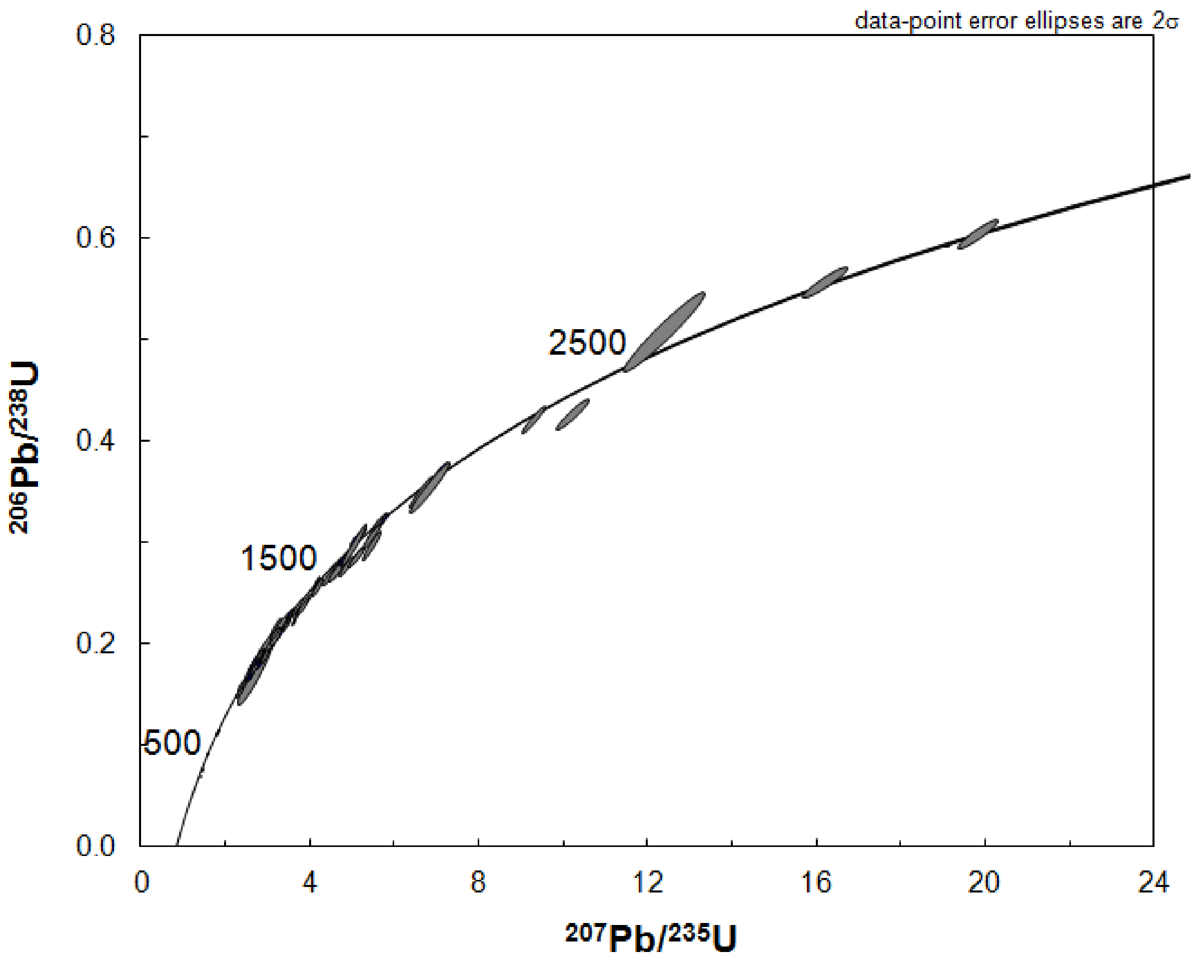
| | Isotopic Ratio | | Apparent Ages | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sample | 206/238 | ±1σ | 206/238 | ±1σ (Ma) | 207/206 | ±1σ (Ma) | Best Age | ±1σ (Ma) |
| WD6_130 | 0.1745 | 0.0023 | 1036.82 | 12.5842 | 1045.21 | 16.0155 | 1045.21 | 16.0155 |
| WD6_129 | 0.3199 | 0.0037 | 1789.19 | 18.2721 | 1791.41 | 9.8664 | 1791.41 | 9.8664 |
| WD6_126 | 0.1660 | 0.0023 | 990.03 | 12.9771 | 1039.92 | 15.3603 | 1039.92 | 15.3603 |
| WD6_125 | 0.1691 | 0.0020 | 1006.90 | 11.0556 | 1038.92 | 12.4545 | 1038.92 | 12.4545 |
| WD6_122 | 0.1826 | 0.0027 | 1081.20 | 14.6771 | 1081.03 | 18.8088 | 1081.03 | 18.8088 |
| WD6_121 | 0.2964 | 0.0056 | 1673.36 | 27.7431 | 1854.26 | 10.5901 | 1854.26 | 10.5901 |
| WD6_119 | 0.2145 | 0.0035 | 1252.62 | 18.8074 | 1257.47 | 10.6525 | 1257.47 | 10.6525 |
| WD6_118 | 0.1860 | 0.0031 | 1099.41 | 16.8687 | 1119.05 | 11.6411 | 1119.05 | 11.6411 |
| WD6_116 | 0.1981 | 0.0035 | 1165.00 | 18.7078 | 1235.07 | 13.2289 | 1235.07 | 13.2289 |
| WD6_114 | 0.3163 | 0.0051 | 1771.62 | 25.0577 | 1789.23 | 7.5145 | 1789.23 | 7.5145 |
| WD6_113 | 0.3496 | 0.0060 | 1932.66 | 28.5303 | 1963.78 | 8.7280 | 1963.78 | 8.7280 |
| WD6_112 | 0.3055 | 0.0052 | 1718.62 | 25.6954 | 1800.18 | 9.2877 | 1800.18 | 9.2877 |
| WD6_111 | 0.2773 | 0.0062 | 1577.90 | 31.2883 | 1654.23 | 16.9686 | 1654.23 | 16.9686 |
| WD6_109 | 0.2350 | 0.0043 | 1360.85 | 22.5214 | 1372.67 | 11.6986 | 1372.67 | 11.6986 |
| WD6_108 | 0.2562 | 0.0034 | 1470.14 | 17.5940 | 1518.75 | 10.7881 | 1518.75 | 10.7881 |
| WD6_106 | 0.1824 | 0.0019 | 1079.81 | 10.2479 | 1146.66 | 6.5343 | 1146.66 | 6.5343 |
| WD6_105 | 0.1765 | 0.0032 | 1047.68 | 17.4512 | 1057.26 | 15.2351 | 1057.26 | 15.2351 |
| WD6_104 | 0.2008 | 0.0024 | 1179.68 | 12.7762 | 1234.06 | 10.5088 | 1234.06 | 10.5088 |
| WD6_102 | 0.3660 | 0.0054 | 2010.60 | 25.2902 | 1999.84 | 8.2080 | 1999.84 | 8.2080 |
| WD6_101 | 0.2763 | 0.0044 | 1572.94 | 22.0358 | 1735.68 | 11.5493 | 1735.68 | 11.5493 |
| WD6_98 | 0.1765 | 0.0151 | 1048.06 | 82.2659 | 1163.01 | 62.5921 | 1163.01 | 62.5921 |
| WD6_97 | 0.2728 | 0.0032 | 1554.89 | 16.3573 | 1615.41 | 6.9391 | 1615.41 | 6.9391 |
| WD6_96 | 0.1697 | 0.0020 | 1010.67 | 10.8170 | 1092.05 | 12.6618 | 1092.05 | 12.6618 |
| WD6_94 | 0.2864 | 0.0034 | 1623.69 | 17.2507 | 1769.65 | 6.7937 | 1769.65 | 6.7937 |
| WD6_93 | 0.4216 | 0.0055 | 2267.85 | 24.6763 | 2304.15 | 6.6201 | 2304.15 | 6.6201 |
| WD6_92 | 0.1774 | 0.0026 | 1052.84 | 14.2868 | 1013.89 | 17.7000 | 1013.89 | 17.7000 |
| WD6_91 | 0.1688 | 0.0020 | 1005.45 | 10.9084 | 1021.62 | 10.5208 | 1021.62 | 10.5208 |
| WD6_90 | 0.1809 | 0.0022 | 1071.68 | 11.8197 | 1025.10 | 13.8131 | 1025.10 | 13.8131 |
| WD6_89 | 0.2142 | 0.0040 | 1251.20 | 21.0388 | 1194.19 | 18.3408 | 1194.19 | 18.3408 |
| WD6_88 | 0.1945 | 0.0021 | 1145.57 | 11.5508 | 1201.09 | 7.8620 | 1201.09 | 7.8620 |
| WD6_86 | 0.1136 | 0.0014 | 693.60 | 7.9849 | 687.45 | 16.0628 | 693.60 | 7.9849 |
| WD6_85 | 0.1841 | 0.0029 | 1089.25 | 15.6068 | 1169.64 | 17.4627 | 1169.64 | 17.4627 |
| WD6_84 | 0.2591 | 0.0029 | 1485.47 | 14.9869 | 1483.39 | 5.9438 | 1483.39 | 5.9438 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD6_80 | 0.1815 | 0.0021 | 1075.37 | 11.2302 | 1105.79 | 14.8870 | 1105.79 | 14.8870 |
