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Provenance of Syn-rift Clastics in the Eastern Gulf of Mexico: Insight from U-Pb Detrital Zircon Geochronology and Thin Sections

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**Provenance of Syn-rift Clastics in the Eastern Gulf of Mexico:
Insight from U-Pb Detrital Zircon Geochronology and Thin Sections**

Kory Stuart Wiley

**Thesis submitted
To Eberly College
At West Virginia University
in partial fulfillment of the requirements
for the degree of**

**Master of Science
In
Geology**

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2017

**Keywords: Eastern Gulf of Mexico, U-Pb Detrital Zircon Geochronology, Wood River Formation,
Newark Supergroup, South Florida Basin, South Georgia Rift**

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ABSTRACT

Provenance of Syn-rift Clastics in the Eastern Gulf of Mexico: Insight from U-Pb Detrital Zircon Geochronology and Thin Sections

Kory Wiley

U-Pb detrital zircon geochronology, supplemented by thin section petrography, point counting, and well logs, were used to constrain the provenance of basal Triassic/Jurassic (?) clastic sedimentary rocks in the Eastern Gulf of Mexico (EGOM). Basal clastics were deposited as syn-rift strata into half grabens present along the EGOM and eastern margin of Laurentia that formed during the initial break up of Pangea. Samples used in this study were collected from the South Florida Basin (SFB) and the South Georgia Rift (SGR). Previous studies of post-rift Jurassic sediment in the Gulf of Mexico has identified a change in source from Laurentian dominated sources in southern Mississippi/Alabama, to Gondwanan dominated sources in the Florida Apalachicola Embayment/offshore. Comparing the provenance of initial syn-rift strata to post-rift strata is used to identify initial sediment sources into the EGOM rift basins, and how provenance changed over time. Detrital zircons were collected from five SFB well cutting samples from the Jurassic (?) Wood River Formation and proximal basal sandstones, and six SGR well cutting samples from the Triassic (?) Newark Supergroup, as well as one sample from offshore southern Florida basement. Predominant age populations for the SFB are consistent with a Pan-African origin (525-680 Ma, 1900-2200 Ma). Samples from the SGR are dominated by Laurentian sources (265-330 Ma, 350-420 Ma, 430-490 Ma, 900-1300 Ma), as well as secondary Pan-African sources (525-680 Ma, 1900-2200 Ma). Provenance data is supported by thin section point counting and well logs. Samples in the northern SGR are predominantly derived from Laurentian sources, while the southern samples 3137 and 1854 are a mix of Laurentian and Gondwana signatures. K-S test comparisons of basal sandstones from this study and post-rift Jurassic Norphlet Formation samples from Lovell (2010) and Lisi (2013) show little correlation between samples, implying they do not share similar sources. The exception is the offshore Apalachicola Embayment samples, which indicates that the SGR may have been a potential source for Jurassic sediment in the northern EGOM. The integration of geochronology and petrographic techniques in this study suggests a mix of primarily sedimentary sources from the Suwannee Terranes and metamorphic sources from Laurentia supplied the initial sediment into the EGOM. Results from this study can be used to better constrain tectonic terranes and paleogeography of the early EGOM.

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Detrital zircon geochronology was completed at the University of South Carolina Center for Elemental Mass Spectrometry. Dr. Barbeau was helpful in sample preparation, running the mass spectrometer, data reduction, and spending long hours dealing with our machine woes.

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Chapter 1: Introduction

Introduction of Research Area

Mesozoic rocks within the eastern Gulf of Mexico (EGOM) have received considerable attention since the 1960's for hydrocarbon exploration (Mancini et al., 1985). Offshore drilling in federal waters of the EGOM has been fairly limited and is currently under moratorium due to the GOM Energy Security Act (2006), which will be in effect until at least 2022; however drilling still continues in state waters of southern Alabama, and on land in the Florida panhandle, and southern Florida (BOEM, 2015). Recent discoveries in the Jurassic Norphlet Formation and Smackover Formation offshore of Alabama and the potential for future discoveries in the offshore western Florida has fueled interest in exploration of these resources (e.g, Rojas, 2015). The extent of the Jurassic Norphlet Formation in southern Alabama/northern offshore Florida has been fairly well delineated, although its regional extent into southern offshore Florida is debated (Mancini et al., 1990; Hunt, 2012). Hydrocarbon discoveries in other Mesozoic units including the Smackover, Haynesville and Cotton Valley formations (e.g, Presley and Reed, 1984; Mancini et al., 2004; Hammes et al., 2011) have spurred interest in the region; however other units such as the Eagle Mills, the basal Wood River Formation of the South Florida Basin (SFB; Fig. 1) and Newark Supergroup of the South Georgia Rift (SGR; Fig. 1) remain relatively unexplored.

Along the Gulf of Mexico margin, a series of Triassic grabens lie buried underneath younger Cenozoic coastal plain deposits. These early Mesozoic units can provide insight into early plate kinematics of EGOM opening and potential source terranes available to supply sediment into the EGOM. In addition, early Mesozoic rift basins that developed during the breakup of Pangea may have provided sediment sources as well as pathways for sediment influx

to the Norphlet Formation eolian erg and other Jurassic units of the Florida panhandle and offshore DeSoto Canyon (MacRae and Watkins, 1995; Weislogel et al., 2015).

In the EGOM region, these early Mesozoic syn-rift sediments are buried, but scattered wells penetrate the syn-rift section in the South Georgia rift and associated Talahassee graben and in the South Florida basin. The South Georgia Rift (SGR) system formed as a failed rift during the opening of the Atlantic, along the ancient collisional zone of the Suwannee suture (Mueller et al., 2014). From observations of seismic profiles, the SGR consists of several half-grabens bound by curved listric faults (MacRae and Watkins, 1993; Akintunde et al., 2013; Clendenin, 2013; Heffner, 2013). Wells into the half-grabens penetrate thick packages of Middle Triassic-Lower Jurassic (?) fluvial and lacustrine syn-rift redbeds referred to as the Newark Supergroup (e.g., Chowns and Williams, 1983; Schlische et al., 2003). These units are considered similar in age and lithology to the Newark Supergroup deposits preserved in other extensional basins along the eastern margin of the U.S (Chowns and Williams, 1983; Rine, 2014). The Tallahassee graben is located in northwest Florida and is likely contiguous with the SGR, and SGR-related extensional basins may extend into the Apalachicola Embayment (MacRae and Watkins, 1993; Hunter, 2014). Previous drilling in the SGR have detected minor gas and oil shows, but no commercial drilling has taken place (Coleman et al., 2015).

Along the western margin of Florida, a series of paleotopographic highs, including the Middle Ground Arch and Sarasota Arch, and lows, such as the Apalachicola embayment (Hunter, 2014) and Tampa embayment (Wilson, 2012), have been imaged using seismic reflection data, however the origin of these is controversial. The southernmost of these paleotopographic lows is the South Florida basin (SFB; Gregg, 2014). The SFB is interpreted as a continental rift basin that formed during the initial breakup of Pangea (Pollastro et al., 2001);

however, it mainly contains thick carbonate sequences deposited throughout the Cenozoic and Cretaceous, indicating Florida was a stable, carbonate platform during much of its history.

At the base of these carbonates, a thin unit of Upper Triassic/Jurassic (?) redbed sandstone and shale known as the Wood River Formation rests above basement and Triassic volcanic rocks. A horizon identified through seismic imaging of the offshore West Florida Basin may also contain basal sands that may be similar in age (Fig. 1., Gregg, 2014); these also lie beneath thick carbonate sequences (Applegate et al., 1981). The basal section of the Wood River Formation likely records early syn-rift sedimentation in the SFB.

Sample Locations

Figure 1. Location of the SFB and SGR in the EGOM. Local structural highs and lows are also identified. Samples collected for this study are listed as Basement, Jurassic-Cretaceous, and Wood River. Previous samples collected from the Norphlet and other offshore clastics are also displayed from Lovell (2010) and Lisi (2013). Structures from Neathery and Thomas (1975); Christenson, (1990); Pollastro et al. (2001). Location of the SGR from Chowins and Williams (1983); Suwannee Suture from Mueller et al. (2014).

Project Goals

Identifying the provenance of Triassic/Jurassic clastic rocks in the SGR, Tallahassee Graben and SFB can identify sediment source terranes available to supply sediment to the EGOM basin during initial rifting, and could test potential sediment transport pathways hypothesized for the Norphlet in the EGOM (e.g., Lovell and Weislogel, 2010; Weislogel et al.,

2015). This thesis reports provenance analysis of Triassic/Jurassic basal clastic rocks in the SGR and SFB using detrital zircon U-Pb geochronology and other methods in order to

Figure 2. Reconstruction of the Gulf of Mexico, with initial separation of Yucatan from Laurentia, and early initiation of the Caribbean during the Middle Jurassic (170 Ma). Modified from Iturralde-Vinet (2003) and Hine (2013).

identify the origin of sediment influx into the early EGOM.

Zircon grains are proven to be excellent provenance tools, due to their ability to be transported long distances without significant physical or chemical weathering (Gehrels, 2014). Although zircon typically crystallizes from felsic magmas, they can also crystallize from mafic magmas if zircon saturation is attained (e.g, Hoskin and Schaltegger, 2003). Zircons contain little initial Pb, so Pb levels measured in zircon are modeled as the result of decay from U to Pb, which permits calculation of a radiometric crystallization age. Comparing the ages of detrital zircons with age of zircon from

igneous or metamorphic rocks of potential source terranes allows for provenance determination and reconstruction of sediment transport pathways.

The Triassic-early Jurassic arrangement of microplates and their relationship to larger plates in the EGOM region during early Mesozoic evolution is poorly constrained, and a variety of tectonic terranes, including Laurentia and associated Precambrian-Paleozoic orogenic belts, South America, West Africa, and small microplates such as Yucatan, may have shed sediment into the SFB (Fig. 2). Zircon age signatures of these potential source terranes vary due to their disparate tectonic evolution. Therefore, comparison of source area to the zircon age signatures of basal deposits of the Jurassic Wood River Formation, and Triassic syn-rift deposits can be used to constrain the distribution of terrane(s) that served as sediment sources. Thin-section point counting supplements U-Pb detrital zircon provenance analysis to identify tectonic setting of the source area (Dickinson and Suczek, 1979). Together, detrital zircon ages and sandstone modal composition data can be used to characterize sediment provenance of lower Mesozoic units in the EGOM in order to test and expand previous Late Jurassic EGOM paleo-geographic models, and refine inferred sediment pathways.

Research Problem Significance

Results of this project will address: 1) the paleogeography of the Early EGOM, 2) provide information regarding the distribution of Jurassic sedimentary reservoirs in the EGOM, 3) help to delineate the Suwannee suture, a major tectonic boundary in the EGOM region, and 3) constrain maximum depositional age of basal units in the EGOM. Reconstructing the origin and distribution of early Mesozoic EGOM deposits is problematic due to the significant tectonic, paleogeographic reorganization and burial that has taken place during subsequent late Mesozoic and Cenozoic evolution of the GOM. Until the Early Cretaceous, drainage systems into Gulf of

Mexico were primarily transporting sediment derived from Appalachian sources. By the Paleocene, tributary systems feeding the Gulf of Mexico extended throughout the American southwest and northwest of North America and Canada (Galloway et al., 2011; Blum and Pecha, 2014). Provenance signatures among lower Mesozoic EGOM units can be used to assess paleo-drainage catchment configuration and potential connections between onshore sources and offshore lower Mesozoic deposits.

Ultimately, comparing provenance of Triassic-Jurassic syrt deposits with provenance of the Norphlet Formation erg in the northern EGOM as determined through previous work will provide constraints on potential for lower Mesozoic reservoir units across the EGOM (Mancini et al., 1985; Lovell, 2010; Hunt, 2012; Lisi, 2013; Weislogel et al., 2015). Previous exploration success with the Norphlet deep-water play in the EGOM supports the potential for future offshore discoveries. Early exploration attempts in the Norphlet Formation around the offshore DeSoto Canyon lease block were largely unsuccessful, largely due to low porosity (Godo, 2006). The first major discovery was made by Shell at the Appomattox well in 2010, with 550 mmboe (Shell Fact Sheet, 2014). Shell discoveries in the Mississippi Canyon Block include the Appomattox, Vicksburg, Rydberg, and most recently the Fort Sumter (World Oil, 2016), indicating the full extent of the play has not been delineated.

The potential for reservoirs is currently untested, but drainage configuration hypothesized by Weislogel et al., (2015) predicts a sediment feeder system routed through the Tallahassee Graben and/or Tampa Embayment into the EGOM. The SGR and Tallahassee Graben have been interpreted to extend into the EGOM offshore near the Apalachicola Embayment and the DeSoto Canyon area (McRae and Watkins, 1996), and Wilson (2012) identified possible Norphlet-equivalent deposits in the Tampa embayment; these sediments may have originated from a

transport system in the Tallahassee Graben (Figure 1). The extent of the Norphlet reservoir facies south of the Sarasota Arch is not well constrained, but seismic analysis by Gregg (2014) identified possible Norphlet equivalent deposits in the West Florida Basin. Establishing input through Florida rift systems would increase the probability for presence of reservoir units in this part of the EGOM.

The exact trace of the Suwannee suture which connects Florida (Gondwana) to North America (Laurentia) is currently unknown (Mueller et al., 2014). The Suwannee Suture has been interpreted to parallel the SGR and at least partially coincide with the Brunswick Magmatic Anomaly (BME), a magnetic low that parallels the SGR and extends into the offshore Atlantic and southern Alabama (Chowns and Williams; 1983; Williams and Hatcher, 1983; Hatcher et al., 2010). However, wells north of the BME tag basement that resembles rocks of the Suwannee terrane, which may indicate the BME is a result of overthrusting of Suwannee-related rocks onto Paleozoic rocks of the Laurentian lower plate (Hatcher et al., 2010), or it may reflect peri-Gondwanan terranes that had accreted to Laurentia prior to Alleghenian orogenesis (e.g., Horton et al., 1989; McBride et al., 2005; Hatcher, 2010). Since the Suwannee suture separates Gondwanan from peri-Gondwanan and Appalachian orogenic rocks, zircon ages of syn-rift deposits can be used to constrain the location of the Suwannee suture, with Laurentia-derived zircons expected near the Laurentia side of the suture, and Gondwana influenced sources near the Suwannee side of the suture. This will permit an assessment of the influence the suture zone exerted on structural and sedimentation patterns produced from Triassic rifting. Results from this project will test previous tectonic models for the configuration of the Suwannee suture identifying variations in detrital zircon signatures across the basin.

Chapter 2: Background

Tectonic Setting and Evolution of the Mesozoic EGOM

Figure 3. Paleogeography in the Gulf of Mexico from the Triassic (230 Ma) and the Jurassic (170 Ma). Modified from Blakey (2016).

The Gulf of Mexico is generally interpreted as a rift basin that formed during the breakup of Pangea starting sometime around 204 Ma (Fig. 3; Dobson and Buffler, 1997). An alternative hypothesis by Stern and Dickinson (2010) suggests that the GOM formed from as a backarc basin related to eastward subduction in western South America. Rifting of Pangea occurred along zones of continental weakness, including sutures where previous terranes had accreted and ancient rifts from the breakup of Rodinia (Salvador, 1987; Hatcher, 2010; Mueller et al., 2014). Tholeiitic basalts found in the Tallahassee graben of northern Florida/South Georgia Rift basins initially formed during opening of the Atlantic ocean as part of the Central Atlantic Magmatic Province (CAMP; e.g, Austin, 1990; Hames et al., 2000; Fillon, 2007), which includes volcanism throughout eastern North America, western Africa, and eastern South American (Austin et al., 1990; Marzoli et al., 1999; Heatherington and Mueller, 2003). Basalt $^{40}\text{Ar}/^{39}\text{Ar}$ ages around 200

Ma indicate the age of the main phase of rifting in the EGOM (Hames et al., 2000). Basalt and rhyolite in the South Florida Basin and offshore western Florida range in age from 175 to 199 Ma, consistent with a Central Atlantic Magmatic Province (CAMP) association, and may indicate another phase of younger volcanism (Dallmeyer, 1983; Heatherington and Mueller, 2003). Extension along the eastern margin of the developing North American continent created a series of basins that infilled with fluvial and lacustrine strata of the Newark Supergroup (e.g., Chowns and Williams, 1983; Smoot, 1991). Many of these basins from Nova Scotia to North Carolina are exposed at the surface (Fig. 5; Withjack et al., 1998); however, the basins continue southward in the subsurface and include the South Georgia Rift (SGR) basin system.

The SGR is a buried Triassic-Jurassic graben rift basin system along the southeastern Atlantic margin of the U.S. that has been infilled with Mesozoic sediment and volcanic rocks (Chowns and Williams, 1983). The Newark Supergroup rocks are proven to include hydrocarbon source rocks, although previous exploration attempts have not proved commercial (Milici et al., 2011; Coleman et al., 2015). The general orientation of SGR sub-basins is NE-SW relative to the N-S orientation of other rift basins along the U.S. Atlantic margin, likely due to structural weaknesses of the NE-SW oriented Suwannee suture (Chowns and Williams, 1983; Klitgord et al., 1988; Mueller et al., 2014). Rifting along the SGR axis failed and continued to the east until seafloor spreading initiated. The region remained a topographic depression, and during periods of sea level rise in the Cretaceous and Cenozoic, the SGR area was submerged by seawater, forming the Georgia Seaway (also known as the South Georgia Trough, or Georgia Channel System; Warzeski et al., 1996; Hine, 2009). The SGR was originally proposed as a series of separate rift basins within a single larger rift basin by Daniels et al. (1983), which is supported by further seismic and aeromagnetic studies (e.g., Klitgord et al., 1988; Sartin and See,

1997; Heffner, 2013). In his study of the SGR structural development, Heffner (2013) identified several sub-basins separated by transfer faults within the SGR, including the Albany Basin and the Valdosta Basin, as well as the Riddleville/Dunbarton Basin and Kibbee Basin (Fig. 4). Of these, the Albany Basin contains significantly thicker strata (upwards of ~3990 meters thick) than other sub-basins, based on seismic interpretation (Heffner, 2013). Maximum basin fill for the SGR approaches 4270 meters in Georgia (Satin and See, 1997).