| WD6_79 | 0.1832 | 0.0032 | 1084.29 | 17.6339 | 1179.17 | 22.6797 | 1179.17 | 22.6797 |
| WD6_76 | 0.2654 | 0.0030 | 1517.20 | 15.1025 | 1619.12 | 10.9495 | 1619.12 | 10.9495 |
| WD6_71 | 0.0695 | 0.0006 | 432.98 | 3.8481 | 472.91 | 14.2959 | 432.98 | 3.8481 |
| WD6_69 | 0.1766 | 0.0032 | 1048.39 | 17.7285 | 1080.98 | 21.0378 | 1080.98 | 21.0378 |
| WD6_68 | 0.2452 | 0.0022 | 1413.43 | 11.2603 | 1508.54 | 9.3118 | 1508.54 | 9.3118 |
| WD6_67 | 0.2661 | 0.0051 | 1520.99 | 25.9751 | 1642.21 | 15.4768 | 1642.21 | 15.4768 |
| WD6_63 | 0.3196 | 0.0024 | 1787.81 | 11.6834 | 1792.07 | 6.9713 | 1792.07 | 6.9713 |
| WD6_62 | 0.1708 | 0.0027 | 1016.65 | 14.7070 | 1025.48 | 27.5271 | 1025.48 | 27.5271 |
| WD6_61 | 0.1585 | 0.0024 | 948.28 | 13.3497 | 991.94 | 22.5269 | 948.28 | 13.3497 |
| WD6_59 | 0.1756 | 0.0012 | 1043.01 | 6.7301 | 1020.64 | 10.5904 | 1020.64 | 10.5904 |
| WD6_58 | 0.0746 | 0.0005 | 464.06 | 3.1996 | 500.97 | 14.5070 | 464.06 | 3.1996 |
| WD6_57 | 0.2114 | 0.0018 | 1236.23 | 9.4427 | 1243.09 | 12.6212 | 1243.09 | 12.6212 |
| WD6_56 | 0.1682 | 0.0015 | 1002.16 | 8.0547 | 1046.55 | 13.8820 | 1046.55 | 13.8820 |
| WD6_55 | 0.1691 | 0.0025 | 1007.14 | 13.4994 | 1099.86 | 16.8384 | 1099.86 | 16.8384 |
| WD6_53 | 0.1584 | 0.0024 | 948.07 | 13.5763 | 1043.37 | 15.1099 | 1043.37 | 15.1099 |
| WD6_51 | 0.1522 | 0.0023 | 913.49 | 12.7230 | 955.83 | 17.7652 | 913.49 | 12.7230 |
| WD6_50 | 0.1827 | 0.0024 | 1081.91 | 13.2332 | 1093.36 | 12.9372 | 1093.36 | 12.9372 |
| WD6_49 | 0.2135 | 0.0057 | 1247.24 | 30.0998 | 1262.31 | 30.8900 | 1262.31 | 30.8900 |
| WD6_48 | 0.1816 | 0.0027 | 1075.61 | 14.4687 | 1140.48 | 13.4214 | 1140.48 | 13.4214 |
| WD6_47 | 0.2855 | 0.0039 | 1618.79 | 19.5844 | 1782.77 | 10.7590 | 1782.77 | 10.7590 |
| WD6_46 | 0.2127 | 0.0029 | 1243.23 | 15.2863 | 1315.42 | 11.5112 | 1315.42 | 11.5112 |
| WD6_45 | 0.1847 | 0.0025 | 1092.60 | 13.7269 | 1137.16 | 12.4307 | 1137.16 | 12.4307 |
| WD6_44 | 0.4263 | 0.0063 | 2288.91 | 28.2986 | 2465.58 | 10.1329 | 2465.58 | 10.1329 |
| WD6_43 | 0.3059 | 0.0040 | 1720.72 | 19.6547 | 1676.97 | 10.5771 | 1676.97 | 10.5771 |
| WD6_42 | 0.2265 | 0.0032 | 1316.27 | 16.6817 | 1454.44 | 11.4769 | 1454.44 | 11.4769 |
| WD6_41 | 0.1957 | 0.0038 | 1152.13 | 20.1873 | 1220.59 | 22.0689 | 1220.59 | 22.0689 |
| WD6_39 | 0.2067 | 0.0035 | 1211.43 | 18.6658 | 1270.98 | 24.7000 | 1270.98 | 24.7000 |
| WD6_37 | 0.1814 | 0.0038 | 1074.69 | 20.8941 | 1044.82 | 24.8287 | 1044.82 | 24.8287 |
| WD6_36 | 0.0915 | 0.0006 | 564.28 | 3.4076 | 547.85 | 15.5340 | 564.28 | 3.4076 |
| WD6_33 | 0.2298 | 0.0014 | 1333.71 | 7.2350 | 1286.17 | 11.9868 | 1286.17 | 11.9868 |
| WD6_32 | 0.6034 | 0.0059 | 3043.59 | 23.5555 | 3036.18 | 6.1682 | 3036.18 | 6.1682 |
| WD6_28 | 0.2198 | 0.0013 | 1281.00 | 6.9457 | 1308.95 | 10.9433 | 1308.95 | 10.9433 |
| WD6_26b | 0.1725 | 0.0020 | 1026.01 | 11.1067 | 1066.31 | 14.0874 | 1066.31 | 14.0874 |
| WD6_25 | 0.1873 | 0.0022 | 1106.97 | 11.6769 | 1163.82 | 12.5067 | 1163.82 | 12.5067 |
| WD6_23 | 0.2372 | 0.0029 | 1371.93 | 15.0214 | 1479.09 | 12.4393 | 1479.09 | 12.4393 |
| WD6_19 | 0.1900 | 0.0023 | 1121.37 | 12.4888 | 1130.83 | 14.2958 | 1130.83 | 14.2958 |
| WD6_18 | 0.1869 | 0.0029 | 1104.29 | 15.5157 | 1108.12 | 14.5055 | 1108.12 | 14.5055 |
| WD6_17 | 0.1836 | 0.0021 | 1086.63 | 11.5839 | 1095.31 | 13.9668 | 1095.31 | 13.9668 |