Evidence of basin inversion is present in many of the rift basins of the eastern U.S., and

Figure 4. Location of the various SGR sub-basins, modified by Heffner (2013). SGR sample locations from this study are shown.

may have occurred in the SGR (Withjack et al., 1998; Schlische and Withjack, 2003) Rine et al. (2014) reconstructed the burial history of the Newark Supergroup in South Carolina from core. A maximum burial depth of ~3500 meters was attained for the interval sampled (2600-6200 ft), followed by deposition of Jurassic strata. Subsequent basin inversion during the

Mesozoic around 200 Ma resulted in at least 2800 meters of uplift based on

$\delta^{18}\text{O}$ of calcite cement (Rine et al., 2014). Inversion may have resulted in significant erosion of strata from exposed rift basins. Uplift ended sometime before deposition of the Cenozoic cover strata (Schlische and Withjack, 2002; Rine et al., 2014).

Along the northern margin of the Gulf of Mexico, a similar series of NE-SW oriented rift basins separated by paleo-highs of thicker, less attenuated crust developed during early Mesozoic

time as the Yucatan Block separated from North America and migrated southward, (Fig. 6; MacRae and Watkins, 1993; Dobson and Buffler, 1997; Wilson, 2011). Paleo-highs in the vicinity of Florida include the Pensacola Arch, South Platform/Middle Ground Arch, and Sarasota Arch, and the intervening paleo-lows include the Apalachicola Embayment, DeSoto Canyon Salt Basin, Tampa Embayment, and South Florida Basin (Dobson and Buffler, 1997; Wilson, 2012). These structures parallel the ancient collisional structures of the Alleghany orogen, so the rift structure orientations may be related to lithosphere heterogeneity inherited from earlier collision events.

During the initial phase of rifting, the Yucatan Block rifted off southern Laurentia and begun to rotate into its current position off South America (Pindell and Kennan, 2009). Previous workers had speculated that another continental block, the Florida-Bahamas Block, rifted off the southern margin of Laurentia and migrated toward the southeast along transform faults along the western margin of the Suwannee Terrane, before attaching to the southern end of the terrane, resulting in a series of tilted fault block basins in southern Florida (Klitgord et al., 1988). However, the existence of the Florida-Bahama block remains speculative, and recent seismic data show no evidence for transform faulting along the western margin of the Suwannee terrane (Wilson, 2011). A seafloor spreading center developed in the Gulf of Mexico that further separated Laurentia from South America beginning in the Middle Jurassic (Fig. 5; Salvador, 1987; Hudec et al., 2013; Boschman et al., 2014). As sea level rose through the Cretaceous and Cenozoic, carbonate platforms accumulated to form the Florida escarpment whereas the northern EGOM coast accumulated a mix of carbonate and clastic deposits (Mancini et al., 1985; Pollastro et al., 2001).

Figure 5. Model for rifting and seafloor spreading and rifting from Hudec et al. (2013). A: 210 Ma, initial rifting of Yucatan from Laurentia. B: 163 Ma, initial deposition of Louann salt in the GOM following rifting. C: End of salt deposition south of Texas. D: 155 Ma, continued extension of crust and salt deposits, E: 149 Ma, seafloor spreading begins. F: Modern extent of the GOM, salt, and ocean crust.

Basement rocks: Paleozoic orogens and Gondwanan Suwannee Terrane

Basement rocks along the eastern margin of Laurentia consist of accreted terranes and synorogenic rocks that developed from Proterozoic to Paleozoic time. The Grenville orogen (900-1300 Ma) extends from the eastern margin of Canada and North America, and formed during the initial assembly of Rodinia (Bream et al., 2004; Rivers, 2008; McLelland et al., 2010). Throughout the Paleozoic, a series of tectonic terranes accreted onto the eastern margin of Laurentia, known as the Appalachian orogenic events. These include the Taconic (430-490 Ma), Acadian/Neoacadian (330-420 Ma), and Alleghanian (265-330 Ma) orogenic events (Hatcher, 1987; Miller et al., 2000; Moecher et al., 2004; Sinha et al., 2012; Steltenpohl et al., 2013). A series of Peri-Gondwanan Terranes, including the Charleston, Savannah River, Milledgeville, Uchee, and Carolina Terranes accreted onto Laurentia through the Paleozoic (525-680 Ma), and now forms the basement of most of eastern South Carolina and eastern Georgia (Wortman et al., 2000; Coler et al., 2000; Hatcher, 2010; Mueller et al., 2014). Peri-Gondwanan Terrane accretion culminated with the collision of Gondwana with Laurentia during the Alleghanian orogeny; a remnant of Gondwana known as the Suwannee terrane remains attached to North America along the Suwannee Suture and comprises the basement of modern-day Florida (Mueller et al., 2014).

After accreting onto North America, some models postulate the northern portion of the Suwannee Terrane was translocated into its current position by transform movement along the Suwannee Suture during opening of the GOM (Mueller et al., 2014). The exact location of the Suwannee Suture in the subsurface is unknown, and has been the subject of numerous studies (e.g., Mueller et al., 2014; Parker, 2014); however, currently it is thought to be stretch from offshore South Carolina across southern Georgia and into southern Alabama, at least partially coincidental with the Brunswick Magnetic Anomaly and/or the trend of the SGR (Chowns and

Williams, 1983; Williams and Hatcher, 1983; Hatcher et al., 2010; Steltenpohl et al., 2013).

Current seismic refraction studies in southern Georgia will better constrain the exact location of the Suwannee suture (e.g., Shillington et al., 2014).

Suwannee terrane basement includes igneous, metamorphic and sedimentary provinces. Igneous and metamorphic provinces associated with the Suwannee Terrane consists of the Osceola Granite (552 Ma), the St. Lucie Metamorphic Complex (530 Ma), and rift related North Florida Volcanics (~199 Ma) and South Florida Volcanics (175 - 199 Ma; Dallmeyer et al., 1987; Dallmeyer et al., 1989; Mueller et al., 1994; Heatherington and Mueller, 1997; Heatherington and Mueller, 2003). Paleozoic sedimentary rocks found throughout the Florida subsurface range in age from Ordovician to Devonian (Applin, 1951; Chowns and Williams, 1983) and yield 525-680 Ma and 2,000-2,250 Ma detrital zircon ages, which is consistent with Pan-African Brasiliano sources and Eburnean/Trans-Amazonian orogenies (Mueller et al., 1994; Mueller et al., 2014). The lack of any zircon with ages corresponding to Laurentian sources suggests that the pre-Mesozoic Suwannee Terrane consists of African and South American sedimentary cover over Pan-African basement (Mueller et al., 2014). A possible correlation between Suwannee Paleozoic sedimentary cover has been proposed to sandstones with similar lithologies to the Bove Basin in West Africa, however recent detrital zircon data from the Bove basin have a prominent 1200-1300 Ma signature that is absent from the Suwannee Basin (Dallmeyer et al., 1987; Mueller et al., 2016).

Generalized Mesozoic Stratigraphy of the Northeastern Gulf of Mexico

The Triassic Eagle Mills Formation sits unconformably on Paleozoic basement and formed during initial syn-rift clastic sedimentation in the EGOM (Fig 6; Mancini et al., 1985).

Although the

formation is poorly

studied, a Carnian

(Late Triassic) age for

the Eagle Mills

Formation is assigned

based on

palynomorphs, (Moy

and Traverse, 1986).

During early

extension and seafloor

spreading, the GOM

experienced

occasional flooding by

seawater; periodic

evaporation resulted in the deposition of the overlying Werner Formation and Louann Salt (Fig.

7; Dobson and Buffler, 1997; Hudec et al., 2013). Deposition of Louann Salt began in the

Callovian (163 Ma), and continued throughout continental rifting until seafloor spreading began

around 155 Ma (Hudec et al., 2013). Thick deposits of the Louann Salt accumulated across much

of the early GOM, including the central onshore and offshore Gulf of Mexico and select regions

in eastern Mexico.

Eastern Gulf Of Mexico Stratigraphy

Figure 6. Stratigraphy of the EGOM. Modified from Mancini et al. (1985). Ages from Goldhammer et al., (2001); Cohen et al. (2013).

Greater evaporate accumulation occurred in areas of higher crustal attenuation and subsidence (Tew et al., 1991; Dobson and Buffler, 1997). Thickest accumulations of lower Jurassic evaporites in the EGOM formed in the Mississippi Interior salt basin; these evaporites thin southeastward toward the Apalachicola basin until they pinch out in the southern EGOM, and so are completely absent from the South Florida Basin and West Florida Basin (Applegate et al., 1981; Wilson, 2011; Hudec et al., 2013; Gregg, 2014). Hudec et al. (2013) hypothesized that salt deposition was restricted to zones of crust that had been hyperextended or that had evolved into transitional crust, indicating that seafloor spreading in the southern EGOM pre-dated salt deposition. As the basin began to subside following rifting, a thick sequence of Jurassic-Cretaceous post-rift sediment was deposited on top of the Louann Salt, beginning with the Upper Jurassic Norphlet (Dobson and Buffler, 1997).

The Upper Jurassic Norphlet Formation clastic deposits formed in an arid environment by alluvial fan, wadi, eolian, and fluvial systems (Mancini et al., 1985). In Alabama, where the Norphlet Formation is best characterized, alluvial fan conglomerate facies were deposited immediately adjacent to highlands of the remnant Alleghany orogen, and wadi and fluvial systems deposited red bed sandstone and shale in the more distal regions (Mancini et al., 1985; Dobson and Buffler, 1997; Hunt, 2012). Further from the Alleghany orogen, sediment was deposited in an eolian erg, which includes dune, interdune/wadi, and playa lake environments that formed well sorted, quartz-rich, thin- to thick-bedded sandstones (Mancini et al., 1985; Gutierrez and Ewing, 2015). The upper section of the Norphlet in southern and offshore Alabama is composed of a quartz-rich, well sorted sandstone known as the Denkman Member, described by Mancini et al. (1984). Sedimentary structures in the Denkman Member range from massive sandstone to lower cross-bedded sandstone. The lower section grades into a red cross-

bedded sandstone, which constitutes the dominant Norphlet lithology in the EGOM region. The red beds coarsen upward into cross-bedded eolian sandstone throughout southern Alabama. The Norphlet Formation grades upward into a carbonate-rich sandstone and eventually into the marine carbonate units of the Smackover Formation (Mancini et al., 1990). The Norphlet Formation contact with the overlying Smackover Formation ranges from sharp to gradational. Lower Smackover Formation facies that is gradational with the Norphlet is known as the Brown Dense, and consists of organic-rich, subtidal mudstone (Claypool and Mancini, 1989). The Brown Dense is interpreted to have sourced hydrocarbons found in Norphlet and other clastic reservoirs in the EGOM.

Figure 7. Stratigraphy of the South Florida Basin. Modified from Pollastro et al. (2001).

Mesozoic Stratigraphy of the South Florida basin

Mesozoic rocks of the SFB include Triassic-Jurassic volcanic rocks, thin Triassic-Jurassic basal clastic rocks, and thick Cretaceous carbonate rocks (Fig. 7 and 8; Pollastro et al. 2001). The Wood River Formation forms the basal

sedimentary deposit of the SFB and was first described by Applegate et

al. (1981). The Wood River Formation rests below the Bone Island Formation, and above

Mesozoic volcanic rocks and Paleozoic sedimentary rocks of the Suwannee terrane.

Hydrocarbon exploration and drilling in southern Florida has concentrated mainly on the Lower Cretaceous dolomite and limestone of the Sunniland Formation (Pollastro et al., 2001). Only 3-4 wells have penetrated through the Cretaceous section into the underlying Jurassic Wood River Formation (Applegate et al., 1981), although at least 7 other wells penetrate into basal clastics that are likely related to Wood River Formation deposits. The Wood River Formation in the type well (P-778) contains red, fine- to coarse-grained sandstone and shale, as well as anhydrite and brown microcrystalline dolomite in the upper 36.5 meters (120 feet). Lithologic characterization is based primarily from cutting interpretations and well logs, which reveal the sandstone is composed mainly of quartz and feldspar. Potential depositional environments proposed for the basal clastic Wood River Formation are based on well log signatures, and include marginal marine deltaic, fluvial, and fluvial-lacustrine depositional settings (Pollastro et al., 2001). Although no direct age information exists for the Wood River Formation basal clastic unit, the rhyolite porphyry that underlies the Wood River Formation in the type well has been dated at 189 Ma using Rb-Sr whole rock geochemistry (Applegate et al., 1981; Tapping, 1994) and biostratigraphy from the overlying Bone Island Formation indicate an age of 138 Ma (Applegate et al., 1981); thus, the basal clastic unit of the Wood River was deposited between 138-189 Ma (Pliensbachian-Neocomian). Tapping, 1994 speculated a late Triassic-Early Jurassic age for the Wood River based on the age of similar clastic units in the northern EGOM. Mesozoic volcanic rocks from other wells in the South Florida Basin have been analyzed using Rb-Sr and K-Ar geochronology, yielding ages between 175 to 199 Ma for basalts, and 165 to 189 Ma for rhyolites (Heatherington and Mueller, 2003).

Figure 8. Cross-section of the Lower Cretaceous South Florida Basin. The South Florida Basin is dominated by thick Cenozoic and Cretaceous carbonates. A thin, Triassic/Jurassic clastic layer rests above interpreted basement. Modified from Pollastro et al. (2001).

Basement and Mesozoic Stratigraphy of the South Georgia Rift

Syn-rift and post-rift strata in the SGR are referred to as the Upper Triassic (?) Newark Supergroup, which includes sedimentary rocks, felsic and mafic extrusive rocks and diabase intrusions (Chowns and Williams, 1983). Unlike the exposed Triassic rift basins in the eastern U.S, which bear vertebrate and invertebrate fossil assemblages (e.g., Fowell et al., 1994), the age of the SGR basin-fill is poorly constrained due to lack of fossil evidence. Mesozoic strata of the

SGR consists of at least 3,500 meters of Triassic (?) red bedded sandstone and shale (Chowns and Williams, 1983). Strata generally dip toward the northeast, implying syn-rift deposition during motion along basin-bounding faults forming the northeast basin margin. Core no longer exists for the SGR in Georgia, although some core has been recovered in South Carolina. Core recovered from South Carolina was interpreted to mainly consist of lacustrine and fluvial facies, based on lithofacies and fossils (Rine, 2014). Electrical log data suggests minor fining upward sections and cross-bedding are present. Chowns and Williams (1983) interpreted that the mainly arkosic sandstone (60%), along with subordinate abundances of red shales and siltstones (40%) were deposited in a continental fluvial setting, with other alternate possibilities including alluvial fan, eolian dunes, playa lakes, and alluvial fans that fringe the basin margins. Other studies have supported a lacustrine origin (e.g., Ziegler, 1983; Rine, 2014).

The northern SGR rests on and is flanked by basement rocks formed during the Grenville orogeny and Appalachian orogenic events, with main lithologies including granites, schist, and gneiss, and Paleozoic sedimentary rocks (Chowns and Williams, 1983). In the segment of the SGR that likely extends south of the Suwannee suture, the SGR rests on and is flanked by Suwannee terrane rocks composed of quartzose sandstone and red to black shale. Accordingly, two distinct petrofacies are identified for SGR deposits based on composition (Chowns and Williams, 1983). In the northern SGR, sandstones are primarily a mix of arkosic/subarkosic and lithic-arkosic, with a dominance of metamorphic lithic fragments indicating derivation from rocks of the Appalachian metamorphic piedmont (Chowns and Williams, 1983). The southern SGR contains mainly arkosic/subarkosic and litharenites bearing sandstone and volcanic fragments, which are interpreted to have been derived from the Paleozoic sedimentary rocks of the Suwannee Terrane and North Florida Volcanics (Chowns and Williams, 1983).