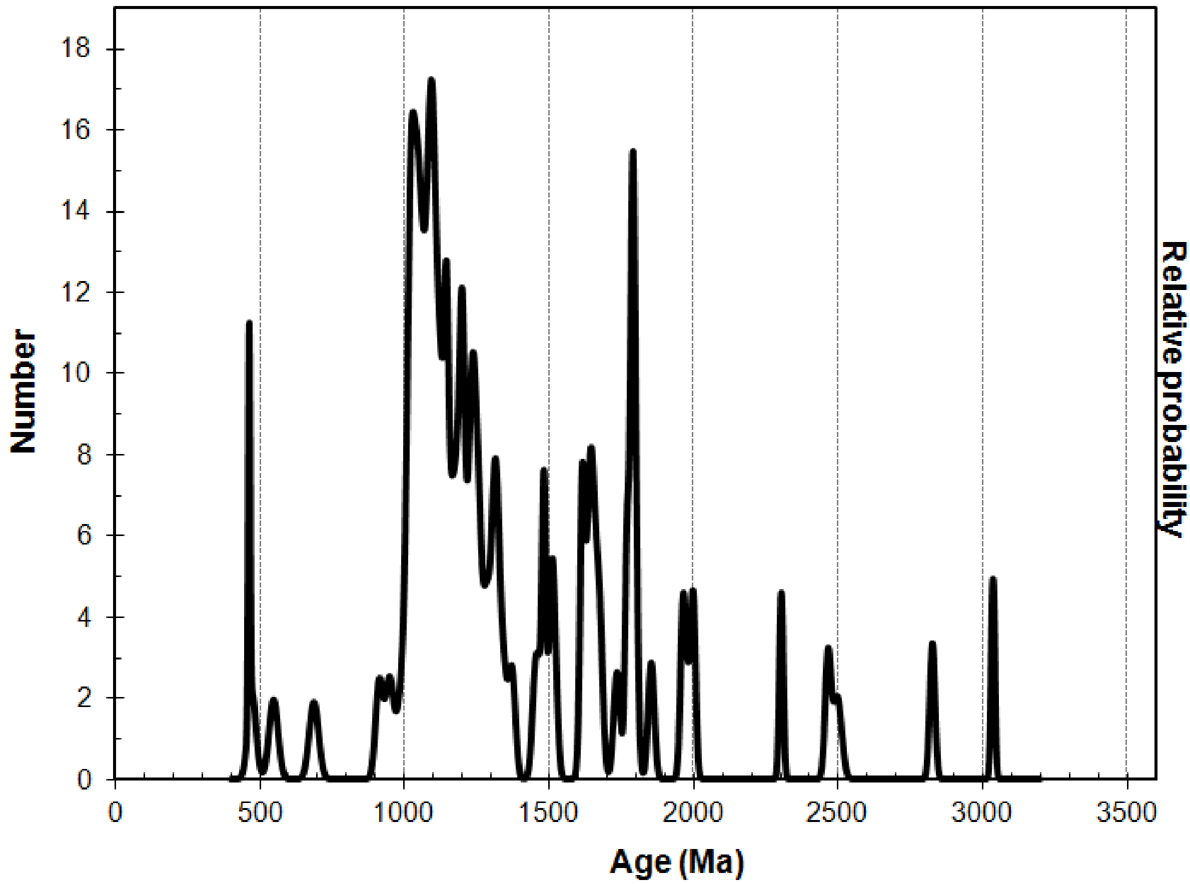
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD6_15 | 0.2102 | 0.0026 | 1230.13 | 14.0733 | 1194.45 | 12.9703 | 1194.45 | 12.9703 |
| WD6_14 | 0.2844 | 0.0031 | 1613.66 | 15.3701 | 1642.59 | 10.2308 | 1642.59 | 10.2308 |
| WD6_13 | 0.1750 | 0.0021 | 1039.48 | 11.4904 | 1085.86 | 15.2256 | 1085.86 | 15.2256 |
| WD6_11 | 0.2295 | 0.0027 | 1331.80 | 14.2074 | 1323.58 | 11.0782 | 1323.58 | 11.0782 |
| WD6_10 | 0.1883 | 0.0025 | 1112.29 | 13.5117 | 1200.45 | 17.9323 | 1200.45 | 17.9323 |
| WD6_9 | 0.2188 | 0.0024 | 1275.42 | 12.7901 | 1343.41 | 12.6333 | 1343.41 | 12.6333 |
| WD6_8 | 0.1892 | 0.0026 | 1116.83 | 14.1614 | 1062.77 | 17.5328 | 1062.77 | 17.5328 |
| WD6_7 | 0.5563 | 0.0061 | 2851.53 | 25.2088 | 2826.49 | 9.0962 | 2826.49 | 9.0962 |
| WD6_5 | 0.3542 | 0.0105 | 1954.70 | 49.5618 | 1980.98 | 14.1539 | 1980.98 | 14.1539 |
| WD6_3 | 0.5077 | 0.0161 | 2646.59 | 68.5561 | 2497.32 | 15.0675 | 2497.32 | 15.0675 |
| WD6_1 | 0.2969 | 0.0084 | 1675.88 | 41.6546 | 1656.80 | 12.4301 | 1656.80 | 12.4301 |
| | | | | | | | | |
| Discordance >10% | | | | | | | | |
| WD6_131 | 0.2131 | 0.0035 | 1245.21 | 18.3817 | 1517.75 | 19.3688 | | |
| WD6_128 | 0.1530 | 0.0019 | 917.86 | 10.8259 | 1170.62 | 14.0677 | | |
| WD6_127 | 0.0837 | 0.0015 | 518.47 | 8.9397 | 586.91 | 44.1138 | | |
| WD6_124 | 0.0695 | 0.0017 | 432.92 | 10.2802 | 617.59 | 46.8132 | | |
| WD6_123 | 0.1138 | 0.0017 | 695.03 | 10.1179 | 926.88 | 19.6125 | | |
| WD6_121 | 0.2511 | 0.0042 | 1444.12 | 21.7295 | 1699.10 | 14.2595 | | |
| WD6_120 | 0.0712 | 0.0014 | 443.67 | 8.6836 | 609.22 | 26.3684 | | |
| WD6_117 | 0.1030 | 0.0031 | 631.99 | 17.8678 | 972.15 | 43.6828 | | |
| WD6_115 | 0.0872 | 0.0017 | 539.17 | 9.9338 | 724.68 | 26.4612 | | |
| WD6_110 | 0.1760 | 0.0036 | 1045.07 | 19.6536 | 1223.89 | 27.7764 | | |
| WD6_107 | 0.3988 | 0.0109 | 2163.61 | 49.8114 | 2795.96 | 9.9211 | | |
| WD6_103 | 0.1798 | 0.0029 | 1065.69 | 15.8039 | 1342.02 | 18.3857 | | |
| WD6_100 | 0.1962 | 0.0037 | 1154.70 | 19.8508 | 1342.98 | 17.1302 | | |
| WD6_99 | 0.1714 | 0.0028 | 1020.04 | 15.4245 | 1632.52 | 16.8912 | | |
| WD6_95 | 0.1518 | 0.0022 | 911.22 | 12.1123 | 1089.51 | 7.5374 | | |
| WD6_87 | 0.2262 | 0.0056 | 1314.33 | 29.1714 | 1554.24 | 20.7765 | | |
| WD6_83 | 0.0680 | 0.0009 | 424.11 | 5.6341 | 575.02 | 19.9162 | | |
| WD6_82 | 0.1640 | 0.0049 | 978.81 | 27.1526 | 1160.22 | 23.3957 | | |
| WD6_81 | 0.1708 | 0.0031 | 1016.57 | 17.0442 | 1328.36 | 16.1971 | | |
| WD6_77 | 0.1950 | 0.0024 | 1148.28 | 13.2026 | 1603.82 | 10.1752 | | |
| WD6_75 | 0.0697 | 0.0011 | 434.64 | 6.6109 | 524.21 | 21.0609 | | |
| WD6_74 | 0.1921 | 0.0042 | 1132.88 | 22.4327 | 1431.39 | 9.0232 | | |
| WD6_73 | 0.1629 | 0.0016 | 972.77 | 8.9359 | 1099.54 | 13.3770 | | |
| WD6_72 | 0.2177 | 0.0025 | 1269.62 | 13.4605 | 1676.91 | 8.2396 | | |
| WD6_70 | 0.0829 | 0.0014 | 513.38 | 8.0909 | 652.38 | 36.0249 | | |
| WD6_66 | 0.1322 | 0.0018 | 800.14 | 10.0977 | 1076.55 | 15.3712 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| WD6_65 | 0.1021 | 0.0019 | 626.72 | 11.0335 | 1180.71 | 11.9727 | | | |
| WD6_64 | 0.0618 | 0.0006 | 386.57 | 3.3761 | 526.55 | 12.7788 | | | |
| WD6_60 | 0.0683 | 0.0004 | 425.79 | 2.3112 | 542.98 | 11.9038 | | | |
| WD6_54 | 0.0390 | 0.0012 | 246.81 | 7.1460 | 503.44 | 54.7563 | | | |
| WD6_52 | 0.0369 | 0.0009 | 233.48 | 5.7023 | 449.06 | 19.7281 | | | |
| WD6_40 | 0.1527 | 0.0027 | 915.93 | 15.2302 | 1644.81 | 12.4814 | | | |
| WD6_38 | 0.2098 | 0.0012 | 1227.70 | 6.5476 | 1060.96 | 11.5333 | | | |
| WD6_35 | 0.2236 | 0.0019 | 1300.98 | 9.9247 | 1150.05 | 16.3207 | | | |
| WD6_34 | 0.2250 | 0.0013 | 1308.15 | 6.9528 | 1132.58 | 10.3780 | | | |
| WD6_31 | 0.2204 | 0.0013 | 1284.10 | 6.6955 | 1041.84 | 11.3524 | | | |
| WD6_30 | 0.2207 | 0.0015 | 1285.77 | 7.7543 | 1098.64 | 14.8393 | | | |
| WD6_29 | 0.2332 | 0.0013 | 1351.12 | 7.0472 | 1137.00 | 11.2543 | | | |
| WD6_27 | 0.0998 | 0.0011 | 613.29 | 6.5075 | 729.81 | 52.7744 | | | |
| WD6_26 | 0.1477 | 0.0068 | 887.94 | 37.9716 | 1056.15 | 16.6906 | | | |
| WD6_24 | 0.0715 | 0.0009 | 445.10 | 5.4744 | 638.49 | 18.1290 | | | |
| WD6_22 | 0.0820 | 0.0010 | 508.04 | 5.8795 | 747.26 | 18.9829 | | | |
| WD6_21 | 0.1869 | 0.0033 | 1104.64 | 17.7973 | 2434.08 | 11.3401 | | | |
| WD6_20 | 0.5486 | 0.0661 | 2819.23 | 269.4132 | 4544.76 | 27.7552 | | | |
| WD6_16 | 0.1702 | 0.0048 | 1013.41 | 26.1221 | 1199.99 | 33.5286 | | | |
| WD6_12 | 0.0812 | 0.0011 | 503.43 | 6.5358 | 751.90 | 22.7353 | | | |
| WD6_6 | 0.4307 | 0.0127 | 2308.94 | 56.8326 | 2768.54 | 10.4216 | | | |
| WD6_4 | 0.1955 | 0.0060 | 1151.35 | 32.1917 | 1492.36 | 21.3838 | | | |
| WD6_2 | 0.0682 | 0.0022 | 425.40 | 13.4018 | 645.31 | 23.9343 | | | |

**WD-6 Concordia Diagram**



**WD-6 Probability Density Plot**



**Appendix G - WD-8**

Sample WD-8 (Pea Ridge) U–Pb detrital zircon LA-ICP-MS analysis results.

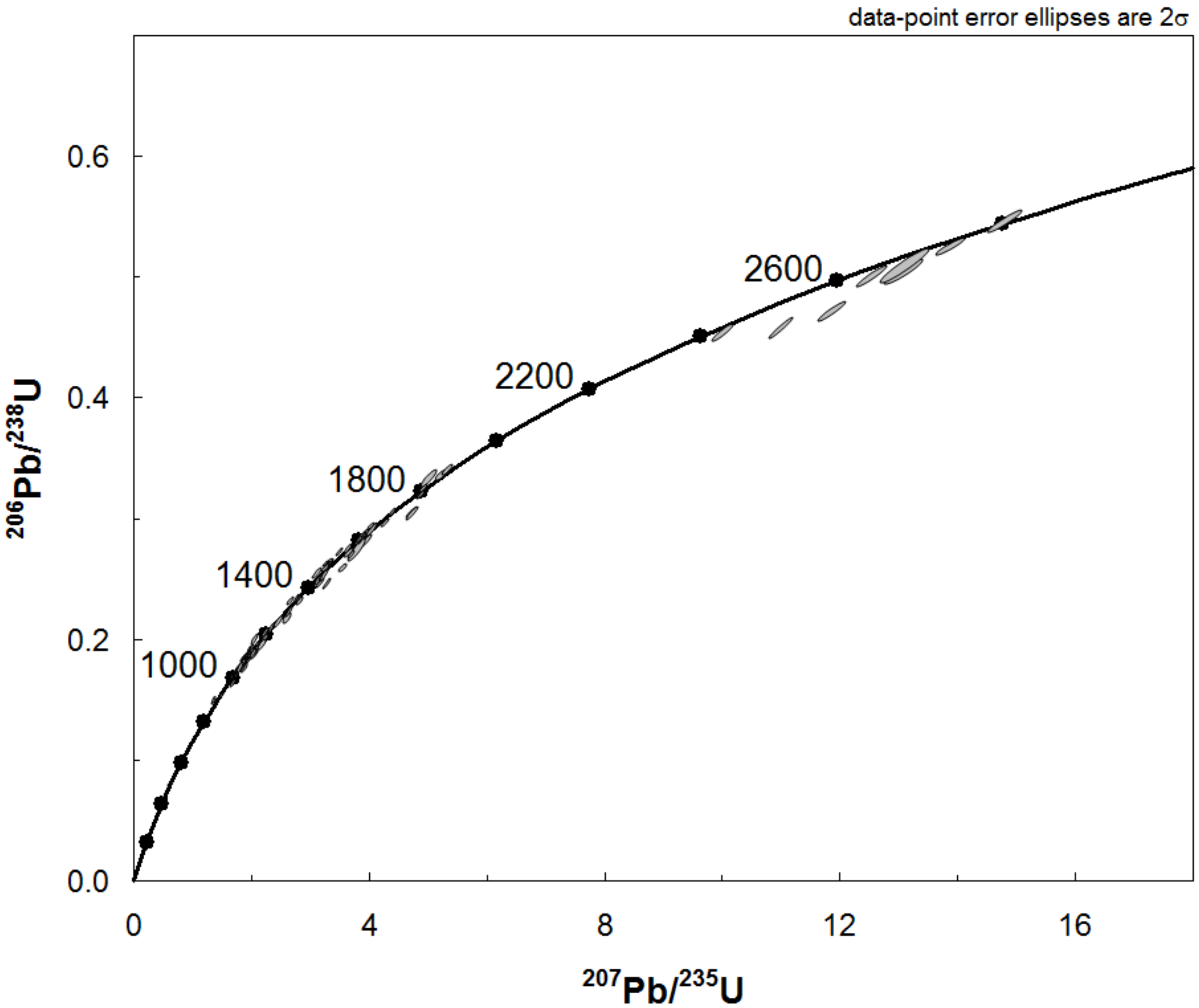
| | Isotopic Ratio | | Apparent Ages | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sample** | **206/238** | **±1σ** | **206/238** | **±1σ (Ma)** | **207/206** | **±1σ (Ma)** | **Best Age** | **±1σ (Ma)** |
| WD8_137 | 0.0687 | 0.0009 | 428.15 | 5.6071 | 424.93 | 29.9720 | 428.15 | 5.6071 |
| WD8_136 | 0.1868 | 0.0028 | 1104.17 | 15.3044 | 1183.28 | 18.9877 | 1183.28 | 18.9877 |
| WD8_135 | 0.1694 | 0.0020 | 1008.89 | 11.2268 | 1043.54 | 16.2845 | 1043.54 | 16.2845 |
| WD8_134 | 0.1890 | 0.0020 | 1116.11 | 10.8046 | 1144.25 | 15.9427 | 1144.25 | 15.9427 |
| WD8_133 | 0.3353 | 0.0037 | 1863.87 | 17.8664 | 1859.37 | 12.7582 | 1859.37 | 12.7582 |
| WD8_132 | 0.1731 | 0.0024 | 1029.16 | 12.9748 | 1022.02 | 20.6964 | 1022.02 | 20.6964 |
| WD8_131 | 0.0808 | 0.0013 | 500.97 | 7.4778 | 503.43 | 34.5197 | 500.97 | 7.4778 |
| WD8_130 | 0.1947 | 0.0020 | 1146.85 | 10.6696 | 1164.19 | 14.7078 | 1164.19 | 14.7078 |
| WD8_128 | 0.1749 | 0.0033 | 1039.03 | 17.8433 | 1161.53 | 23.7643 | 1161.53 | 23.7643 |
| WD8_127 | 0.0739 | 0.0008 | 459.62 | 4.6634 | 496.28 | 18.8978 | 459.62 | 4.6634 |
| WD8_126 | 0.1813 | 0.0019 | 1074.19 | 10.5942 | 1135.57 | 14.4027 | 1135.57 | 14.4027 |
| WD8_125 | 0.1999 | 0.0024 | 1174.53 | 13.1423 | 1214.66 | 18.0610 | 1214.66 | 18.0610 |
| WD8_124 | 0.2304 | 0.0028 | 1336.67 | 14.7142 | 1410.92 | 13.7528 | 1410.92 | 13.7528 |
| WD8_123 | 0.2899 | 0.0037 | 1640.78 | 18.2189 | 1655.66 | 12.3757 | 1655.66 | 12.3757 |
| WD8_122 | 0.0701 | 0.0009 | 437.05 | 5.1379 | 465.94 | 18.4209 | 437.05 | 5.1379 |
| WD8_121 | 0.0775 | 0.0009 | 481.11 | 5.5561 | 460.88 | 27.5958 | 481.11 | 5.5561 |
| WD8_120 | 0.1741 | 0.0021 | 1034.94 | 11.7063 | 1090.93 | 19.0667 | 1090.93 | 19.0667 |
| WD8_119 | 0.2580 | 0.0030 | 1479.37 | 15.5811 | 1640.83 | 14.4414 | 1640.83 | 14.4414 |
| WD8_118 | 0.2157 | 0.0035 | 1259.20 | 18.3325 | 1398.79 | 20.5211 | 1398.79 | 20.5211 |
| WD8_117 | 0.1750 | 0.0021 | 1039.66 | 11.4740 | 1124.61 | 18.4874 | 1124.61 | 18.4874 |
| WD8_115 | 0.1928 | 0.0020 | 1136.77 | 10.9474 | 1202.27 | 19.5991 | 1202.27 | 19.5991 |
| WD8_114 | 0.1823 | 0.0019 | 1079.60 | 10.3643 | 1066.34 | 16.2359 | 1066.34 | 16.2359 |
| WD8_113 | 0.2629 | 0.0023 | 1504.78 | 11.7431 | 1494.62 | 12.7581 | 1494.62 | 12.7581 |
| WD8_112 | 0.2535 | 0.0033 | 1456.65 | 16.7873 | 1425.17 | 17.1239 | 1425.17 | 17.1239 |
| WD8_111 | 0.1905 | 0.0033 | 1124.05 | 18.0350 | 1100.07 | 29.5298 | 1100.07 | 29.5298 |
| WD8_110 | 0.1842 | 0.0030 | 1090.03 | 16.1912 | 1092.84 | 25.1271 | 1092.84 | 25.1271 |
| WD8_109 | 0.1732 | 0.0019 | 1029.94 | 10.5465 | 1058.57 | 14.6102 | 1058.57 | 14.6102 |
| WD8_108 | 0.1847 | 0.0033 | 1092.57 | 18.1106 | 1105.13 | 27.7055 | 1105.13 | 27.7055 |
| WD8_107 | 0.2473 | 0.0030 | 1424.75 | 15.6555 | 1493.78 | 14.6788 | 1493.78 | 14.6788 |
| WD8_106 | 0.1779 | 0.0020 | 1055.56 | 10.8484 | 1073.15 | 14.0373 | 1073.15 | 14.0373 |
| WD8_105 | 0.5244 | 0.0060 | 2717.70 | 25.1385 | 2779.70 | 10.5982 | 2779.70 | 10.5982 |
| WD8_104 | 0.2303 | 0.0028 | 1335.99 | 14.4001 | 1312.86 | 16.1436 | 1312.86 | 16.1436 |
| WD8_103 | 0.5033 | 0.0088 | 2628.13 | 37.7159 | 2750.16 | 14.1982 | 2750.16 | 14.1982 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD8_102 | 0.2769 | 0.0034 | 1575.93 | 17.1979 | 1660.48 | 12.9880 | 1660.48 | 12.9880 |