Diabase dikes and tholeiitic basalt sills are common in the lower Mesozoic section of the eastern SGR. Clastic rocks surrounding the intrusions exhibit slight contact metamorphism, mainly zeolite and hornfels facies (Chowns and Williams, 1983). Mafic volcanic rocks in the SGR likely related to the Central Atlantic Magmatic Province (CAMP) locally cap the red bed section (Heffner et al., 2012). Isotopic $\text{Ar}^{40}/\text{Ar}^{39}$ dating of north-trending diabase from South Carolina yielded an age of ~200 Ma (Hames et al., 2000), similar to other CAMP volcanic rocks (e.g., 200 Ma ages reported from volcanic rocks of the Fundy Basin in southeastern Canada; Hodych and Dunning, 1992). Age of volcanism in the SGR may be slightly younger than CAMP magmatism to the north, as rifting is thought to have progressively developed southward (Withjack et al., 1998). In addition, volcanic deposits penetrated in southern Georgia interpreted as rift-related include granites, volcanic tuffs, and rhyolites, with granites U-Pb zircon dated at 159 Ma (Heatherington et al., 1999). The volcanic rocks are capped by white and red coarse grained siltstone interpreted as post-rift deposits (Chowns and Williams, 1983). These deposits are labeled as the Cretaceous Cotton Valley Formation, which is also present in the EGOM

Previous Work

Detrital zircon U-Pb geochronology from previous work by Lovell (2010), Lisi (2013) and Jessee and Weislogel (2014) identified provenance for eolian facies of the Jurassic Norphlet Formation in the EGOM. Dipmeter interpretation by Hunt (2012) determined a net eolian transport direction of south to southeast towards Florida within the Norphlet dune fields in Alabama, which substantially reworked sediments entering the EGOM sub-basins. Mixing between sub-basins was relatively minor. Synthesis of these results reveal that the Norphlet Formation in the southern Alabama onshore is sourced primarily from Laurentian sources, while Gondwanan input increases for the Norphlet Formation toward the southeast in the Pensacola

Arch, Apalachicola Embayment, and offshore Destin Dome lease block (Fig. 9; Lovell and Weislogel, 2010; Weislogel et al., 2015). Furthermore, results from this study will be used to constrain maximum depositional age (e.g., Dickinson and Gehrels, 2009) of basal units in the EGOM. Basal clastic units in the SFB have been poorly studied, aside from their initial description by Applin and Applin (1965) and Applegate et al. (1981). The age of the Wood River Formation is based on age constraints from whole rock Rb-Sr age of 189 Ma for lower rhyolites, and 138 Ma, based on biostratigraphy of overlying carbonate units. The age of Newark Supergroup strata in the SGR is also poorly constrained, and Chowns and Williams (1983) speculated an Upper Jurassic age based on the overlying Upper Jurassic Cotton Valley Formation, the presence of Proterozoic/Paleozoic rock fragments, and basalt intrusions similar to other eastern Laurentian rift-related intrusions. Results from this study will further constrain depositional age based on the maximum depositional age determined from detrital zircons in SFB and SGR syn-rift deposits.

Figure 9. Potential provenance model for the Norphlet Formation in the EGOM. Arrows indicate sediment transport directions for the Norphlet in the EGOM. Two dominant source systems were identified for the Norphlet, a W-western system and the E-eastern system. In addition, sediment may also have been derived from the Ar-Arkoma Basin, BW-Black Warrior Basin, and Ap-Appalachian Basin. From Weislogel et al. (2015).

Chapter 3: Methods

Sample Collection

Provenance analysis was conducted on a total of 17 samples collected from cuttings and cores. Nine samples were collected from the Florida Geological Survey in March 2015 (Table 1). Sampling targeted the basal sandstone and shale of the Wood River Formation and the basal sandstones found along the southern portion of the Peninsular arch. One additional sample was also collected from syn-rift deposits of the Tallahassee Graben in northern Florida. Due to sampling restrictions, cuttings samples were collected in 3-6 meters (10-20 foot) intervals, with total ranges between 30-120 meters (100-400 feet) thick. Sample size from each 3 meter (10 foot) interval was limited to at most 3.00 grams; sample size ranged from 20-120 grams for each well. Zircon recovery for samples 1411, 1655, and 966 was poor and samples were not dated. Detrital zircon samples were collected from a total of five wells, four which penetrated the basal clastic Wood River (15095, 10566, 778, 3578), and one which likely penetrated the Lower-Upper Cretaceous transgressive sandstones/or Paleozoic clastics (2012) (Figure 1).

Three additional samples from offshore southern Florida were acquired from the International Ocean Discovery Program (IODP) Gulf Coast Repository (GCR), at Texas A&M University in College Station, Texas (Table 2). The samples were collected during Ocean Drilling Project Leg 77, from holes 537 and 538, which penetrated a succession of sandstone and conglomerate, overlying Paleozoic basement. Basement samples collected for this study consist mainly of metamorphosed phyllite and igneous intrusions. Sample sizes were less than 100 grams, and of the three samples, only the lower Paleozoic metamorphic basement sample from hole 537 at 200 m depth yielded zircon grains; this is labeled sample ODP in this study. Samples

that did not contain zircon were collected from the Cretaceous sandy carbonate from hole 537 (~180 m depth; Unit IV), and the diabase intrusion from hole 538 (~270 m depth).

Samples of Triassic Newark Supergroup deposits were collected from cuttings from 5 wells in the SGR from the Georgia Environmental Protection Division core and cutting repository in Rutledge, Georgia in July of 2015 during a visit (Table 3). Samples were manually picked, with approximately 15-20 grams was typically collected every 3 to 6 meters (10-20 foot intervals) until 300-400 grams was collected. Samples of Newark Formation were collected from wells 108, 619, 3137, 3113, and 442 in the SGR. Thin-sections were prepared from cuttings/rock chips collected from wells 442, 108, 619, and 3137. Diabase intrusions are present in several of the wells (3113, 3137, 442), but previous cutting logs from Chowns and Williams, (1983) were used to avoid the sections.

Detrital Zircon Geochronology

Cuttings were prepared for zircon analysis following the methods proposed by Gehrels et al. (2014). Separation involved crushing using a disk mill, followed by hydrodynamic separation using a Gemini table if significant sample was present (> 300 grams). Hydraulic separation was performed only on samples of cuttings from Georgia; Florida and IODP samples were too small for hydraulic separation on the Gemini table. After crushing, magnetic separation was performed using a Frantz magnetic separator, followed by liquid separation using lithium polytungstate (LPT) and methylene iodide (MEI). Samples were soaked in nitric acid to dissolve any pyrite that was present. After separation, the final sample consisted mainly of zircon and barite. Samples were mounted on tape, and non-zircon was manually removed. The zircon was mounted

using epoxy on circular mounts, polished, and imaged using reflected and transmitted light for zircon dating.

U-Pb analysis was completed at the University of South Carolina Center for Elemental Mass Spectrometry in September and December of 2015. Analysis involved laser ablation with a PhotonMachine Analyte G2 1943 nm (deep ultraviolet) ArF exciplex laser to determine $^{206}\text{Pb}/^{238}\text{U}$, $^{207}\text{Pb}/^{235}\text{U}$, and ^{235}U to ^{207}Pb ratios. Spots on sample grains were analyzed using a Photon Machine Analysis using a Thermo Element II ICP-MS. Sample grains were randomly selected from the mount in groups of 5, followed by measurements from each standard. Two standards spots were analyzed, including one from a primary standard grain SL2 Shri Lanka zircon (563.2 ± 4.8 Ma; Gehrels et al., 2008), and one from a secondary standard 91500 (1065 ± 0.3 Ma; Wiedenbeck et al., 1995). Analysis standards are used to correct for instrumental offset, and down-hole fractionation. Analysis included an initial 10 s delay to record background noise, including ^{202}Hg , ^{206}Pb , ^{207}Pb , ^{208}Pb , ^{232}Th , and ^{238}U . Unknown and standard zircon grains were ablated by a 10-Hz laser for 28 seconds, followed by 15 s of chamber washout. Before running a spot on an unknown sample, three spot analyses were taken on both zircon standards to calibrate the Element II. Both standards were analyzed once between every five unknowns. Between 46-125 spots were recorded from single grains for each sample if enough zircons were present.

Data was reduced by Dave Barbeau at the University of South Carolina using the applet U-Pb Geochronology 3 data reduction scheme (DRS) of the Iolite software package within IgorPro (Paton et al., 2010). Initial data reduction removes anomalous data points, which included non-zircon/zoned zircons. Ratios of $^{238}\text{U}/^{206}\text{Pb}$, $^{235}\text{U}/^{207}\text{Pb}$, $^{232}\text{Th}/^{208}\text{Pb}$, and $^{207}\text{Pb}/^{206}\text{Pb}$ were calculated using the measured counts. Following processing, all grains with 2 standard deviations or greater were removed from the dataset. A concordance filter was applied to all

grains older than 500 Ma to correct for lead loss/gain. Analyses with <70% concordance, or >105% concordance were removed. Unknowns analyzed with SL2 were selected over the 915 standard due to greater reproducibility.

Probability Density Plots (PDP) and Kernel Density Estimates (KDE) were constructed using DensityPlotter (Vermeesch, 2012). A PDP uses the ages and associated error estimates to generate a probability density of the age distribution. In contrast, the KDE assumes Gaussian distribution of ages and associated uncertainty for age sources and creates a smoothed distribution representing the probability of contribution of the age from a source (Vermeesch, 2012). Age distributions were compared with ages known from surrounding tectonic terranes to test for potential sediment sources. U-Th plots were also constructed to identify any metamorphic populations that may have been present to further constrain sediment source. Any zircons with a U/Th ratio over 5 were identified as metamorphic zircons (e.g, Hoskin and Schaltegger, 2003).

Cumulative Density Estimates Plots (CDP) and the K-S test were used to determine if multiple samples may have shared similar sources. The CDP plots age versus the relative probability of an age. It displays the same data as a Probability Density Plot, but individual sample distributions can be plotted together in order to identify changes in probability between age populations within samples.

The K-S is a hypothesis test, which can be used to determine if two samples were derived from the same parent population. The test produces a probability value (P), and α value (level of significance). A Confidence Interval of 95% and an α value of 5% were used for this study. α corresponds to 5% uncertainty in the confidence of the hypothesis test. If the P-value exceeds

0.05, then there is 95% confidence that the two samples are not statistically different and may be derived from the same source. If the P-value is less than 0.05, then the samples are statistically different, and are likely derived from different sources. The K-S test can be highly biased by degree to which the sample distribution is characterized, particularly samples with diverse zircon ages. The K-S test can also be biased by differences in sample size. Although the majority of the samples from this study had relatively similar sample sizes, some sample sizes were very small, such as sample 10566 which only recovered around 46 zircons. The CDP and K-S test were also used to compare samples between the SFB and the SGR with Norphlet samples from Lisi (2013) and Lovell (2010) to determine if the Norphlet may have shared a similar source with either basin, and if either basin could be a potential sediment pathway into the EGOM.

Thin-Section Petrography

Thin-Section Petrography was completed to understand variations in lithology and source for the syn-rift clastics. Standard size thin sections (27x46 mm) were ordered from Spetrum Petrographics Inc and Texas Petrographic Services Inc. Thin sections were impregnated with a blue epoxy, and stained with Barium Chloride and Rhodizonate for Feldspar. Observations were made using a Nikon Eclipse LV100 microscope using transmitted and reflected light, as well as polarized light. Objectives used include 2X, 4X, 10X, and 20X. A Nikon camera was used for photomicrographs. NIS-Elements software was used to take photos and create figures.

Thin-section point-counting was completed on 12 samples from the SFB to determine tectonic setting (Table 4) using the digital SteppingState with PetrogLite software. Thin-sections were point-counted for detrital grain composition using the Gazzi-Dickinson method (Dickinson and Suczek, 1979), which identifies and classifies sandstone composition by tectonic source

based on the abundance of detrital framework grains, such as quartz (monocrystalline or polycrystalline), feldspars (orthoclase and plagioclase), and lithics (metamorphic, igneous, or sedimentary). Identification is based on the composition of individual grains, including quartz, lithics, and feldspar. Point-counting included at least 400 points per sample to limit error of 5% at 2 standard deviations (Van Der Plas and Tobi, 1965). Compositions were then plotted on a ternary diagram to determine tectonic setting. Thin-sections from the SGR and select SFB samples were too fine-grained for point-counting, but could be used for petrographical observations. In addition to point counting, observations were also recorded on porosity, grain size, sorting, rounding, and other notable features. Overall, 22 thin-sections from the SFB and SGR were examined for this study. Point Counting was used to supplement U-Pb dating to determine provenance.

FGS Samples: Sample name	Permit #	County/State	Well Name	Lat/Long	Sample Type	Lithology	Formation	Depth (ft)	Operator of Well	Basement	Zircons recovered?
2012	105	Levy, FL	Humble Oil and Refining Co 1	29° 4' 47.99" N/ 82° 37' 14" W	Cuttings	red sandstone/shale	Paleozoic/Lower Mesozoic clastics	4000-4370	Humble Oil	Serpentinite	Yes
3578	225	Highlands, FL	Continental Carleton	27° 9' 34" N/ 81° 32' 9" W	Cuttings	dolomite, shale, uncommon sandstone	Wood River/lower Cretaceous	12130-12550	Continental Oil	Metamorphic shale/Basalt	Yes
10566	407	Lee, FL	Humble oil Lehigh Acres	26° 33' 38" N/ 81° 35' 5" W	Cuttings	red sandstone/shale/dolomite	Wood River	1550-15660	Penrod Drilling	Quartz diabase	Yes
15095	unknown	Collier, FL	Exxon Corp Sunniland Field	26° 17' 29" N/ 81° 20' 51" W	Cuttings/core chips	red sandstone	Wood River	16802-16949	Exxon	Rhyolite Porphyry	Yes
1854	95	Jefferson, FL	E.P Larsh #1	30° 20' 15.648" N/ 81° 58' 296" W	Cuttings	sandstone	Basal sandstone	7280-7610	Coastal Petroleum Company	Did not penetrate	Yes
778	778	Collier, FL	Collier Co. #12-2	25° 57' 31" N/ 81° 33' 49" W	Cuttings	sandstone	Wood River	18300-18640	Hodges Well Drilling	Did not penetrate	Yes
1411	31	Osceola, FL	W.P Hayman-Apoxsee	27° 47' 25.74"/80° 58' 43"	Cuttings	sandy dolomite, red sandstone/shale	Wood River/lower Cretaceous section	8540-8775	Loffland Brothers Co	Rhyolite	Insufficient for Dating
1655	62	Hardee, FL	B.T. Keen No. 1	27° 24' 47.03"/ 81° 59' 3.5"	Cuttings	dolomite, shale, and sandstone	Wood River	11450-11800	Lottland	Basalt	Insufficient for Dating
966	225	Highlands, FL	C.C. Carlton Est. 1	27° 7' 46"/ 81° 24' 16"	Cuttings	dolomite, some shale/sandstone	Wood River/Cretaceous clastics	12040-12250	Humble Oil	Quartzite	No

Table 1. Wells sampled for detrital zircon geochronology from the Florida Geological Survey.

EPD Samples: Sample Name/ GGS Number	Well Name	County /State		Sample type	Lithology	Formation	Depth (ft)	Operat of Well	Zircon Recovered?
52	Brunswick Peninsular Corp #1	Wayne, GA	31 23' 28"/ - 81 48' 22"	Cuttings	Arkosic sandstone	Newark Group	4560-4630	California Oil Co	Yes, but not dated
108	Cecil Pate #1	Crisp, GA	31 49' 35"/ - 83 46' 10"	Cuttings	Sandstone/shale	Newark Group	4820-5010	Kerr McGee Oil	Yes
442	Walter F Stevens #1	Sumter, GA	32 01' 05"/ - 84 18' 30"	Cuttings	Arkosic sandstone and red shale	Newark Group	3980-4520	Flinn Austin Co	Yes
619	H E Walton #1	Dooley, GA	32 02' 29"/ - 83 39' 00"	Cuttings	Arkosic sandstone	Newark Group	3512-3750	Georgia Florida Drilling Co	Yes
3113	J. T. Stalvey #1	Lowndes, GA	32 59' 259"/ - 83 15' 08"	Cuttings	Arkosic sandstone, red and black shale, and diabase	Newark Group	8130-8510	Hunt Oil Co.	Yes
3137	Griffiths #1	Pulaski, GA	32 19' 32"/ - 83 15' 08"	Cuttings	Red sand and shale	Newark Group	5320-5827	Atlanta Gas Co, S	Yes
3154	Key #1	Worth, GA	unknown	Cuttings	Red sandy shale	Newark Group	5465-5675	So. Inv.	Yes, but not dated

Table 2. Samples collected from the Georgia Geological Survey.

ODP Sample: Sample Name	Expedition	Site	Lat/Long	Depth interval	Lithology	Zircon Recovered ?
ODP	77	0537	23° 56.010 N/ 85° 27.618 W	22-24.5	Phyllite	Yes
ODP-2	77	0537	23° 56.010 N/ 85° 27.618 W	95-110	Carbonate cement with quartz and perthite grains	No
ODP-3	77	0538	23°50.98'N; 85°10.26'W	54.57-57	diabase	No

Table 3. ODP samples collected for this study.

Logs

Wireline well logs for 15 wells provided by the Florida Geological Survey were evaluated to identify and map the extent of the Wood River Formation/Peninsular arch basal sands in the subsurface. Paper logs were uploaded, georeferenced, and digitized in Petra. Logs included gamma ray, caliper, spontaneous potential, resistivity, neutron and density porosity. Logs were digitized in Petra, and tops were created based on driller's logs and electronic log curves. A map of the basal clastic tops and basement was created to identify the general orientation in the South Florida Basin. An isochore map was created to determine thickness variations. V-shale was calculated from gamma ray to identify shale content, and lateral variations in lithology. Regions of low v-shale may correlate to more proximal parts of the basin, while higher v-shale may correlate to more distal.