| WD8_101 | 0.2766 | 0.0044 | 1574.12 | 22.4233 | 1642.21 | 18.1396 | 1642.21 | 18.1396 |
| WD8_100 | 0.2804 | 0.0039 | 1593.21 | 19.4564 | 1687.90 | 14.2171 | 1687.90 | 14.2171 |
| WD8_99 | 0.4528 | 0.0053 | 2407.86 | 23.6331 | 2479.28 | 11.2886 | 2479.28 | 11.2886 |
| WD8_98 | 0.2847 | 0.0037 | 1614.83 | 18.7332 | 1642.19 | 13.1618 | 1642.19 | 13.1618 |
| WD8_96 | 0.2330 | 0.0026 | 1350.40 | 13.6361 | 1384.73 | 13.2980 | 1384.73 | 13.2980 |
| WD8_95 | 0.3325 | 0.0057 | 1850.26 | 27.6874 | 1803.26 | 18.6553 | 1803.26 | 18.6553 |
| WD8_94 | 0.2048 | 0.0031 | 1201.01 | 16.6776 | 1191.66 | 20.0886 | 1191.66 | 20.0886 |
| WD8_93 | 0.2456 | 0.0033 | 1415.95 | 17.0963 | 1519.48 | 13.5339 | 1519.48 | 13.5339 |
| WD8_92 | 0.5083 | 0.0117 | 2649.35 | 49.6595 | 2729.76 | 15.0892 | 2729.76 | 15.0892 |
| WD8_91 | 0.4997 | 0.0073 | 2612.46 | 31.1696 | 2687.32 | 11.4971 | 2687.32 | 11.4971 |
| WD8_89 | 0.2216 | 0.0033 | 1290.41 | 17.6004 | 1364.84 | 16.7823 | 1364.84 | 16.7823 |
| WD8_88 | 0.1764 | 0.0025 | 1047.28 | 13.5033 | 1123.23 | 18.1473 | 1123.23 | 18.1473 |
| WD8_87 | 0.1864 | 0.0025 | 1102.05 | 13.5013 | 1204.76 | 16.8804 | 1204.76 | 16.8804 |
| WD8_86 | 0.2822 | 0.0047 | 1602.54 | 23.7850 | 1619.20 | 15.5636 | 1619.20 | 15.5636 |
| WD8_85 | 0.2449 | 0.0035 | 1412.37 | 18.0772 | 1582.69 | 14.5268 | 1582.69 | 14.5268 |
| WD8_84 | 0.1627 | 0.0029 | 971.53 | 15.9699 | 1071.23 | 28.6371 | 1071.23 | 28.6371 |
| WD8_82 | 0.0717 | 0.0010 | 446.13 | 5.7571 | 496.28 | 19.7041 | 446.13 | 5.7571 |
| WD8_81 | 0.1863 | 0.0038 | 1101.07 | 20.5261 | 1190.17 | 32.7522 | 1190.17 | 32.7522 |
| WD8_80 | 0.1903 | 0.0029 | 1122.92 | 15.8507 | 1185.91 | 18.7178 | 1185.91 | 18.7178 |
| WD8_75 | 0.1895 | 0.0028 | 1118.58 | 15.1045 | 1086.13 | 14.3622 | 1086.13 | 14.3622 |
| WD8_74 | 0.1982 | 0.0035 | 1165.70 | 18.6561 | 1087.98 | 21.3004 | 1087.98 | 21.3004 |
| WD8_73 | 0.1828 | 0.0029 | 1082.06 | 15.7742 | 1086.06 | 16.1654 | 1086.06 | 16.1654 |
| WD8_72 | 0.1688 | 0.0025 | 1005.56 | 13.9022 | 1016.26 | 19.7182 | 1016.26 | 19.7182 |
| WD8_71 | 0.1833 | 0.0027 | 1085.19 | 14.6981 | 1068.57 | 17.5231 | 1068.57 | 17.5231 |
| WD8_70 | 0.1481 | 0.0024 | 890.30 | 13.6345 | 866.27 | 23.4671 | 890.30 | 13.6345 |
| WD8_69 | 0.1701 | 0.0024 | 1012.51 | 13.0378 | 1049.63 | 14.8086 | 1049.63 | 14.8086 |
| WD8_67 | 0.4701 | 0.0068 | 2483.90 | 29.6490 | 2708.20 | 11.1047 | 2708.20 | 11.1047 |
| WD8_66 | 0.1816 | 0.0024 | 1075.56 | 13.0208 | 1069.68 | 13.2803 | 1069.68 | 13.2803 |
| WD8_64 | 0.5451 | 0.0078 | 2804.86 | 32.6448 | 2827.01 | 11.2012 | 2827.01 | 11.2012 |
| WD8_63 | 0.2131 | 0.0042 | 1245.56 | 22.0691 | 1313.52 | 22.5945 | 1313.52 | 22.5945 |
| WD8_62 | 0.3039 | 0.0040 | 1710.67 | 19.6749 | 1874.08 | 11.6097 | 1874.08 | 11.6097 |
| WD8_61 | 0.2512 | 0.0034 | 1444.49 | 17.3711 | 1502.72 | 13.7445 | 1502.72 | 13.7445 |
| WD8_59 | 0.2083 | 0.0030 | 1219.96 | 15.8503 | 1260.48 | 18.7090 | 1260.48 | 18.7090 |
| WD8_58 | 0.2518 | 0.0038 | 1447.95 | 19.7779 | 1517.68 | 15.5476 | 1517.68 | 15.5476 |
| WD8_57 | 0.3032 | 0.0045 | 1707.30 | 22.0314 | 1883.09 | 12.7513 | 1883.09 | 12.7513 |
| WD8_56 | 0.1724 | 0.0019 | 1025.39 | 10.5018 | 1081.78 | 16.7176 | 1081.78 | 16.7176 |
| WD8_55 | 0.1794 | 0.0022 | 1063.80 | 11.9862 | 1091.39 | 18.8672 | 1091.39 | 18.8672 |
| WD8_52 | 0.2739 | 0.0027 | 1560.72 | 13.5281 | 1570.07 | 14.0651 | 1570.07 | 14.0651 |