Sample #	Well Name	County/ State	Lat/Long	Sample Type	Lithology	Formation	Depth (ft)	Point Count?
SFB								
778-1	Collier Co #12-2	Collier, FL	25° 57' 31" N/ 81° 33' 49" W	cuttings/core chips	Sandstone/shale/limestone	Wood River	17800- 17900	No
778-2	Collier Co #12-2	Collier, FL	25° 57' 31" N/ 81° 33' 49" W	Cuttings/core chips	sandstone	Wood River	18400- 18410	Yes
ODP-1	Site 0537	Offshore EGOM	23°56.01'N/ 85°27.62'W	core	Sandstone/carbonate	unnamed	Interval 95-110	No
ODP-2	Site 0538.	Offshore EGOM	23°50.98'N; 85°10.26'W	core	diabase	unnamed	Interval 54.57-57	No
10566	Humble Oil Lehigh Acres	Lee, FL	27° 9' 34" N/ 81° 32' 9" W	cuttings	sandstone	Wood River	15708	Yes
1411	Jean McArthur Davis 9-3	Okeechobee, FL	27° 26' 17.063" N/ 80° 50' 17.07" W	cuttings	sandstone	Wood River (?)/proximal clastics	10560	Yes
1655	B.T Keen ET UX #1	Hardee, FL	27° 24' 47.03" N/ 81° 59' 3.5"	cuttings	sandstone	Wood River (?)/proximal clastics	11930	No
2012-1	Humble Oil and Refining Co #1	Levy, FL	29° 4' 48.0684" N/ 82° 37' 14.1168 W	cuttings	sandstone	Wood River (?)/proximal clastics	4305- 4310	Yes
2012-2	Humble Oil and Refining Co #1	Levy, FL	29° 4' 48.0684" N/ 82° 37' 14.1168 W	cuttings	sandstone	Wood River (?)/proximal clastics	4384- 4391	Yes
3578-1	Continental Coil Company well	Highlands, FL	27° 9' 34" N/ 81° 32' 9" W	cuttings	shale	Wood River (?)/proximal clastics	12550- 12554	No
3578-2	Continental Coil Company well	Highlands, FL	27° 9' 34" N/ 81° 32' 9" W	cuttings	sandstone	Wood River (?)/proximal clastics	12600- 12614	Yes
3578-3	Continental Coil Company well	Highlands, FL	27° 9' 34" N/ 81° 32' 9" W	cuttings	sandstone	Wood River (?)/proximal clastics	12614- 12629	Yes
966-1	Carlton Est. #1	Highlands, FL	27° 9' 34" N/ 81° 32' 9" W	cuttings	sandstone	Wood River (?)/proximal clastics	12256	Yes
966-2	Carlton Est. #1	Highlands, FL	27° 9' 34" N/ 81° 32' 9" W	cuttings	sandstone	Wood River (?)/proximal clastics	12288	Yes
966-3	Carlton Est. #1	Highlands, FL	27° 9' 34" N/ 81° 32' 9" W	cuttings	sandstone	Wood River (?)/proximal clastics	12235- 12240	Yes
966-4	Carlton Est. #1	Highlands, FL	27° 9' 34" N/ 81° 32' 9" W	cuttings	sandstone	Wood River (?)/proximal clastics	12246- 12249	Yes
SGR								
442-1	Walther F Stevens #1	Sumter, GA	32° 01' 05" N/ 84° 13' 30" W	cuttings	shale	Newark	4120- 4130	No
442-2	Walther F Stevens #1	Sumter, GA	32° 01' 05" N/ 84° 13' 30" W	cuttings	shale	Newark	4440- 4450	No
108	Cecil Plate #1	Grisp, GA	31° 49' 35" N/ 83° 46' 10" W	cuttings	sandy shale	Newark	4860- 4870	No
619	H. E Walton #1	Dooly, GA	32° 02' 30" N/ 83° 39' 00" W	cuttings	sandy shale	Newark	3770- 3780	No
3137-1	Griffiths #1	Pulaski, GA	32° 19' 32" N/ 83° 32' 27" W	cuttings	shale	Newark	5630- 5640	No
3137-2	Griffiths #1	Pulaski, GA	32° 19' 32" N/ 83° 32' 27" W	cuttings	Sandy shale	Newark	5440- 5450	No

Table 4. Thin sections collected for this study.

Chapter 4: RESULTS

Florida Detrital Zircon Ages

Figure 10. Location of samples collected from Florida. Samples 778, 10566, and 15095 are from the Wood River Formation. Sample 3578 likely represents correlative facies of the Wood River Formation, or Jurassic-Cretaceous transgressive strata. Sample 2012 was collected from central Florida strata of Paleozoic or Jurassic/Cretaceous origin. ODP was collected from offshore basement. No zircons were recovered from 12696, 966, or 1411.

A map of samples collected from South Florida is displayed in Figure 10. Zircon grains were recovered from samples 15095, 778, 10566, 3578, 2012, and ODP. Samples 15095, 778, and 10566 were collected from Wood River Formation clastic deposits, initially described in Applegate et al. (1981). Lithology of sample 3578 was similar to the Wood River Formation, and is likely a continuation of the Wood River, or Upper Jurassic/Lower Cretaceous Transgressive clastic deposits. Sample 2012 is from central Florida Suwannee Basin, and is likely Paleozoic or

Triassic/Jurassic in age (Mueller, et al., 1994; Boote and Knapp, 2016).

Sample ODP was collected from the

offshore IODP hole 537, and was collected from phylite basement rocks.

Sample 15095 Triassic-Jurassic (?) Wood River

Figure 11. Sample 15095, collected from rock chips, is composed of coarse-grained sandstone and limestone.

Sample 15095 was collected from well 15095 from Collier county Florida from cuttings and core chips (16,802-16,949 feet), for a total sample mass of ~56 grams. The section consists primarily of coarse-grained red sandstone (Fig. 11).

In all, 108 zircons were analyzed; of the 108, 17

analyses were removed due to high uncertainty and/or discordance (Fig. 12). Zircon ages range from 194 +/-

4 Ma to 2,321 +/- 215 Ma. There is one main population of ages between 419 to 694 Ma (90.5% of all ages) with a peak at 486 Ma.

Figure 12. PDP (black line) and KDE (blue) from sample 15095. The X axis is age (Ma), and the Y axis is number of grains.

Sample 3578 Wood River/ Triassic-mid Cretaceous proximal sandstone?

Figure 13. Sample 3578, collected from cuttings, is composed of coarse grained sand, limestone and shale.

Sample 3578 was collected from well 3578 (permit 225) from Highlands county, Florida. The sample was collected from cuttings between 12,130-12,550 feet, yielding ~86 grams. The base of the section consists primarily of sandstone, which grades vertically into shale, and dolomite/limestone (Fig. 13).

In all, 119 zircons were analyzed.

Eleven were removed due to high uncertainty and/or discordance (Fig. 14). Ages range from 426 Ma $\pm$ 11 Ma to 2,732 $\pm$ 40.5 Ma. Most ages range from 510 to 718 Ma (92%). The major peak of this population is 580 Ma.

Figure 14. PDP (black line) and KDE (blue) from sample 3578. The X axis is age (Ma), and the Y axis is number of grains.

Sample 778 Triassic-Jurassic (?) Wood River

Sample 778 was collected from Well 12838 (permit number 778) from Collier county, Florida.

Figure 15. Sample 778, collected from cuttings, is composed of mixed anhydrite, sand, and limestone.

Sample size was ~45 grams of cuttings collected from 18,300-18,640 feet depth. The sample consists predominantly of red, medium-grained sandstone and coarse siltstone. The upper section grades upward into a limestone/dolomite (Fig. 15).

In all, 112 ages were analyzed. Three ages were removed due to high uncertainty and/or high discordance. Ages range from 201 $\pm$ 4 Ma, to

2,673 $\pm$ 16 Ma. Most ages range from 450 to 650 Ma (79 %) with a major age peak at 550 Ma, and a much smaller population ranges from 2,000-2,200 Ma (7.3%) with a peak at 2,016 Ma (Fig. 16).

Figure 16. PDP (black line) and KDE (blue) from sample 3578. The X axis is age (Ma), and the Y axis is number of grains.

Sample 15066- Triassic-Jurassic (?) Wood River

Sample 15066 was collected from well 10566 (permit number 407) from Lee county, Florida. It was sampled from cuttings from 15,547-15,660 feet from the Wood River Formation (~68

grams), which consists predominantly of red, coarse-grained sandstone and shale, which grades up into a limestone/dolomite and anhydrite (Fig. 17). In all, 46 zircons were analyzed. Three were removed for discordance and high uncertainty (Fig. 18). An age of 108 Ma with low uncertainty (± 2

Figure 17. Sample 10566, collected from cuttings, is composed mainly of coarse grained shale, sandstone, and limestone.

Ma) was considered questionable based on its young age and the age of the Wood River formation, but uncertainty was low. One major age populations range from 494 to 673 Ma (79%), with two peaks at

538 Ma and 588 Ma. Ages range from 227 $\pm$ 4 to 2,266 $\pm$ 18 Ma.

Figure 18. PDP (black line) and KDE (blue) from sample 10566. The X axis is age (Ma) and the Y axis is the number of grains.

Sample 2012- Triassic – Cretaceous (?)/Paleozoic Clastic deposits

Figure 19. Sample 2012, collected from cuttings, is composed mainly of coarse grained shale and sandstone.

Sample 2012 was collected from Well 2012, Permit Number 105 from Levy county Florida within the Suwannee Basin. The sample was collected from cuttings from 4,230-4,370 feet for a total of ~120 grams. The cuttings consist primarily of coarse-grained sandstone and siltstone (Fig. 19).

In all, 106 grains were analyzed from Sample 2012. Two grains were eliminated due to high discordance. The distribution shows two age populations. The largest ranges from 465-718 Ma (52%), with peaks at 310 Ma and 544 Ma. A smaller population ranges from 2,000-2,306 Ma (17%) and shows a peak at 2,132 Ma.

Figure 20. PDP (black line) and KDE (blue) from sample 2012. The X axis is age (Ma), and the Y axis is number of grains.

Sample ODP- Offshore south Florida phyllite.

ODP was collected from ODP Expedition 77, site 0537, core 16, interval 54.57-57 (Fig. 21). Core interpretations were presented in the Deep Sea Drilling Initial Reports Volume 77 (Buffler et al., 1984). The sample was collected from around 210.5 meters below the seafloor on a small knoll north of the Campeche Escarpment. The knoll is interpreted as an uplifted tilted fault block, based on seismic interpretation. The core penetrates through a thick succession of nanofossil ooze (Pliocene to Aptian), a Cretaceous oolitic limestone (Valanginian-Berriasian), Dolomite and arkosic sandstone (Berriasian), nonmarine (?) arkosic sandstone (Berriasian) and phyllite (Cambrian). A sample from the Cretaceous arkosic sandstone section was collected, but no zircons were recovered. The arkosic

Figure 21. Sample collected from interval 22-24.5, composed of phyllite. Core photo provided from ODP online database.

sandstone deposits are interpreted as a transgressive sequence that grades from clastic alluvial sandstones to nearshore marine sandstones, to dolomite. The sandstone overlies pre-Mesozoic crystalline basin, which consists of foliated, metamorphic phyllite (Fig. 22). Zircon grains were recovered from the metamorphic phyllite section.

In all, 99 grains were analyzed. One age was eliminated for discordance. All ages range from 473 +/- 14 Ma to 756 +/- 23 Ma (Fig. 22) and form one peak at ~590 Ma.

Figure 22. PDP (black line) and KDE (blue) for sample ODP. The x axis is age (Ma) and the Y axis is number of grains.

South Florida Detrital Zircon Composite

A composite PDP plot of only detrital zircon ages from South Florida sedimentary samples shows two main age populations (Fig. 23). A ~400-700 Ma (81% of sample) population with a prominent peak at 605 Ma, and a smaller 2,000-2,200 Ma population (6.8% of sample) with a peak around 2,080 Ma. A plot comparing distributions of individual South Florida samples shows the samples all share one predominant age population between 580-610 Ma for all samples (Fig. 24; Fig. 25). Common age peaks were identified if they were present in four or more samples. Populations common to multiple South Florida samples include 180-450 Ma, 500-620 Ma, 630-900 Ma, 1,900-2,300 Ma (Fig. 26).

Figure 23. Cumulative PDP and KDE for the SFB (excluding sample ODP). The X axis is age (Ma), and the Y axis is number of grains. The two predominant peaks are 605 Ma and 2080 Ma.

Figure 24. Normalized Probability Plot for all samples in South Florida, from north to south. Largest populations range from ~580 -610 Ma for all samples.

Figure 25. All age peaks for the SFB samples. Boxes correspond to major age populations. Major populations are 240-450 Ma, 500-650 Ma, 700-900 Ma and 2000-2300 Ma.

Major Age Groupings

Major Age Groups (South Florida)	Sample
250-450 Ma	15095 (0 zircons, 0%), 3578 (1 zircon, 0.9%), 10566 (2 zircons, 4.5%), 778 (4 zircons, 3.6%), 2012 (7 zircons, 8.0%), ODP (0 zircons, 0%)
500-650 Ma	15095 (72 zircons, 81.8%), 3578 (89 zircons, 80.1%), 10566 (32 zircons, 72.8%), 778 (80 zircons, 71.4%), 2012 (47 zircons, 53.4%), ODP (82 zircons, 77.6%)
700-900 Ma	15095 (0 zircons, 0%), 3578 (4 zircons, 3.6%), 10566 (0 zircons, 0%), 778 (6 zircons, 5.4%), 2012 (2 zircons, 2.2%), ODP (1 zircon, 1.02%)
2000-2300 Ma	15095 (1 zircon, 1.1%), 3578 (6 zircons, 5.4%), 10566 (3 zircons, 6.8%), 778 (8 zircons, 7.1%), 2012 (16 zircons, 18.2%), ODP (0 zircons, 0%)

Table 5. Table of major age groups within the SFB samples, and their relative proportions.

Evaluation of U/Th ratios in South Florida zircon reveals two age populations of metamorphic zircon were present in all samples: 400-800 Ma, and 1900-2300 Ma (Fig. 26). The percentage of these populations represented in each sample are listed in Figure 27 and Table 6. A population of 400-800 Ma metamorphic zircon is the most abundant within the SFB. Metamorphic zircon make up 28% of sample 3578, and >10% of samples 15095, 10566, 778, and 2012. A less abundant population of 1900-2300 Ma zircon grains form up to 6.9% of a single sample (sample 2012).

Figure 26. Ages and U/Th ratios for detrital zircon of the South Florida samples. Metamorphic zircons were identified based on a U/Th ratio greater than 5.

Figure 27. Major age peaks for metamorphic detrital zircon in the SFB (blue boxes). Two groupings are present between 400-800 Ma and 1900-2300 Ma.

Metamorphic Zircons

Age Group Metamorphic Zircons (South Florida)	Sample
400-800 Ma	15095 (14 zircons, 15.9%), 3578 (31 zircons, 28%) 10566 (5 zircons, 11.4%), 778 (13 zircons, 12%), 2012 (4 zircons, 10.2%) ODP (4 zircons, 4.0%)
1900-2300 Ma	15095 (0 zircons, 0%), 3578 (2 zircons, 1.8%), 10566 (1 zircons, 2.2%), 778 (2 zircons, 1.8%), 2012 (5 zircons, (6.9%), ODP (0 zircons, 0%)

Table 6. Major metamorphic zircon age groupings identified in the SFB. Major age groups present are 400-800 Ma and 1900-2300 Ma.

South Georgia Rift Detrital Zircon Ages

A map of samples collected from Southern Georgia is displayed in Figure 28. Samples

collected for detrital zircon analysis from the South Georgia rift include samples 442, 619, 108, 3137, and 3113. Sample 1854 was collected from the Florida Geological Survey from the Tallahassee Graben, which is likely an extension of the South Georgia Rift.

Figure 28. Location of the Newark deposits (green) sampled in this study. Other samples localities are Norphlet samples (blue) from Lovell (2010) and Lisi (2013).

Sample 108- South Georgia Rift Newark Group

Sample 108 was collected from well GGS number 108, Crisp county, Georgia from

4820-5010 feet from drill cuttings for a total sample mass of ~340 grams. The lithology consists primarily of coarse-grained sandstone (Fig. 29).

In all, 121 zircons were dated for this study. Twenty two ages were eliminated that had high uncertainty and/or high discordance. Ages range from 323 +/- 7 Ma to 1655

+/- 35 Ma (Fig. 30). Age populations are

307 to 376 Ma (24%), 384 to 507 Ma (40%),

530 to 590 Ma (7.5%), 630 to 680 Ma (6.5%), and 900 Ma to 1400 Ma (26%). Major peak within these populations occur at are 329 Ma, 440 Ma, 554 Ma, 667 Ma, 1110 Ma, and 1640 Ma.

Figure 30. PDP (black line) and KDE (blue) from sample 108. The X axis is age (Ma), and the Y axis is number of grains. A: Detrital zircons from 0 to 3000 Ma. B: Detrital zircons from 0 to 800 Ma. C: Detrital zircons from 800 to 3000 Ma.

Sample 3113- South Georgia Rift Newark Group

Sample 3113 was collected from well GGS number 3113, Lowndes county, Georgia. The

Figure 31. Sample 3113, collected from cuttings and composed mainly of quartz, shale.

sample was collected from 8130-8510 feet from cuttings yielding a sample mass of ~420 grams. Lithology varies from medium-grained sandstone to red and black shale (Fig. 31).

In all, 98 zircons were analyzed, of which 4 were removed due to discordance.

Ages range from 291 $\pm$ 3 Ma to 2653 $\pm$ 17 Ma (Fig. 32). Age populations include 290 to 450 Ma (40.4%), 560 to 741 Ma (30.9%), 989 to 1296 Ma (10.6%), and 2006 to 2158 Ma (8.5%). Peak ages are 290 Ma, 339 Ma, 444 Ma, 600 Ma, and 656 Ma.

Figure 32. PDP (black line) and KDE (blue) from sample 3113. The X axis is age (Ma), and the Y axis is number of grains. A: Detrital zircons from 0 to 3000 Ma. B: Detrital zircons from 0 to 800 Ma. C: Detrital zircons from 800 to 3000 Ma.

Sample 619- South Georgia Rift Newark Group

Figure 33. Sample 619. Collected from cuttings, and composed mainly of barite, quartz, shale and sandstone.

Sample 619 was sampled from well GGS

number 619, Dooley county, Georgia. The sample was collected from 3,510-3,750 feet depth from cuttings for a total sample mass of ~330 grams. Lithology is composed almost entirely of quartz sandstone (Fig. 33).

In total, 90 zircons were analyzed during this

study. Five were not included due to high

uncertainty and/or discordance. Ages range from

250 +/- 7 to 2394 +/- 17 Ma (Fig. 34). Major age populations include 310 to 421 Ma (34.1%), 456 to 503 Ma (14.1%), 550 to 670 Ma (13.0%, and 900 to 11370 Ma (25.9%). Age peaks are 322 Ma, 372 Ma, 406 Ma, 487 Ma, 592 Ma, and 1058 Ma.

Figure 34. PDP (black line) and KDE (blue). The X axis is age (Ma), and the Y axis is number of grains. A: Detrital zircons from 0 to 3000 Ma. B: Detrital zircons from 0 to 800 Ma. C: Detrital zircons from 800 to 3000 Ma.

Sample 3137- South Georgia Rift Newark Group

Sample 3137 was sampled from Pulaski county, Georgia. Sample was collected from 5320-5827 feet from cutting totaling ~400 grams. Lithology consists mostly of interbedded, medium-grained sandstone, siltstone, and shale (Fig. 35). Diabase intrusions were also common, but were not sampled in this study.

Figure 35. Sample 3137 Sample was collected from cuttings, and consists mainly of red sandstone and shale, as well as barite.

In total, 98 zircons were dated.

Four were removed for high uncertainty and/or discordance. Age ranges from 294 +/- 6 to 3470 +/- 90 Ma (Fig. 36). Major age populations include 290 to 340 Ma (17%), 370 to 440 Ma (26.6%), 490 to 640 Ma (20%), 870 to 940 Ma (5.3%), and 1000 to 1400 Ma (11.8%). Age peaks at 320 Ma, 442 Ma, 533 Ma, 632 Ma, 902 Ma, and 1044 Ma.

Figure 36. PDP (black line) and KDE (blue) from sample 3137. The X axis is age (Ma), and the Y axis is number of grains. A: Detrital zircons from 0 to 3000 Ma. B: Detrital zircons from 0 to 800 Ma. C: Detrital zircons from 800 to 3000 Ma.

Sample 442-South Georgia Rift Newark Group

Sample 442 was collected from well GGS number 442, Sumter country, Georgia. Sample

was collected from 3980-4520 feet from cuttings and totaled ~500 grams. Lithology consists mainly of coarse-grained red shale and coarse grained sandstone (Fig. 37).

Figure 37. Sample 442. Sample was collected from cuttings/rock chips, and consists mainly of coarse grained sandstone and shale.

In total, 105 zircons were analyzed for this study.

Twelve were removed due to high uncertainty and/or

discordance. Ages range from 279 +/- 6 to 2934

+/- 28 Ma (Fig. 38). Major age clusters include

248-300 Ma (8.6%), 310 to 340 Ma (13.9%), 380 to 450 Ma (31.2%), and 598 to 750 Ma

(21.5%). Age peaks are observed at 248 Ma, 345 Ma, 430 Ma, 549 Ma, 633 Ma, and 671 Ma.

Figure 38. PDP (black line) and KDE (blue) from sample 442. The X axis is age (Ma), and the Y axis is number of grains A: Detrital zircons from 0 to 3000 Ma. B: Detrital zircons from 0 to 800 Ma. C: Detrital zircons from 800 to 3000 Ma.

Sample 1854- Tallahassee Graben Rift Newark (?) rift clastics

Sample 1854 was collected from the well 1854 (permit number 95) from Jefferson

county, Florida. Sample was collected from 7280-7610 feet from cuttings and amassed ~68 grams. Lithology consists mainly of interbedded red fine-grained (?) sandstone and shale (Fig. 39).

Ninety four zircons were analyzed. One zircon was excluded due to high uncertainty. Ages range from

197 +/- 3 to 3295 +/- 28 Ma (Fig. 40).

Figure 39. Sample 1854. Sample was collected from cuttings/rock chips, and consists of coarse grained sandstone and shale.

Major age populations include 390 Ma to

440 Ma (7.5%) 490 Ma to 650 Ma, 955 to 1061 Ma (45%) 1000 Ma to 1240 Ma (18%) and 2000 Ma to 2270 Ma (8.6%; Fig.40) Major age peaks include 424 Ma, 566 Ma, 596 Ma, 1024 Ma, and 1161 Ma.

Figure 40. PDP (black line) and KDE (blue) from sample 1854. The X axis is age (Ma), and the Y axis is number of grains A: Detrital zircons from 0 to 3000 Ma. B: Detrital zircons from 0 to 800 Ma. C: Detrital zircons from 800 to 3000 Ma.

South Georgia Rift Composite

A composite probability density plot of detrital zircon ages from all SGR samples shows three major populations are present. Comparison of individual sample normalized probability plots show these ages form populations in all SGR detrital zircon age signatures: 300 to 480 Ma (41.3%), 500 to 672 Ma (24.9%), and 1300 to 1500 Ma (17.0%; Figures 41 and 42). Major age peaks are listed in Figure 43 and Table 7. Samples 3137, 1854, 619, 108, and 442 have large peaks between 200-500 Ma, ranging from 13.3% to 62.9% for all samples. Samples 442, 3137, 619, and 108 all have a large population from 525 -725 Ma that makes up 12.8% to 33.0% of each sample. Samples 1854, 3137, 619, 108 all have populations between 750-1100 Ma that make up 6.7-20.9% of all samples.

Figure 41. Cumulative PDP (black line) and KDE (blue) for all SGR samples. Major peaks include 297 to 480 Ma, 509 Ma 672 Ma, and 982 to 1184 Ma.

Figure 42. Normalized Probability Plot for the SGR.

Figure 43. Major Age peaks for the SGR. Major age groups of peaks include 200-500 Ma, 525-725 Ma, 750-1100 Ma, 1200-1500 Ma, and 2275-2600 Ma.

Age Groupings (South Georgia)

Major Age Groupings (South Georgia)	Sample
200-500 Ma	108 (66 zircons, 62.9%), 3113 (39 zircons, 41.5%), 619 (47 grains, 54.7%), 3137 (54 zircons, 57.4%), 442 (51 zircons, 54.8%), 1854 (12 zircons, 13.3%)
525-725 Ma	108 (14 zircons, 13.3%), 3113 (31 zircons, 33.0%), 619 (11 grains, 12.8%), 3137 (14 zircons, 14.9%), 442 (24 zircons, 25.8%), 1854 (37 zircons, 41.4%)
750-1100 Ma	108 (7 zircons, 6.7%), 3113 (7 zircons, 7.4%), 619 (18 zircons, 20.9%), 3137 (13 zircons, 13.8%), 442 (5 zircons, 5.4%), 1854 (7 zircons, 7.8%)
1200-1550 Ma	108 (6 zircons, 5.7%), 3113 (3 zircons, 3.2%), 619 (4 zircons, 4.7%), 3137 (3 zircons, 3.2%), 442 (3 zircons, 3.2%), 1854 (6 zircons, 6.7%)
2275-2600 Ma	108 (0 zircons, 0%), 3113 (1 zircon, 1.1%), 619 (1 zircon, 1.2%), 3137 (1 zircon, 1.06%), 442 (1 zircon, 1.1%), 1854 (1 zircon, 1.1%)

Table 7. Major age groupings for the South Georgia Rift.

Metamorphic zircon age populations were identified for the SGR samples based on a U/Th ratio greater than 5 (Fig. 44). Two age populations of metamorphic zircons were identified and are evident in all samples (Fig. 45; Table 8). Metamorphic zircon groupings range from 200-600 Ma, and 900-1450 Ma. The percent of metamorphic zircons per sample ranges from 10.6% in sample 3113 to 35% in sample 108.

Maximum Depositional Age

The maximum depositional age for each sample is listed in Table 9. Maximum depositional age is based on the youngest grain from each sample (Dickinson and Gehrels, 2009). Typically, the maximum depositional age is based on the age of the youngest peak. Mesozoic zircon are very rare in these samples, so the youngest grain present was used to to determine max age instead. Maximum depositional ages for South Florida Basin range from 195-426 Ma and from 197-235 Ma for the South Georgia basin. Maximum depositional ages in south Florida are consistent with ages reported for igneous intrusions in Florida, indicating that the Wood River Formation was likely deposited no later than 195-235 Ma. Maximum depositional ages for the South Georgia Rift are not considered indicative of depositional age, as only one grain was younger then 190 Ma, and the rest were greater than 300 Ma. This is considerably older than the expected age of syn-rift deposition. Mesozoic magmatic activity likely did not contribute to the deposition in the South Georgia Rift during deposition of the Newark Supergroup, suggesting magmatic activity postdated deposition.

Table 44. Metamorphic zircons for the SGR. Metamorphic zircons were identified based on a U/Th ratio greater than 5.

Figure 45. Major metamorphic peaks for the SGR. Major groupings are between 200-600 Ma, and 900-1400 Ma.

Age Group Metamorphic Zircons (South Georgia)	Sample
200-600 Ma	108 (30 zircons, 28.6%), 3113 (7 zircons, 7.5%), 619 (12 zircons, 14.0%), 3137 (15 zircons, 16.0%), 442 (10 zircons, 10.8%), 1854 (7 zircons, 7.8%)
900-1400 Ma	108 (7 zircons, 6.7%), 3113 (3 zircons, 3.1%), 619 (4 zircons, 4.7%), 3137 (10 zircons, 10.7%), 442 (2 zircon (1 zircon, 1.1%), 1854 (8.9%)

Table 8. Major metamorphic zircon age groupings identified in the SFB. Major age groups present are 200-600 Ma, and 900-1400 Ma.

Age Group Metamorphic Zircons (South Georgia)

SFB								SGR					
#	ODP	2012	778	10566	3578	15095		1854	442	3137	619	3113	108
Youngest grain (Ma)	473	234	201	112, 240	426	195		197	279	294	250	291	323

Table 9: Maximum Depositional Age for basal clastics in the SFB and SGR.

Correlation between Basins

Comparison of normalized probability density plots for all samples included in this study reveal major age groupings include 300 to 500 Ma in all of the SGR samples, as well as small peaks in 2012, 778, and 10566 of South Forlida (Fig. 46). Another common cluster is 500 to 700 Ma, which is present in all of the SFB samples, and peaks in samples 3113, 619, and 1854 from the SGR. SGR samples contain diverse age distributions, while samples from SFB typically show only one cluster of ages from 500 to 700 Ma. Cumulative density plots (CDP) were constructed to compare major age probabilities between samples. The greater the similarity between the curves, the more likely it is that those samples share a source.

A CDP plot for the SFB is displayed in Figure 47. For the majority of samples, 90% of the grains are younger than ~700 Ma, aside from sample 2012. A CDP for the SGR is displayed in Figure 48. Major probability differences are noticeable around 500, 900, and 2000 Ma. Sample 1854 has significantly less grains around 500 and 900 Ma than the rest of the samples.

Figure 46. Normalized Probability Plot for the SGR and SFB.

A CDP plot for the SFB is displayed in Figure 47. For the majority of samples, 90% of the grains are younger than ~700 Ma, aside from sample 2012. A CDP for the SGR is displayed in Figure 48. Major probability differences are noticeable around 500, 900, and 2000 Ma. Sample 1854 has significantly less grains around 500 and 900 Ma than the rest of the samples.

Figure 47. Cumulative density plot for SFB samples. 90% of the samples are younger than ~700 Ma, aside from sample 2012.

Figure 48. Cumulative density plot for the SGR. The largest differences are the abundances of the 500-600 Ma, 900 Ma, and 1500-2200 Ma age populations.

The Kolmogorov-Smirnoff test (i.e., K-S test) is used to identify if two populations share a similar source based on population distribution. The test is based on the CDP plots constructed in Figure 46, 47, and 48. The K-S test calculates the probability difference between two samples (D_{obs}) and generates a probability (P) value that reflects the probability that the samples came from the same source. If P is low, then the two samples being compared likely did not come from the same source. For the purpose of this study, a cut off P value of 0.05 is used. If the P value is higher than .05, then there is 95% confidence that the samples are statistically similar. The D_{obs} and P value can be highly dependent on the number of grains sampled, especially for samples with a diversity of ages; number of ages acquired for each sample should be roughly the same in order for the K-S test to be accurate.

The K-S test results for the SGR samples and SFB samples is displayed in Table 10. Within the SGR, samples are fairly statistically similar, aside from samples 3113 and 1854. Sample 3113 is statistically likely to be derived from a different source than the most other SGR samples, but shares similarities with samples 619 and likely 442. Sample 1854 is statistically different from all samples in the SGR, implying it does not share a similar source. Sample 619 and 442 are statistically similar to all of the samples, implying they share a source. Samples 108 and 3137 also are similar to all samples, aside from 3113 and 3137 respectively.

Samples from the SFB are not as statistically similar to each other, aside from sample 10566. Sample 10566 is statistically similar to all samples except 3578. Sample 778 is similar to all samples, except 3578. Sample 15095 is statistically similar to all populations except for 3578 and 2012. With the exception of 2012 and 3578, zircon ages from sample ODP is similar to all other SFB samples, suggesting these rocks or similar rocks supplied sediment to the SFB. Sample 2012 is different from all samples, aside from 778 and 10566. Sample 3578 is

statistically different from other samples in the basin. Based on the K-S test, samples from SFB and SGR are not statistically similar, aside from sample 2012 and 1854.

K-S Test South Florida Basin and South Georgia Rift

K-S P-values using error in the CDF												
	108	3113	619	3137	442	1854	10566	3578	ODP 77	778	2012	15095
108		0.002	0.443	0.805	0.543	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3113	0.002		0.290	0.013	0.074	0.003	0.023	0.000	0.000	0.000	0.003	0.000
619	0.443	0.290		0.846	0.192	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3137	0.805	0.013	0.846		0.882	0.000	0.000	0.000	0.000	0.000	0.000	0.000
442	0.543	0.074	0.192	0.882		0.000	0.000	0.000	0.000	0.000	0.000	0.000
1854	0.000	0.003	0.000	0.000	0.000		0.011	0.001	0.000	0.000	0.393	0.000
10566	0.000	0.023	0.000	0.000	0.000	0.011		0.030	0.396	0.447	0.270	0.597
3578	0.000	0.000	0.000	0.000	0.000	0.001	0.030		0.000	0.000	0.001	0.000
ODP 77	0.000	0.000	0.000	0.000	0.000	0.000	0.396	0.000		0.273	0.001	0.980
778	0.000	0.000	0.000	0.000	0.000	0.000	0.447	0.000	0.273		0.082	0.146
2012	0.000	0.003	0.000	0.000	0.000	0.393	0.270	0.001	0.001	0.082		0.007
15095	0.000	0.000	0.000	0.000	0.000	0.000	0.597	0.000	0.980	0.146	0.007	

Table 10. K-S test for the SGR and SFB. A P value above .05 is considered statistically similar. SGR samples (108, 3113, 619, 3137, 442, and 1854) are overall statistically different than samples from the SFB (10566, 3578, ODP, 778, 2012, and 15095).

Thin Sections: South Florida

The table of thin section data from southern Florida is displayed in Table 4. Sample descriptions are provided below. Coarse-grained samples were point counted and described using the Folk (1980) classification scheme (Figure 49).

ODP

Although no zircons were obtained from the clastic interval of the IODP wells 0537 and 0538, two thin-sections were made. No thin-sections were made for the basement section due to the small sample size, and to increase the chances of getting a usable number of zircons for dating.

Sample 1 was collected from ODP Site 0537 from Core 13R, section 1, and interval 95-110 (Figure 50). It is interpreted as arkosic conglomeratic sandstone with calcite cement. Grains consist primarily of quartz and perthite fragments. Quartz grains are large (up to 1 mm), and well rounded. Inclusions are present in several quartz grains. Calcite cements are sparry with a second phase of blocky calcite cement.

Sample 2 was collected from ODP site 77 hole 0538A, 034R, 01W, interval 54.57-57 (Figure 50). It is interpreted as mudstone from Deep Sea Drilling report (Dallmeyer, 1984). It consists of fine-grained mudstone with plagioclase, biotite, chlorite clays, and opaque minerals. Quartz veins are common, and occur at three different angles. En echelon fractures may be present. Ribbons of quartz are interpreted as interstitial quartz, which formed during low grade metamorphism (Buffler et al., 1984).

South Florida Basin Clastics

Overall, SFB samples are 50-100% quartz, 5-50% feldspar, and typically less than 5% lithics, except for sample 1411. Samples plot in the quartz arenite, subarkose region on a ternary diagram. Samples consist primarily of angular-subrounded monocrystalline quartz fragments. Feldspar fragments are predominantly plagioclase, and twinning is common (Figure 52). Minor twinned feldspar and orthoclase/microcline is also present. Lithic fragments are extremely uncommon, although some igneous fragments are present. Perthite is common in sample 1411,

and present in samples 10566 (Figure 53). Perthite is composed of a plagioclase core, with a mixed plagioclase/orthoclase rim. Grain-size is fairly unimodal ~.4 mm, and ranges from .2-.5 mm. Samples are typically sub-angular to angular (Figure 52). Porosity is highest in sample 1411 (>20%), but typically ranges from 5%-10%. Compacted quartz is present, as well as overgrowth quartz cement. There is some secondary feldspar due to feldspar dissolution. Sedimentary structures cannot be recognized from the cuttings alone.