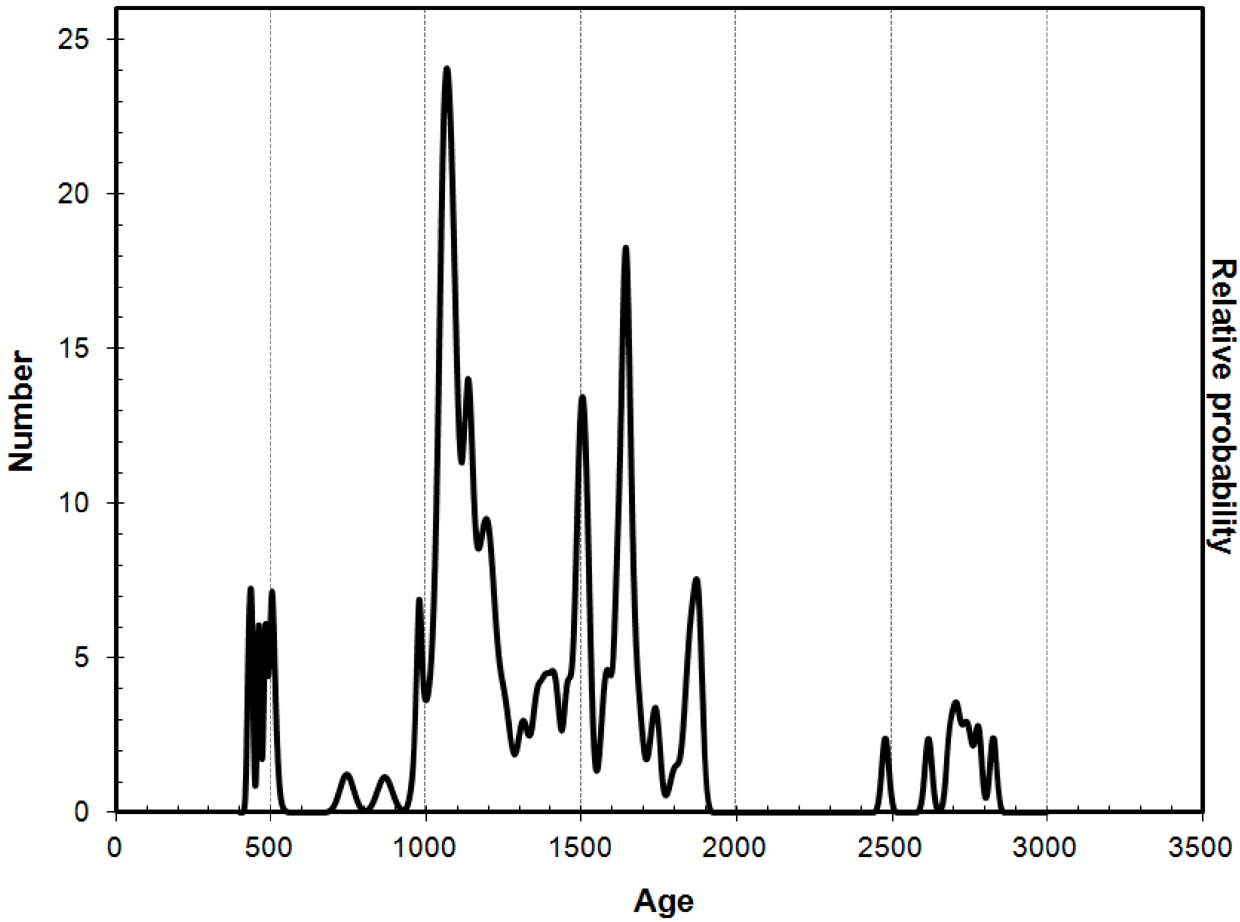
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WD8_51 | 0.3388 | 0.0035 | 1881.06 | 16.6749 | 1873.31 | 13.7983 | 1873.31 | 13.7983 |
| WD8_50 | 0.2714 | 0.0024 | 1547.72 | 12.3436 | 1500.37 | 12.9883 | 1500.37 | 12.9883 |
| WD8_49 | 0.2868 | 0.0028 | 1625.43 | 13.9177 | 1633.14 | 13.8209 | 1633.14 | 13.8209 |
| WD8_47 | 0.1692 | 0.0020 | 1007.95 | 10.8819 | 1070.80 | 22.3785 | 1070.80 | 22.3785 |
| WD8_46 | 0.2708 | 0.0030 | 1544.88 | 15.1785 | 1594.53 | 15.4634 | 1594.53 | 15.4634 |
| WD8_44 | 0.2948 | 0.0028 | 1665.60 | 14.0195 | 1727.44 | 13.2969 | 1727.44 | 13.2969 |
| WD8_42 | 0.1760 | 0.0024 | 1045.34 | 13.0335 | 1057.10 | 16.0435 | 1057.10 | 16.0435 |
| WD8_41 | 0.2896 | 0.0049 | 1639.32 | 24.4621 | 1664.82 | 17.7149 | 1664.82 | 17.7149 |
| WD8_40 | 0.2728 | 0.0073 | 1554.90 | 36.8334 | 1659.24 | 28.5198 | 1659.24 | 28.5198 |
| WD8_38 | 0.1776 | 0.0022 | 1053.68 | 12.0164 | 1133.17 | 13.2276 | 1133.17 | 13.2276 |
| WD8_37 | 0.2592 | 0.0034 | 1485.62 | 17.5947 | 1470.51 | 13.9643 | 1470.51 | 13.9643 |
| WD8_36 | 0.1717 | 0.0022 | 1021.64 | 12.2258 | 1054.15 | 14.2883 | 1054.15 | 14.2883 |
| WD8_35 | 0.2322 | 0.0029 | 1346.01 | 15.2670 | 1354.41 | 13.9929 | 1354.41 | 13.9929 |
| WD8_34 | 0.1696 | 0.0022 | 1009.97 | 11.9356 | 1058.02 | 15.2540 | 1058.02 | 15.2540 |
| WD8_33 | 0.1997 | 0.0029 | 1173.48 | 15.5557 | 1241.34 | 18.5883 | 1241.34 | 18.5883 |
| WD8_32 | 0.1876 | 0.0031 | 1108.51 | 17.0012 | 1173.06 | 19.9900 | 1173.06 | 19.9900 |
| WD8_31 | 0.4568 | 0.0068 | 2425.22 | 29.9472 | 2618.45 | 11.3784 | 2618.45 | 11.3784 |
| WD8_29 | 0.2826 | 0.0036 | 1604.63 | 18.2680 | 1636.44 | 12.8705 | 1636.44 | 12.8705 |
| WD8_28 | 0.1946 | 0.0039 | 1146.43 | 20.7644 | 1237.11 | 28.9402 | 1237.11 | 28.9402 |
| WD8_26 | 0.3039 | 0.0023 | 1710.66 | 11.4906 | 1745.17 | 12.1182 | 1745.17 | 12.1182 |
| WD8_25 | 0.1704 | 0.0015 | 1014.56 | 8.0138 | 1032.90 | 16.0298 | 1032.90 | 16.0298 |
| WD8_24 | 0.3237 | 0.0027 | 1807.64 | 12.9931 | 1836.82 | 12.2404 | 1836.82 | 12.2404 |
| WD8_23 | 0.2597 | 0.0030 | 1488.27 | 15.3977 | 1505.62 | 17.4952 | 1505.62 | 17.4952 |
| WD8_22 | 0.2579 | 0.0030 | 1478.89 | 15.4007 | 1491.87 | 15.9490 | 1491.87 | 15.9490 |
| WD8_19 | 0.3185 | 0.0026 | 1782.61 | 12.6274 | 1851.00 | 11.7114 | 1851.00 | 11.7114 |
| WD8_18 | 0.1636 | 0.0014 | 976.91 | 7.5521 | 1019.25 | 15.5098 | 1019.25 | 15.5098 |
| WD8_17 | 0.0821 | 0.0017 | 508.39 | 10.0007 | 555.19 | 31.9896 | 508.39 | 10.0007 |
| WD8_16 | 0.2615 | 0.0022 | 1497.67 | 11.0502 | 1517.29 | 12.1800 | 1517.29 | 12.1800 |
| WD8_11 | 0.2922 | 0.0023 | 1652.65 | 11.6922 | 1645.24 | 10.3815 | 1645.24 | 10.3815 |