Other samples from wells 1655, 778, and 3578 are composed mainly of mudstone, and were not point-counted. Cutting samples were also not point-counted. These samples were very fine-grained mudstone. Muscovite fragments are common in shale fragments in fine-grained samples (3578). Sample 1655 cuttings consist of mixed shale and limestone clasts. Carbonate clasts consist of calcite cement with ooid fragments.

South Georgia Rift

The table of thin-sections from the South Georgia Rift is displayed in Table 2. All samples from the South Georgia Rift collected were too fine-grained for point counting, but observations were recorded on grain-size and composition. The majority of the samples are composed of muscovite and feldspar fragments. Sample 442 and 3137 is composed primarily of quartz, as well as secondary muscovite and feldspar (Figure 54). Beds are fairly well laminated, with alternating layers of mud and small quartz fragments. Quartz grains range from 0.05-0.1 mm (Figure 54), and are very angular. The grain-size of quartz increases from layer to layer and although the up direction is not known, the sequence likely represents a coarsening or fining upward sequence (442-1). Fossils include bivalves, and chambered gastropods present in sample 442. Calcite fragments are present in some samples, and calcite fracture-fill is also present in sample 619. Opaque minerals, micas, and feldspars are present in sample 3137 (Figure 54).

South Florida

Figure 49. QFL plot of the Wood River and proximal clastics in the SFB. Samples fall predominantly in the subarkose range, although sample 12542 is lithic arkose.

Figure 50. Thin sections. Thin sections from core. A: ODP-1. Folded quartz veins in mudstone. B: ODP-1. Calcite veins showing two directions of growth. C: ODP-2. Quartz grain with inclusions. D: ODP-2. Calcite veins showing two stage growth: First episode of micritic calcite, second stage blocky. E: ODP-2. Perthite fragment surrounded by blocky calcite cement F: ODP-2. Perthite fragment surrounded by calcite cement.

Figure 51. Thin sections. A: 10566 (from cuttings). Detrital quartz fragments. B: 10566. Quartz and feldspar (?) fragments. Well sorted, low porosity. C: 10566. Microcline surrounded by quartz. D: 778 (from cuttings). Detrital quartz fragments. E: 778. Detrital quartz and feldspar (?). F: 778. Detrital quartz and microcline.

Figure 52. Thin sections. A: 12542 (from cuttings). Mix of feldspar (stained red) and detrital quartz fragments. B: 12542. Perthite with two stages of growth: plagioclase inner core, with mixed plagioclase/orthoclase outer rim. C: 12542: Perthite fragment with mixed plagioclase and orthoclase. D: 3578-1 (from sidewall core). Siltstone lithic fragment. E: 3578-1: Metamorphic fragment of quartzite (?) surrounded by quartz grains. F: 3578-1. Rounded quartz grain with vacuole and quartz overgrowth cement.

Figure 53. Thin sections. A: 442-1 (from cuttings). Shale with layers of fine-medium grain quartz that appear to coarsen up or down (up direction unknown). B: 442-2. Detrital quartz fragments with shell fragments. C: 108 (from cuttings). Quartz (?) fragment in fine grained shale. D: 619. Calcite (?) veins in fine grained shale. E: 3137 (from cuttings). Volcaniclastic quartz, feldspars, and micas, as well as opaques. F: 3137. Calcite cement.

Log Analysis

Figure 54. Electronic log from the type well 778. Clastic and basement tops are picked. Above the clastic surface is a transition to the limestone/dolomite interval of the Wood River.

Fifteen wells that tag clastics and/or basement from the South Florida Basin were evaluated to identify the depth and thickness of the basal clastic deposits. Logs were downloaded from the Florida Occulus portal, and logs were digitized in Petra. Few wells are present in South Florida, and only a handful tag the basal section and/or basement, making correlation difficult. Log signatures for the type well for the Wood River Formation is displayed in Figure 54. Tops were picked based on drillers log picks, mud logs, SP, Gamma, Neutron/Density Porosity, and Resistivity.

Lithologies were identified for the basal shale, basal sandstone and overlying

carbonate/dolomite. The basal shale typically at the bottom of the Wood River Formation is identified based on high SP and gamma ray signatures (100-150). Basal shale facies generally rest on basement of varying lithologies. The basal shale typically coarsens upward into a sandstone.

The basal section of the Wood River Formation contains a basal sandstone unit. Sandstone facies were identified based on low gamma and SP log signatures. Serrations in the SP and gamma ray curve indicate immature sandstone composition. Some curve signatures indicate large-scale fining and coarsening-upward sequences. Bell shaped curves are also present, as the facies shifts upward from shale, to sandstone, to dolomite.

The majority of the Wood River Formation consists of thick Dolomite with interbedded limestone layers, which is present in all wells. The base of the dolomite/limestone facies grades from a basal sandstone/shale to a dolomite, marked by a gradual increase in the SP and resistivity curves. Limestone and dolomite were difficult to identify from gamma ray logs but typically have a higher SP and resistivity values than sandstone with decreased porosity. Anhydrite layers are also common, which were identified based on a sharp spike in the SP and the resistivity.

Based on the picked tops, a depth to the clastic rock interval of the Wood Formation surface was constructed (Figure 56). A depth to basement map was not considered reliable, as very few wells penetrate into basement. The depth to the surface increases towards the south, indicating the SFB is likely deepest in the southern tip of Florida. An isochore map was constructed for the few wells that penetrate the entire section (Figure 57). Thickness appears to increase towards the northern part of the basin, but complete penetration through the Wood River is poor. V-shale was calculated for the samples to identify changes in lithology (Figure 58).

Figure 55. Map of the top of clastic surface in the SFB. The depth of the surface increases toward the south.

Figure 56. Isochore map calculated for the basal clastic succession. Clastic succession thickens toward the north.

Chapter 5: Discussion

Potential Source Terranes

Locations of potential source terranes of North America are displayed in Figure 58 and zircon forming tectonic events are listed in Table 11, and are discussed below.

Tectonic Terranes of North America

Figure 58. Terrane map of North America. Modified from Dickinson and Gehrels (2009).

Potential Sources for the SFB and SGR

Age (Ma)	Potential Sources	Sources
150-250	Pangea Rifting	Mueller et al. (1994); Heatherington et al. (1999); Applegate et al. (1981); Hames et al. (2000)
265-330	Alleghenian	Miller et al. (2006); Heatherington et al. (2010); Schwartz et al. (2011)
350-420	Acadian Orogeny	Miller et al. (2000); Sinha et al. (2012)
430-490	Taconic Orogeny & Cherokee orogeny	Miller et al. (2000)., Moecher et al. (2004)., Sinha et al. (2012)
525-680	Gondwanan (Pan-African and Brasiliano)	Dallmeyer and Villeneuve, (1987); Dallmeyer, (1989), Delor et al. (2002)
430-460, 525-680, 700, 900-1300, 1900-2200	Peri-Gondwanan Terranes	Bream et al. (2004); Carter et al., (2006); Merschhat and Hatcher, (2007); Hatcher, (2010); Merschhat et al. (2010); Steltenpohl, (2010)
700-760	Mount Roger	Goldberg et al. (1986); Fetter and Goldberg, (1995); Aleinikoff et al. (1995)
900-1300	Grenville	Rivers, (2008); Park et al. (2010)
1900-2200	Trans-Amazonian/Eburnean	Mueller et al. (2014)

Table 11. Potential sources and associated zircon ages that may have sourced the SFB and SGR.

Laurentia and associated sources

Grenville orogen: The Grenville orogen is present throughout the eastern United States, west of the Appalachians and east of the Superior Province (Figure 58). It extends into South America south of the Amazonian Craton where it is referred to as the Sunsas Belt (Tohver et al., 2016). The Grenville orogen formed during the collision of the Amazonia continent with Laurentia and the assembly of Rodinia between 900-1300 Ma (Keppie and Ortega-Gutierrez, 1999). The Grenville is divided into three units by Rivers et al. (1989), including the Parautochthonous Belt, which consists of deformed Superior Province foreland basin strata and was metamorphosed around 980-1700 Ma, an Allochthonous Polycyclic Belt, with thrusting around (1050 M) and an older Allochthonous Monocyclic Belt with rocks younger than 1350 Ma (Rivers et al., 1989; McLelland et al., 2010).

A fragment of the eastern Laurentian margin composed of Grenville crustal rocks and overlying strata were involved in younger orogenic events and ultimately formed the Blue Ridge.

The Blue Ridge was uplifted during the Alleghanian orogeny when Gondwana collided with Laurentia (Merschat et al., 2010). The Blue Ridge extends from northern Alabama/Georgia to central Maryland. The Blue

Ridge is composed

predominantly of granites,

limestones, and metamorphosed

volcanic and sedimentary

metasedimentary rocks, as well as

Paleozoic felsic and mafic

volcanic rocks (Hatcher et al.,

1989; Merschat et al., 2010).

Several terranes compose the

Blue Ridge including the

Tugaloo, Cartoogechaya,

Cowrock and Cat Square (Fig. 59; Hatcher et al., 2007). These terranes consist primarily of

metamorphosed sandstone, schist, gneiss and quartzite along with Neoproterozoic to Cambrian

volcanic rocks that formed during the breakup of Rodinia (700-760 Ma; Hatcher et al., 2005;

Burton and Southworth, 2010). Zircon ages in Blue Ridge units are dominated by 1100 Ma

zircons, as well as smaller abundances of 2900 Ma, 2700 Ma, 1900-2200 Ma, 1300-1500 Ma,

1100 Ma, and 600-700 Ma zircon ages (Merschat et al., 2010; Hatcher, 2010). The southernmost

Map of Sample Locations and Triassic Basins of the Eastern United States

Figure 59. Potential Tectonic Peri-Gondwanan Terranes along the eastern margin of Laurentia. From Bowman and Weislogel. (2015).

known exposure of Grenville associated rocks is found in the Pine Mountain window. The Pine Mountain window is located in north-central Georgia, and is bound by the Charleston Terrane/Carolina Superterrane to the north and the Suwannee Terrane to the south (Fig. 59; Steltenpohl et al., 2010). The rocks exposed in the Pine Mountain window are interpreted to consist primarily of Grenville (1100 Ma) aged gneiss, and granite charnockites (Odom and Fullagar, 1973; Odom et al., 1984; Steltenpohl et al., 2010).

Rodinia Rifting: Evidence of Neoproterozoic rifting of Rodinia consists of a series of dike swarms present throughout the middle and eastern United States (Burton and Southworth, 2010). Dike swarm ages range from 700-760 Ma (Goldberg et al., 1986; Fetter and Goldberg, 1995; Aleinikoff et al., 1995; Ownby et al., 2004; Burton and Southworth, 2010). Zircon crystals formed from this rifting event are found as detrital grains reworked in early Paleozoic rocks contained in the eastern Blue Ridge.

Taconic Orogen: The Taconic orogen formed by subduction and volcanic arc development along the Laurentian margin between 430 and 490 Ma (Miller et al., 2000; Moecher et al., 2004; Sinha et al., 2012; Hatcher, 2010). The Taconic orogen extends in to the southern Appalachians, mainly represented by granitoid plutons of the Eastern Blue Ridge that contain 460 Ma zircon (Miller et al., 2006; Hatcher et al., 2007). A few Ordovician plutons (430 to 465 Ma) that intrude into Taconic structures have been identified throughout northern Georgia and South Carolina (Wilson et al., 2001; Miller et al., 2006).

Acadian Orogeny: Plutonism and structure associated with the Acadian orogeny is not prevalent in the southern Appalachians aside from a suite of plutonic rocks in the Carolina Terrane, which have been dated between 415-421 Ma (Samson and Secor, 2000; Hatcher et al., 2005; Hibbard et al., 2010). Along the eastern margin of US, Acadian subduction-related

plutonism occurred between 350-420 Ma; these Acadian plutons are common in the central and northern Appalachian regions, but are rare in the southeastern US (Miller et al., 2000; Sinha et al., 2012). Granites associated with the Acadian Orogeny are present in the Salisbury plutonic suite of Georgia and North and South Carolina (Butler and Fullagar, 1978; McSween et al., 1991). A Famennian metamorphic event in the southern Appalachians also occurred between 375-345 Ma (Merschhat et al; 2005).

Alleghenian: The Alleghany orogen formed from subduction and terrane accretion along the eastern margin of Laurentia from 265-330 Ma (Miller et al., 2006; Schwartz et al., 2011). The Alleghanian orogeny is associated with the closing of the Theic ocean, and oblique collision along the eastern margin of Laurentia, with southward suture propagation from 340-380 Ma (Fullagar and Butler, 1979; Speer et al., 1994; Coler et al., 1994; Wortman et al., 2000; Hatcher, 2010; Mueller et al., 2014). In the southeastern US, Alleghany orogenesis culminated with collision of the Suwannee Terrane (Hatcher, 2010; Mueller et al., 2014). Magmatism of the Alleghenian orogeny is rare in the southern US, and is expressed as granitoids both in eastern Laurentia and the northern Suwannee Terrane that range in age from 270-335 Ma (McSween et al., 1991; Speer et al., 1994; Heatherington et al., 2010). These ages are supported by previous 293 Ma age dating determined from $^{40}\text{Ar}/^{39}\text{Ar}$ thermochronology of plutons in southern Alabama near the Suwannee suture (Thomas et al., 1989).

Alleghany Foreland Basin: Alleghanian clastic wedge deposits extend from central Pennsylvania to northern Georgia (Hibbard et al., 2010). Sediment shed into the Appalachian foreland basin were derived mainly from Laurentian sources dominated by Taconic, Acadian, and Alleghanian signatures, as well as other western sources (e.g., Mazatzal, Rhyolite, etc; Becker, 2005; Park, 2010) In particular, Acadian signatures are prevalent in the Alleghanian

wedge, implying recycling of grains from older orogenic events, likely contained within older clastic wedge units involved in the Alleghany fold-thrust belt. However, small populations of 530-680 Ma detrital zircon were detected in the Acadian wedge, implying that some material originated from the Carolina Terrane or other Peri-Gondwanan Terranes and served as sources of sediment by the Devonian.

Peri-Gondwanan Terranes

A series of terranes derived from Gondwana were accreted to eastern Laurentia during the early to mid-Paleozoic (Fig. 59; Hatcher, 2010). The Peri-Gondwanan Terranes are dominated by igneous and volcanogenic sedimentary deposits with abundant 550 to 680 Ma zircons (Hatcher, 2010). In addition to Neoproterozoic zircon, some Peri-Gondwanan terranes (e.g., Cat Square Terrane) contain older zircon derived from Laurentia (430 Ma, 460 Ma), indicating sediment transfer by Laurentian sedimentary systems to these Gondwanan crustal fragments (Merschhat et al., 2010).

Cat Square Terrane: The Cat Square Terrane lies to the west of the Carolina Terrane and east of the Blue Ridge. The Cat Square Terrane consists of deep-water sandstones that were accreted along the east of the Tugaloo Terrane due to the westward subduction of the Carolina Terrane, and closing of the Cat Square ocean during the late Paleozoic (Merschhat and Hatcher, 2007; Merschhat et al., 2010). The Cat Square and Tugaloo Terrane have been metamorphosed into schists and gneiss, with zircon rims within the Cat Square indicate peak metamorphism between 350-360 Ma, coincidental with collision of the Carolina Terrane (Merschhat et al., 2010). The Cat Square and Tugaloo received input from the Carolina Terrane and Laurentia, as indicated by zircons ages dominated by 1,100-1,400 Ma ages, but also include 430 Ma, 500 Ma,

600 Ma, 1,900-2,200 Ma, and 2,700-2,900 Ma (Bream et al., 2004; Carter et al., 2006; Mershat et al., 2010).

Carolina Superterrane: The Carolina Superterrane consists of a series of Peri-Gondwanan Terranes that accreted onto eastern Laurentia during the Paleozoic (Hatcher, 2010; Mershat et al., 2010; Figure 64) including the Charlotte Terrane, Uchee Terrane, Charleston Terrane and Milledgeville Terrane. Overall, The Carolina Superterrane is dominated by volcanic plutons and mafic-felsic rocks that range from 500-600 Ma (Hibbard et al., 2002). Several arc systems are incorporated into the Carolina Superterrane, including the Hyco Arc (633-612 Ma) and the Albemarle Arc (555-528 Ma) (Hibbard et al., 2013).

The Charlotte Terrane is interpreted to be at least partially related to other Peri-Gondwanan Terranes, although the aeromagnetic signatures are not congruent (Hatcher et al., 2007). Most of the Charlotte terrain is buried in the subsurface, but the terrane is delineated based on subsurface data. The Charlotte Terrane consists mainly of plutonic rocks, including 530-540 Ma and 570-580 Ma (Butler, 1984; McSween et al., 1991, Hibbard et al., 2002).

The Uchee Terrane lies between Laurentian rocks exposed in the Pine Mountain Window and the Gondwanan Suwannee Terrane (Steltenpohl, 2008). The Uchee Terrane consists of a lower gneiss, metasedimentary rocks, and an upper layer of migmatites and amphibolites (Steltenpohl et al., 2008). The Uchee Terrane is also intruded by plutonic rocks, which are interpreted as Alleghenian (McRae, 1992). These rocks contain 620 to 640 Ma zircon, consistent with an arc terrane origin within the larger Carolina Superterrane (Hibbard et al., 2002). In addition, 300 Ma zircon rims preserve an Alleghanian overprint. No older overprints from the Taconic or Acadian orogenies were dated, indicating that the Uchee Terrane was not connected to North America before the Alleghenian orogeny. Uplift of the Uchee Terrane is estimated to

have occurred between 276 and 300 Ma based on $^{40}\text{Ar}/^{39}\text{Ar}$ thermochronology, indicating the Uchee Terrane was uplifted during deposition of the Newark Supergroup (Harrison et al., 1985; Mezger and Krogstad, 1997; Steltenpohl et al., 2008).

The Charleston Terrane and Milledgeville Terrane are located to the East of the Uchee Terrane. The Charleston Terrane is completely buried by coastal plain sediments, while the Milledgeville Terrane is exposed at the surface (Hibbard et al., 2002). Both Terranes are poorly constrained and understood, although they are believed to be composed of rocks metamorphosed during the Alleghanian orogeny. Zircon from a granitoid within the Charleston Terrane yielded a U-Pb age of 600 Ma (Heatherington, 1993).

Gondwana Terranes

The Suwannee Terrane: Florida basement rocks were initially recognized as exotic to North America by Wilson (1996), and successive studies have supported this interpretation based on geochemical data (e.g., Mueller et al., 2014), and tectonic reconstructions (e.g., Pollock et al., 2012). The exotic crustal fragment that forms the Florida Peninsula is called the Suwannee Terrane, and it accreted onto southeastern Laurentia during the late Paleozoic Alleghanian orogenesis, following the earlier accretion of the Charleston and Carolina terranes (Fig. 60; Hibbard et al., 2002; Mueller et al., 2014). The terrane is thought to have been translocated into its current position by transform movement following accretion (Mueller et al., 2014).

The geology of the Suwannee Terrane is poorly understood, due to the scarcity of wells that penetrate basement rocks. Paleozoic clastic rocks of the Suwannee Terrane are classified as Gondwanan on the basis of fossil assemblages and detrital zircon studies (e.g., Pojeta et al., 1976; Mueller et al., 1994). Zircon signatures are dominated by 515-636 Ma and 1967-2250 Ma

peaks, which is consistent with Pan-African (525-680 Ma) and Eburnean-Trans Amazonian peaks (1900 Ma-2200 Ma), typical for a Gondwana source (Mueller et al., 1994., Ennih and Liegois., 2008) and similar to the Peri-Gondwanan Terranes (525-680 Ma; Mueller et al., 1994; Heatherington et al., 1999; Heatherington et al., 2003). The lack of any Laurentian signatures suggests that the pre-Mesozoic Suwannee Terrane was not in contact with Laurentia during the Paleozoic (Mueller et al, 2014).

Basement Geology of Florida

Figure 60. Potential source map for the SGR and SFB of Florida. The SGR is marked above. The SFB rests above the South Florida Extrusive volcanics. Modified from Dallmeyer, (1987) Heatherington et al. (1997); Mueller et al. (2014).

Volcanic and plutonic rocks are prevalent in the subsurface throughout northern and central Florida (Dallmeyer, 1989; Heatherington and Mueller, 1991; Heatherington and Mueller, 1999). The oldest rocks identified in the Suwannee Terrane is the Osceola Granite Complex (552 Ma; Heatherington and Mueller, 1996), thought to have formed during the Pan–African orogeny in West Africa and the Brasiliano orogeny in South America (Dallmeyer; 1989). The St. Lucie metamorphic complex in central and southern Florida is composed of amphibolite and biotite-muscovite schist (Dallmeyer, 1989), which has been dated at 504-530 Ma by K-Ar and Rb-Sr geochronology (Arthur 1988; Dallmeyer, 1989).

Wiggins Block: The Wiggins Block is a structural arch west of the Suwannee Suture Zone overlain by Jurassic sediment of the Haynesville Formations (Rhodes and Maxwell, 1993; Montgomery, 2000). Cooling ages of 275 to 300 Ma were calculated based on K-Ar dating (Dallmeyer, 1989; Tew et al., 1991) indicate the Wiggins block was uplifted during Alleghanian collision and before deposition of Triassic strata in the EGOM (Montgomery, 2000). Lithologies of the Wiggins block include metamorphic schist, quartzite, gneiss, and granite, although the petrology of these rocks is poorly understood since so few wells have penetrated to that depth (Dallmeyer, 1989). Thus, the origin of the Arch is still poorly understood, as is its relation to Laurentia and Gondwana. The Suwannee suture has been interpreted by previous authors to extend north of the Wiggins arch into southern Alabama, and thus the Wiggins arch is likely of Gondwanan origin (Thomas, 2010; Mueller et al., 2014).

Yucatan: The Yucatan peninsula is largely composed of the Maya block (also known as the Yucatan block; Dickinson and Lawton, 2001). Pan-African zircons are fairly common in Yucatan, including the Mississippian Santa Rosa Formation and shocked zircons from the Chicxulub impact crater (Krogh et al., 1993; Weber et al., 2006; Weber et al., 2009). The

Mississippian to Penyslvanian Santa Rosa Formation contains a mix of Pan-African (560 to 660 Ma), Mesoproterozoic (900 to 1600 Ma), and Paleozoic ages (318 to 415 Ma; Weber et al., 2006; Weber et al., 2009). Mesoproterozoic age likely indicate sourcing from the Oaxacan complex (Weber and Köhler, 1999; Solari et al., 2003), Pan-African ages are likely from Yucatan and Suwannee, and Paleozoic ages are likely derieved from the Maya mountains (Steiner and Walker, 1996).

Northern South America: South America lithosphere is composed largely of cratons, including the Amazonian Craton in northern South America. The Amazonian craton is composed of a series of at least six distinct Archean and Proterozoic tectonic provinces, including Sunsas Belt (950-1280 Ma), the San Ignacio (900-1500 Ma), Rio Negro-Juruena (1550-1780 Ma) Ventuari-Tapajò (1810-1980 Ma), the Maroni-Itacaiunas (2005-2250 Ma), and the Central Amazonian (greater than 2600 Ma; Cordani et al., 2009). The Amazonian Craton is bound to the south by Neoproterozoic and Paleozoic terranes, and to the east by the late Mesozoic-Cenozoic foreland basin sediments and mountains associated with the Andean belt (Cordani et al., 2000). Paleozoic volcanic and metamorphic rocks in South America formed during the Famatinian Orogen (460-480 Ma), which consists of high-grade metamorphic rocks and granites (Salda et al., 1991). The timing of orogenic activity in the Famatinian is comparable to the Taconic in Laurentia, and is a possible extension of the Taconic into South America (Salda et al., 1998). Paleozoic volcanics in South America may have served as a source of sediment during the Triassic/Jurassic into the GOM near Cuba, based on 398 Ma and 452 Ma detrital zircons in the San Cayetano Formation (Rojas-Agramonte et al., 2008).

West Africa: West Africa is an Archean craton bounded to the west by the Pan-African collisional belt, including the Liberian province (2700 Ma; Colver et al., 1991; Ennih and

Liègeois, 2008). Proterozoic rocks include the Eburnean gneiss, quartzites, and marbles (1900-2200 Ma; Culver and Hunt., 1991; Schofield and Gillespie, 2007). Pan-African orogeny produced synorogenic magmatic and metamorphic rocks that range in age from 550-650 Ma (Dallmeyer and Villeneuve, 1987).

EGOM Rift Volcanism

In rift basins throughout Florida/Georgia, tholeiitic basalt, diabase, and tuffs associated with the CAMP volcanism are common. Rift-related volcanism in the Southern Florida Volcanic Series erupted alkali basalts and rhyolites (Heatherington and Mueller, 1991). The basalts of southern Florida are believed to be sourced from a zone of mantle upwelling, which may have driven extension (Heatherington and Mueller, 1991). Basalt ages in southern Florida Rb-Sr range from 183 to 199 Ma, and are similar to the ages of basalts of northern Florida (Heatherington and Mueller, 2003). Diabase from offshore western Florida records a crystallization age at 190 Ma based on Ar-Ar dating (Dallmeyer, 1984). Rhyolite in southern Florida are interpreted to have formed from silica-rich magma, believed to have formed due to intracrustal melting (Heatherington and Mueller, 1991). Rhyolite range in age from 165 to 189 Ma based on Rb-Sr and K-Ar dating (Heatherington and Mueller, 2003).

Provenance Interpretation

South Florida Basin

Age populations for the South Florida Basin are displayed in Figure 61. The offshore ODP sample is excluded from this discussion, as it is not part of the early Mesozoic rift sedimentary sequence. Interpreted source terranes for the detrital zircon ages of samples 778,

10566, 3578, 10595, and 2012 samples are displayed in Figure 60 and 61. These SFB samples are dominated by a Gondwanan/Peri-Gondwanan signature (525-680 Ma), which constitutes 76% of the composite age distribution. Paleoproterozoic zircon grains are interpreted to have originated from Eburnean/Trans-Amazonian terranes; these Paleoproterozoic zircon form the second largest population at 9% of the composite age distribution. Grenville-aged zircon grains are not common in the SFB (1%), nor are Taconic, Acadian and Alleghanian zircon ages (5%, ~1% and 2%, respectively). Together, these Neoproterozoic and Paleoproterozoic age populations, with a lack of 1,000-1,200 Ma zircon grains, are consistent with sediment derivation from rocks in the Suwannee Terrane. Both of these populations are present in all samples from the South Florida Basin. U/Th ratios consistent with metamorphic zircons around 600 Ma, especially common in sample 3578, were likely derived from the St. Lucie Metamorphic Complex in southern Florida. Other potential sources of metamorphic zircon this age include the margin of West Africa and northern South America, which could have sourced the Pan-African and Trans-Amazonian/Eburnean zircon found in the Suwannee metamorphosed sedimentary rocks. Sourcing from South America is unlikely as this influx would also include Mesoproterozoic ages. The Archean Peak (2%) likely originated from the West Africa Craton, and recycled zircons from Suwannee metamorphic rocks or Paleozoic clastics.

Figure 61. Cumulative plot and interpreted terranes for the SFB.

Figure 62. Percentage of each terrane population present in the SFB. The SFB is dominated by a Gondwanan/Peri-Gondwanan Peak (525-680 Ma).

Figure 63. Cumulative plot and interpreted terranes for the SGR.

Figure 64. Percentage of each terrane present in the SGR. The SGR contains a mix of Gondwanan and Laurentian Terranes.

Surprisingly, only a minor peak (1%) is consistent with South Florida Volcanics in the SFB associated with rifting of Pangea (150-250 Ma); thus the South Florida Volcanics do not appear to have been major contributors of sediment to the SFB clastics. Maximum depositional age for SFB samples in this study range from 195-237 Ma, which is consistent with South Florida Volcanic age ranges (165 to 199 Ma; Heatherington and Mueller, 2003). South Florida ages are slightly younger than the expected ~200 Ma CAMP rifting event in Laurentian rift basins, indicating volcanism in the South Florida region may have post-dated rifting in the central Atlantic region. Basalts in southern Florida may have been zircon poor, but silica-rich basalts similar to the basalts in southern Florida can often contain zircon. The South Florida Volcanics may have either been eroded away from uplifted horst blocks, or were deposited in depositional lows and buried by sediment before they could be incised and eroded to serve as a sediment source in the EGOM.

Only 12% of zircon ages present in the SFB could be associated with Laurentian sources. This includes Alleghenian (265-330 Ma), Acadian (350-420), Taconic (430-490), Mt Rogers (700-760) Grenville (900-1300 Ma), and Yavapai-Mazatzal (1600-1800). None of these ages are prevalent in the Suwannee Terrane. One potential source that may have fed Paleozoic and older detritus is the Maya block, also known as the Yucatan block (Fig. 68). Detrital zircon geochronology of the Upper Carboniferous Santa Rosa Formation from Yucatan by Weber et al. (2006) identified a dominant Pan-African source (540-560 Ma), as well as secondary populations of Paleozoic (421 Ma), Mesoproterozoic (1000-1600 Ma), Paleoproterozoic (1800-2100 Ma) and Archean ages (2600-3100 Ma). Provenance of the Santa Rosa Formation was interpreted to be the Suwannee Terrane and/or West Africa, as well as additional sediments from northern South

America (Fig. 65). Provenance of the Santa Rosa Formation indicates Late Carboniferous docking of Yucatan with Laurentia during the Alleghenian. Sediment derived from Yucatan was likely shed into the SFB as it was rifted away from the southern margin of Laurentia and West Florida during the opening of the GOM.

Another possible explanation is that at least some sediment derived from southern Laurentia was deposited in the SFB, either by eolian or fluvial input. Similar sediment pathways from the SE Appalachian extended across northern and south Florida during the Oligocene,

leaving a thin deposit of sand (Warzeski et al., 1996; Hine, 2009). These deposits are inferred to have been deposited during a marine regression by prograding deltas that extended into southern Florida. This theory is considered controversial, as rivers would have had to flow over

Figure 65. Late Carboniferous provenance model for the Santa Rosa Formation in Western Yucatan. Florida and West Africa served as a dominant source of sediment for the Santa Rosa. From Weber et al. (2006). F-Florida, Y-Yucatan, SM-Southern Maya Block, R-Rokelides, Cho-Chortis block, BR-Brasiliano, Chis-Chiapas Massif, CA-Colombian Andes, BA-Bassarides—Mauritanides, Ac-Acatlan Complex, D-Delicias Basin, M-Merida Terran.

topographically high terrain in northern Florida. The Oligocene transport of Appalachian

sediment occurred during shoreline regression, which allowed river deltas to prograde into southern Florida. The end of the Triassic was marked by a similar slight fall in sea level (Haq et al., 1987). A similar system of rivers may have existed during the early Mesozoic.

Interpreted tectonic settings for the SFB are displayed on the QtFL diagram in Figure 66. All samples plotted within the Cratonic Interior/Transitional Crust source terrane. Samples are dominated by high quartz content (50-93%) and secondary minor plagioclase, orthoclase, microcline, and perthite (6-50%). Lithics are very uncommon. The cratonic interior the samples were likely derived from Paleozoic clastics of the Suwannee

South Florida

Figure 66. QtFL ternary diagram for the SFB. The majority of the samples are dominated by quartz and feldspar, interpreted as cratonic interior. Perthites are common in select samples. The Wood River was likely derived from Paleozoic cover of the Suwannee Terrane, and the Osceola Granite. Diagram modified from (Dickinson and Suczek, 1979).

Terrane, as well as input from igneous and metamorphic rocks including the Osceola Granite and metamorphic St Lucie Metamorphic complex. Feldspar laths indicate input from volcanic rocks, but the scarcity of volcanic lithic fragments and Mesozoic detrital zircon ages indicate volcanic rocks were not a major source of sand. Sample 1411 is dominated by perthite. Perthite is typically altered very quickly, indicating source area was proximal to the basin. Perthites are common in deeply-exhumed granites, and so perthite grains in SFB sandstones were likely derived from the Osceola Granite of the Suwannee Terrane. Sample 1411 is located far north of other samples in the South Florida Basin, and rests above the Osceola granite, which supports proximal sourcing.

South Georgia Rift

Population ages for the SGR are displayed in Figure 63 and 67. The SGR contains a mix of Laurentian zircon ages (61%) and Gondwanan zircon ages (39%). Acadian-aged zircon form significant populations in the SGR (~21%). Around 12% of zircons from the SGR are consistent with an Alleghenian source. Grenville-aged zircon grains are fairly common in the SGR (16%). Taconic ages account for 15% of the SGR samples. Gondwanan/Peri-Gondwanan signatures constitute 23% of detrital zircon ages from the SGR, considerably less than what was observed in the SFB. Mount Rogers sourcing is not common in the SGR (~3%).

The proportion of source terranes differs spatially between SGR samples. Age signatures for each sample are displayed in Figures 61, 63, and 68. All samples contain significant Laurentian zircon age signatures. The SGR samples are dominated by a mix of Alleghenian (265-330 Ma), Acadian (350-420 Ma), Taconic (430-490 Ma), Gondwanan (525-680 Ma), Mt. Rogers (700-760 Ma), Grenville (900-1300 Ma), and Granite Rhyolite (1300-1500 Ma) sources. Together, Laurentian-affinity zircons constitute 73% of the sample. The Blue Ridge rocks, which extends into northern Georgia, contain abundant Grenville zircons, which may have served as a potential source. Grenville rocks are also exposed in the Pine Mountain Window in western Georgia, although these rocks may not have been exposed during deposition of the Newark (Steltenpohl et al., 2010). The Acadian population is especially abundant (21%). Acadian orogenic rocks are not abundant in the southern Appalachians. Acadian populations may have been derived from unroofing events that were later sequestered in the SGR. Plutons associated with the Taconic, Acadian, and Alleghenian orogenies are common in the Blue Ridge and multiple Peri-Gondwanan Terranes, including Alleghenian plutons in northern and southern Georgia (Speer et al., 1994). Laurentian age signatures in the South Georgia Rift may have been

sourced from a combination of long distance transport from Laurentian terranes, recycled zircons from Peri-Gondwanan Terranes, or Appalachian associated plutons. Taconic, Acadian, and Alleghanian-aged zircons are common in the Cat Square Terrane, which may have contributed sediment into the South Georgia Rift. The Alleghanian Clastic Wedge foreland basin sequence in the eastern Appalachians contains Acadian, Taconic, and Alleghanian aged zircons, and likely at least partially sourced the SGR (Thomas et al., 2004).