| WD8_9 | 0.1860 | 0.0017 | 1099.51 | 9.3288 | 1140.74 | 13.2565 | 1140.74 | 13.2565 |
| WD8_8 | 0.1521 | 0.0018 | 912.70 | 10.1054 | 987.41 | 16.1969 | 912.70 | 10.1054 |
| WD8_7 | 0.1733 | 0.0013 | 1030.43 | 7.2150 | 1052.42 | 12.4303 | 1052.42 | 12.4303 |
| WD8_6 | 0.2610 | 0.0022 | 1494.74 | 11.0907 | 1453.86 | 10.7178 | 1453.86 | 10.7178 |
| WD8_5 | 0.2691 | 0.0022 | 1536.43 | 11.1844 | 1641.64 | 10.3461 | 1641.64 | 10.3461 |
| WD8_4 | 0.1744 | 0.0040 | 1036.37 | 21.8396 | 1082.59 | 26.4337 | 1082.59 | 26.4337 |
| WD8_3 | 0.1899 | 0.0018 | 1120.97 | 9.8132 | 1137.37 | 15.2811 | 1137.37 | 15.2811 |
| WD8_1 | 0.2819 | 0.0021 | 1600.72 | 10.4826 | 1616.43 | 9.8864 | 1616.43 | 9.8864 |
| | | | | | | | | |
| | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Discordance >10% | | | | | | | | |
| WD8_129 | 0.0701 | 0.0011 | 437.04 | 6.7242 | 858.34 | 50.4075 | | |
| WD8_116 | 0.1912 | 0.0020 | 1127.62 | 10.5797 | 1395.30 | 15.4749 | | |
| WD8_90 | 0.0768 | 0.0011 | 476.85 | 6.8258 | 545.99 | 26.2775 | | |
| WD8_83 | 0.2491 | 0.0032 | 1433.91 | 16.5182 | 1790.66 | 19.1184 | | |
| WD8_79 | 0.3288 | 0.0069 | 1832.47 | 33.3123 | 2141.53 | 21.2178 | | |
| WD8_78 | 0.1996 | 0.0031 | 1172.91 | 16.3895 | 1324.73 | 17.8079 | | |
| WD8_77 | 0.0750 | 0.0011 | 465.98 | 6.3359 | 555.10 | 18.4193 | | |
| WD8_76 | 0.0673 | 0.0010 | 420.02 | 6.1010 | 500.46 | 21.9550 | | |
| WD8_68 | 0.0826 | 0.0014 | 511.49 | 8.0536 | 806.30 | 27.8334 | | |
| WD8_65 | 0.0768 | 0.0012 | 477.20 | 6.9769 | 743.37 | 21.8656 | | |
| WD8_54 | 0.1275 | 0.0024 | 773.71 | 13.8237 | 1187.55 | 20.6058 | | |
| WD8_53 | 0.1040 | 0.0018 | 637.94 | 10.3810 | 2248.61 | 63.4970 | | |
| WD8_48 | 0.0871 | 0.0010 | 538.22 | 5.8977 | 663.44 | 27.2554 | | |
| WD8_45 | 0.4255 | 0.0046 | 2285.30 | 20.6188 | 2779.40 | 11.5306 | | |
| WD8_43 | 0.0912 | 0.0011 | 562.50 | 6.3397 | 761.76 | 25.9136 | | |
| WD8_39 | 0.2088 | 0.0027 | 1222.20 | 14.1675 | 1819.05 | 11.6870 | | |
| WD8_30 | 0.0741 | 0.0010 | 460.93 | 6.1210 | 544.42 | 20.7267 | | |
| WD8_21 | 0.1908 | 0.0036 | 1125.66 | 19.4496 | 1599.29 | 16.9331 | | |
| WD8_20 | 0.0889 | 0.0028 | 549.06 | 16.3025 | 850.17 | 52.4139 | | |
| WD8_15 | 0.0699 | 0.0006 | 435.53 | 3.7164 | 573.47 | 19.3775 | | |
| WD8_14 | 0.1244 | 0.0015 | 755.95 | 8.7151 | 854.92 | 18.8636 | | |
| WD8_13 | 0.1604 | 0.0020 | 959.02 | 10.8425 | 1248.54 | 12.9128 | | |
| WD8_12 | 0.3065 | 0.0041 | 1723.67 | 20.1020 | 2634.92 | 12.3292 | | |
| WD8_10 | 0.2002 | 0.0043 | 1176.39 | 23.2318 | 3549.77 | 14.4247 | | |
| WD8_2 | 0.1629 | 0.0013 | 972.89 | 7.2938 | 1099.22 | 11.8101 | | |

**WD-8 Concordia Diagram**



**WD-8 Probability Density Plot**



**Appendix H - Surface Thicknesses (From Price, 1980)**

| Point | Locations | Gross Sand Thickness |
|---|---|---|
| 1 | SE1/4, NW1/4, Sec. 27, T.16N, R.32W. | 62 |
| 2 | SE1/4, NE1/4, Sec. 13, T.16N, R.33W. | 21 |
| 3 | Wedington Mtn. | 25 |
| 4 | SE1/4, NW1/4, Sec. 27, T.17N, R.32W. | 32 |
| 5 | NW1/4, SE1/4, Sec. 15, T.17N, R.32W. | 25 |
| 6 | NW1/4, NE1/4, Sec. 7, T.15N, R.32W. | 30 |
| 7 | SE1/4, NW1/4, Sec. 6, T.15N, R.32W. | 48.5 |
| 8 | SW1/4, NW1/4, Sec. 27, T.15N, R.32W. | 77.5 |
| 9 | NE1/4, SW1/4, Sec. 2, T.13N, R.32W. | 8 |
| 10 | NE1/4, NE1/4, Sec. 5, T.14N, R.30W. | 75 |
| 11 | NE1/4, NE1/4, Sec. 30, T.18N, R.29W. | 70 |
| 12 | Price Mtn. | 75 |
| 13 | NW1/4, NE1/4, Sec. 14, T.17N, R.28W. | 34 |
| 14 | NE1/4, NE1/4, Sec. 3, T.17N, R.28W. | 63 |
| 15 | NE1/4, SW1/4, Sec. 2, T.15N, R.30W. | 13.5 |
| 16 | NE1/4, SE1/4, Sec. 25, T.16N, R.29W. | 16.5 |
| 17 | NW1/4, NW1/4, Sec. 34, T.17N, R.27W. | 11 |
| 18 | SE1/4, NE1/4, Sec. 19, T.16N, R.25W. | 7.25 |
| 19 | SE1/4, NE1/4, Sec. 1, T.15N, R.24W. | 9.5 |
| 20 | NE1/4, NW1/4, Sec. 26, T.12N, R.33W. | 3.75 |
| 21 | SW1/4, NE1/4, Sec. 17, T.14N, R.32W. | 29 |
| 22 | NW1/4, SW1/4, Sec. 14, T.15N, R.31W. | 6.75 |
| 23 | NE1/4, SE1/4, Sec. 23, T.16N, R.29W. | 16 |
| 24 | NW1/4, NW1/4, Sec. 14, T.21N, R.25E. | 9.5 |
| 25 | SW1/4, NE1/4, Sec. 8, T.16N, R.25E. | 25 |
| 26 | NE1/4, SW1/4, Sec. 27, T.16N, R.26E. | 16 |
| 27 | NE1/4, SW1/4, Sec. 18, T.17N, R.21W. | 50 |
| 28 | NW1/4, SW1/4, Sec. 34, T.15N, R.29W. | 25 |
| 29 | NW1/4, NW1/4, Sec. 22, T.15N, R.29W. | 28 |
| 30 | NW1/4, NW1/4, Sec. 27, T.15N, R.29W. | 25 |
| 31 | NW1/4, SW1/4, Sec. 14, T.21N, R.28W. | 48 |

**Appendix I - Subsurface Thickness**

| Well | Point | Latitude | Longitude | Gross Sand Thickness | County |
|---|---|---|---|---|---|
| Mason 1 | 32 | 35.5295 | -94.1259 | 42 | Crawford |
| Bearden 3 | 33 | 35.5565 | -93.9840 | 20 | Franklin |
| MayCarty 1 | 34 | 35.5553 | -93.9934 | 58 | Franklin |
| Magruder 1 | 35 | 35.5308 | -93.8717 | 11 | Franklin |
| Wilson 4 | 36 | 35.5248 | -93.9845 | 44 | Franklin |
| Hamm 1 | 37 | 35.5894 | -93.7856 | 8 | Franklin |
| Ray 1 | 38 | 35.5482 | -93.7958 | 7 | Franklin |
| Magruder 2 | 39 | 35.5321 | -93.8784 | 14 | Franklin |
| Whiterock 1 | 40 | 35.6888 | -93.9547 | 15 | Franklin |
| Richason Mountain 1 | 42 | 35.6925 | -93.9943 | 7 | Crawford |
| Hayes - 1 | 43 | 36.0624 | -93.7830 | 8 | Madison |
| Rogers - 1 | 44 | 35.9454 | -93.8134 | 8 | Madison |
| L. Keck 3 | 45 | 35.9437 | -93.6882 | 5 | Madison |
| Lambeth 1 | 46 | 35.9157 | -93.9611 | 14 | Washington |
| Yett 1 | 47 | 35.8672 | -93.8525 | 10 | Madison |
| Waldrop -1 | 48 | 35.8478 | -93.5565 | 4 | Madison |
| McRay Baker 1 | 49 | 35.7521 | -93.7906 | 10 | Franklin |
| Deffenbaugh - 1 | 50 | 35.6154 | -94.3919 | 26 | Crawford |
| Brewer 1 | 51 | 35.6278 | -94.0172 | 6 | Franklin |
| Federal Es. 11609 | 52 | 35.6467 | -93.7437 | 2 | Franklin |
| Montgomery 3 | 53 | 35.6409 | -93.5487 | 0 | Johnson |
| Bruce 1 26 | 54 | 35.5151 | -94.1599 | 10 | Crawford |
| F. Johnson Et al 1 | 55 | 35.5463 | -93.8740 | 2 | Franklin |
| N. Orr 1 | 56 | 35.4769 | -94.4260 | 2 | Crawford |
| Arkansas Valley Trust 1 | 57 | 35.4493 | -94.0138 | 4 | Franklin |
| Hiatt V 1 | 58 | 35.4087 | -94.0633 | 6 | Franklin |
| Nall Johnny Mark 1 | 59 | 35.8987 | -94.3436 | 12 | Washington |
| Butler A 1 | 60 | 35.8166 | -94.1008 | 14 | Washington |
| Ray Henson 1 | 61 | 35.8179 | -94.0020 | 4 | Washington |
| Hampton A2 | 62 | 35.8066 | -94.1055 | 12 | Washington |
| Timmons Seth and Clarrissa 1 | 63 | 35.9195 | -94.2436 | 46 | Washington |
| Beller 1 | 64 | 35.5001 | -94.2651 | 15 | Crawford |

**Appendix J**

**Location of Thickness Measurements**