Gondwanan-derived zircons include Neoproterozoic-early Cambrian ages (525-680 Ma) constituting 23% of the composite population, and Paleoproterozoic ages (1,900-2,200 Ma) constituting 2% of the composite population (Fig. 64 and 69). The mix of Laurentian ages indicates transport from the north, and so supports derivation from Peri-Gondwanan Terranes along eastern Laurentia. However, it is possible that these Gondwanan zircon grains originated from the Suwannee Terrane as well. The 1,900-2,200 Ma Trans-Amazonian/Eburnean population is more common in Suwannee rocks than the Peri-Gondwanan Terranes. Because this population in the SGR is minor, it suggests that while it is possible that some sediment was contributed from the Suwannee Terrane, this contribution was less than the influx from northern source areas.

There is great variation in proportion of Laurentian versus Peri-Gondwanan/Gondwanan input across the SGR. Samples 1854 (15%) and 3113 (35%) located in the Florida Panhandle and near the Georgia/Florida border, respectively, contain significantly less Appalachian sources than other samples (60% for 108, 50% for sample 619, 55% for 3137, 52% for 442). Samples 1854 and 3113 are dominated by Neoproterozoic-early Cambrian ages (525-680 Ma). Sample 1854 contains 42% Neoproterozoic-early Cambrian ages (525-680 Ma) and 5% Paleoproterozoic (1,900-2,200 Ma) ages, whereas sample 3113 is composed of 25% Neoproterozoic-early

Cambrian ages (525-680 Ma), and 3% Paleoproterozoic (1,900-2,200 Ma) ages. The lack of Appalachian age signatures and presence of Neoproterozoic-early Cambrian ages (525-680 Ma), and 3% Paleoproterozoic (1,900-2,200 Ma) age, consistent with zircon ages known in the Suwannee Terrane, indicates that both of these samples were likely deposited on the Suwannee side of the Suwannee suture at or near the Suwannee Suture within the Tallahassee Graben. In contrast, samples 3137, 108, and 619 are dominated by Appalachian signatures, and were likely deposited on the Laurentia side of the suture. Neoproterozoic-early Cambrian detrital zircons could reflect Gondwanan Suwannee Terrane input and/or Peri-Gondwanan Terrane input. The occurrence of Neoproterozoic-early Cambrian detrital zircons with Appalachian-aged detrital zircon implies a northern source area that suggests at least partial sourcing from Peri-Gondwanan terranes was likely. Sample 442 contains a relatively large (27%) Neoproterozoic-early Cambrian age signature along with a significant (52%) Taconic, Acadian, and Alleghanian age signature, indicating derivation from Appalachian and Gondwanan sources. Grenville peaks (7%) and Paleoproterozoic peaks (1%) are both minor compared to other samples. Its location in the northern and western SGR suggests it may have received sediment from both Laurentia and Peri-Gondwanan Terranes.

Sample 3113 from the southern part of the SGR has a large Pan-African zircon age population, but insignificant Appalachian zircon age populations, implying the majority of sediment was derived from the Suwannee Terrane. Only samples 1854 from the Tallahassee Graben and 3113 from the southern SGR contain significant quantities of Paleoproterozoic ages (1,900-2,200 Ma), interpreted to represent a Trans-Amazonian/Eburnean signature. U/Th ratios suggest metamorphic origin for 600 Ma zircon grains, which were likely derived from metamorphic Peri-Gondwanan Terranes or recycled from younger clastic wedges.

Figure 67. Relative proportion of terrane sourcing for each sample from the SGR.

No samples from the South Georgia Basin were coarse enough to be point counted, but samples collected for thin sections were dominated by shale, with a mixed feldspar and quartz composition, and very few lithics identified. The high amount of mica fragments is consistent with a metamorphic source lithology, which based on detrital zircon ages indicate metamorphic rocks in Peri-Gondwanan Terranes. Previous point counting interpretations from the SGR in South Carolina from Rine et al. (2014) interpreted a Peri-Gondwanan source based on the abundance of metamorphic minerals and lithic fragments. Based on the U/Th results there are not a significant number of Metamorphic zircon, aside from samples 442, and 3137.

Data Comparison with other Studies

Thin Section observations are supported by previous provenance studies in the EGOM (Figure 68). Lisi (2013) noticed a similar dominance of quartz in Norphlet samples in the Florida Panhandle and offshore western Florida, which was attributed to input from dominantly Gondwanan clastic and granitic rocks. Norphlet Formation samples from the Destin Dome and Florida Panhandle contain abundant feldspar, interpreted to have been derived from Laurentia metamorphic and igneous sources. Bovay et al. (2014) also noticed a similar trend in early Cretaceous clastic rocks in offshore western Florida, and they proposed that Gondwanan source areas in the Peninsular Arch are dominated by shales interbedded with fine-grained sandstones, while Appalachian source areas contain predominantly fine-grained micaceous sandstone interbedded with shale. They interpreted Gondwanan sources to be primarily from Paleozoic sandstones and Precambrian granites, based on the presence of fine to coarse grained pure sandstones, while the Cretaceous clastic rocks of the Peninsular Arch were sourced primarily from Peri-Gondwanan Terranes and sources exposed in the Appalachian mountains, based on the

presence of micaceous sandstones. They proposed that the Peninsular Arch of Florida served as a dominant source of sediment into the EGOM, with sediment transportation to the west.

Figure 68. Provenance of the Norphlet Formation in the EGOM from previous studies. The Norphlet is dominated by Cratonic Interior, Transitional Crust, and Recycled Orogen sources.

Zircon data collected during this study was compared to previous studies by Lovell (2010), Lisi (2013), and Jesse and Weislogel (2014) of the Norphlet in the EGOM to determine if the SGR, SF, and Norphlet in the EGOM may share similar sources. If so, this could support the conclusion that both basins may have received sediment routed through similar pathways into the EGOM. Based on similarities between zircon provenance and paleogeographic location, 8 major sample groupings were identified (Table 12). The K-S test was used to identify statistical similarities between the sample groupings (Table 13). A CDP for the 8 groupings is displayed in

Figure 69. Major differences are noted ~530 and 1000 Ma. An overview of the major groupings and the implications of provenance are described below.

Population	Samples	Major Age Peaks	Sources	Youngest Age
<i>West Florida</i>	382, 383, 2523, 2516, 2012	559 Ma, 637 Ma	Suwannee Terrane	456 Ma
<i>South Florida</i>	2012, 3578, 10566, 15095, 778, ODP	568 Ma	Suwannee Terrane	108/105 Ma
<i>Apalachicola Embayment</i>	6406, 6396, 1623, 563	294 Ma, 430 Ma, 560 Ma, 617 Ma	Alleghanian, Taconic, (peri)-Gondwanan Terranes, Grenville	198 Ma
<i>Florida Panhandle</i>	1004, 1096, 1196, 1193	316 Ma, 392 Ma, 424 Ma, 583 Ma, 1064 Ma	Alleghanian, Acadian, Taconic, (peri) Gondwanan Terranes, Grenville	284 Ma
<i>Southern Alabama</i>	5115, 1036, M-6, 949, 6805, 1552, 1543, 5115, 860, 6848	298 Ma, 336 Ma, 435 Ma, 561 Ma, 629 Ma, 1088 Ma	Acadian, Taconic, Pan-African, Grenville	201 Ma
<i>South Georgia Rift northern subbasin</i>	108, 619, 3137, 442	332 Ma, 432 Ma, 584 Ma, 1077 Ma	Acadian, Taconic, Pan-African, Grenville	250 Ma
<i>South Georgia Rift southern subbasin</i>	1854, 3113	345 Ma, 430 Ma, 569 Ma, 602 Ma, 640 Ma	Acadian, Taconic, Pan-African	197 Ma
<i>Mississippi Interior Salt Basin</i>	DZ 1, DZ 2, DZ 3, DZ 4, DZ 5, DZ 6	360 Ma, 427 Ma, 605 Ma, 1068 Ma, 1151 Ma, 1477 Ma	Acadian, Taconic, Pan-African, Grenville, Granite-Rhyolite	204 Ma

Table 12. Major groupings identified from Lovell (2010), Lisi (2013), and this study. Samples include the Wood River Formation, Newark Supergroup, Norphlet, and Haynesville.

	West Florida	South Florida Basin	Norphlet Apalachicola Embayment	South Georgia Rift South	Norphlet Southern Alabama	Norphlet Florida Panhandle	South Georgia Rift North	Mississippi Interior Salt Basin
	4 samples	6 samples	4 samples	2 samples	10 samples	4 samples	4 samples	6 samples
West Florida	0%	12.5%	12.5%	4.12%	0%	8.3%	0%	0%
	South Florida	53%	20.8%	10%	0%	0%	0%	0%
		Norphlet Apalachicola Embayment	83.33%	75%	8.3%	25%	6.25%	0%
			South Georgia Rift South	50%	0%	16.67%	20%	10%
				Norphlet Southern Alabama	85.67%	70.83%	0%	91.7%
					Norphlet Florida Panhandle	66.67%	0	69.44%
						South Georgia Rift North	87.5%	0%
							Norphlet Mississippi Interior Salt Basin	86.67%

Table 13. Major groupings identified, and statistical similarity between each grouping. The percentage indicates how many pairings passed the K-S test ($p > .05$). A higher percentage indicates a higher likelihood for a shared source.

Figure 69. CDP for the 8 major groupings identified in this study. Major groupings are present around 530 Ma and 1000 Ma.

Regional Provenance Model

Based on the K-S test, Cumulative Probability Density Plots, Normalized Probability Density Plots, and provenance studies in Lovell, (2010), Lisi, (2013) and Jesse and Weislogel (2014), eight major depocenters were identified between samples. A composite CDP of detrital zircon ages for each region is displayed in Figure 69. A Normalized PDP for all groupings is displayed in Figure 71, and a potential provenance model in Figure 72.

Offshore Western Florida (Haynesville)

Offshore Western Florida samples (382, 383, 2523, 2516) analyzed by Lisi (2013) were collected from interpreted Haynesville and basement samples. Samples were collected from the Tampa Embayment. Samples are derived from primarily Pan-African sources, with two age populations between 580 and 680 Ma. Minor populations from 800-2800 Ma are also common but not prevalent. Rocks of the Suwannee Terrane uplifted in the Peninsular Arch were likely a dominant source for West Florida.

Sample 2012 from this study was collected from central, onshore Florida, from the Suwannee Basin. Sample 2012 rests above diabase ~190 Ma (Heatherington and Mueller, 2003). Sample 2012 is interpreted to lie within the Paleozoic clastic fill (Ordovician-Devonian) of the Suwannee Basin (e.g, Heatherington and Mueller, 1994; Boote and Knapp, 2016). Detrital zircon ages of 234 to 324 Ma imply that the clastics are Triassic/Jurassic, and may indicate Triassic syn-rift clastic deposition. Sample 2012 zircon ages are similar to the Tampa Embayment samples from Lisi (2013).

South Florida Basin (Wood River)

The SFB provenance results (samples 15095, 778, 3578, 10566; this study) are from the Wood River Formation, and zircon ages are significantly different from the other age populations in EGOM region, aside from offshore Tampa Embayment samples from Lisi (2013). The SFB is dominated by one population between 480-720 Ma, which is interpreted as predominantly Pan-African. A population between 2000 to 2200 Ma is also present, which is interpreted as Eburnean/Trans-Amazonian. Provenance for the SFB is interpreted as Suwannee Terrane rocks based on the abundant and overall unimodal Neoproterozoic zircon signatures. Smaller populations around 200 Ma have been attributed to South Florida volcanics, and smaller populations between 300-400 Ma are possibly related to minimal input from Appalachian sources or Yucatan. The ODP sample indicates detrital zircon in the SFB essentially reflect reworking of underlying Suwannee Terrane basement rocks.

Apalachicola Embayment (Norphlet)

The Apalachicola Embayment (563, 162, 6396, 6406; Lovell 2010; Lisi, 2013) is the most similar to the SFB composite. Populations between 520-680 Ma, and 1900-2300 Ma are interpreted as a large Pan-African population and Eburnean population similar to the South Florida Composite. Appalachian (240-500 Ma) and Grenville (920-1280 Ma) populations are present in the Apalachicola Embayment. The Apalachicola Embayment likely received input from a mix of Suwannee and Laurentian sources, which was initially proposed by Lisi (2013). The Apalachicola Embayment was likely proximal to the Suwannee Suture, similar to samples 1854 and 3113 as proposed earlier.

Southern South Georgia Rift (Newark)

The southern SGR samples analyzed (1854, and 3137; this study) have a large population at 500-680 Ma, consistent with Pan-African sources, and sharp populations between 340-460 Ma typical with an Appalachian sources. The southern SGR contains a very small population consistent with an Eburnean/Trans-Amazonian population. The southern SGR was likely derived from Peri-Gondwanan and Suwannee sources.

Similarities between offshore Destin Dome Norphlet zircon data from Lovell (2010) and Lisi (2013) with samples from the Tallahassee Graben and southern South Georgia Rift supports the interpretation that they may share a similar source. Sample 1854 and 3113 of the SFB are similar to the Apalachicola Embayment composite, as both have a large age peaks associated with Pan-African and Appalachian source, and the composite distributions pass the K-S test. Therefore, it is likely that either: 1) Both western Florida panhandle and Tallahassee Graben/southern portion of the South Georgia Rift share a similar source with the Norphlet in the Apalachicola Embayment and/or, 2) The Tallahassee Graben and southern portion of the South Georgia Rift may have served as a sediment pathway into the EGOM. The Pan-African age population is present all samples through the Florida EGOM, and was likely sourced from Suwannee Terrane rocks uplifted in the Peninsular Arch.

Southern Alabama Composite (Norphlet)

The Southern Alabama Composite (5115, 1552, 1193, 4557, 860, 949, 1196, M6, 162, 10361, 6805; Lovell, 2010 and Lisi, 2013) marks a shift from predominantly Suwannee Terrane age populations, to predominantly Laurentian age populations, as initially proposed by Lisi (2013). The southern Alabama composite does not have a significant Pan-African (520-680 Ma)

age population and Eburnean ages are absent. Instead, Appalachian (320-500 Ma) age populations are more abundant than compared to the Apalachicola and SFB composite age distribution. There is a very large population (900-1300 Ma) in southern Alabama, which is attributed to Grenville. In contrast, the SFB and Appalachiicola embayment composite distribution contains very few Grenville-aged zircon. The southern Alabama composite was likely dominated by Laurentian and Peri-Gondwanan sources. The lack of Eburnean/Trans-Amazonian populations indicates that a Suwannee source was unlikely.

Florida Panhandle (Norphlet)

The Florida Panhandle composite (1004, 1096, 1080; Lisi, 2013) has large populations attributed to Appalachian (300-500 Ma), Pan-African (540-680 Ma), and Grenville (900-1300 Ma). It also has a small population (2100-2200 Ma) that may be consistent with a Eburnean/Trans-Amazonian population. The Florida Panhandle deposits likely contain sediment from a mix of Laurentian Peri-Gondwanan and Suwannee sources.

Northern South Georgia Rift (Norphlet)

Northern samples from the SGR (108, 3137, 442, and 619; this study) contain a large population of 320-490 Ma zircon, consistent with Appalachian sources, as well as a second population of 550-680 Ma zircon associated with a Pan-African source. The northern SGR deposits were likely derived from a mix of Laurentian and Peri-Gondwanan/Suwannee Terrane sources.

Mississippian Interior Salt Basin (Norphlet)

The Mississippian Interior Salt Basin (MISB) is located in southern Mississippi (samples DZ1, DZ2, DZ3, DZ4, DZ5, DZ6; Jesse and Weislogel, 2014). Samples in the MISB are dominated by Grenville (900-1300 Ma) zircons, as well as Taconic, Acadian, and Alleghanian sources (300-520 Ma). Pan-African Gondwanan zircons are rare in these deposits.

Figure 70. Composite Normalized PDP for the Mesozoic EGOM. Results from this study, Lovell (2010), Lisi (2013) and Jesse and Weislogel (2014).

Provenance Model

Figure 71. Provenance model for the Norphlet, Haynesville, Wood River, and Newark in the EGOM from this study. Gondwana, Laurentia, and mixed sources are identified. The 8 groupings identified are listed in Figure 71.

Paleogeographic Interpretations and Regional Provenance Model

South Florida Basin

Detrital zircon geochronology, thin-sections, and well logs interpretations are used to reconstruct early Mesozoic EGOM paleogeography and provenance. The Peninsular Arch, a structural feature of controversial origin, was likely a paleotopographic high in the middle of Florida throughout the Mesozoic. Sediment shed from this arch was distributed across the SFB and out into the Tampa Embayment, providing texturally immature detritus containing the Neoproterozoic-early Cambrian detrital zircon and quartzose sand along with perthite grains. Provenance studies of Valanginian strata in the northern EGOM indicates that the Peninsular arch was a source of sediment until at least the Lower Cretaceous (Bovay et al., 2014). Small Paleozoic detrital zircon populations in SFB may indicate some sediment was sourced from the Maya block (Yucatan) during rifting.

The lack of diverse populations in the South Florida Basin could provide direct insight into the reservoir potential of the basal clastic section in the South Florida Basin. The absence of other sources could indicate that large-scale, regionally integrated drainage systems were not present in southern Florida during the deposition of the basal clastics. Basal clastic sections appear to be relatively thin (100-300 feet) in southern Florida, although distribution is poorly constrained. The thickness and extent of clastics into offshore South Florida is not publicly available, but provenance results suggesting localized, small-scale drainages in onshore southern Florida indicates limited potential for the development of thick sandstone units. Triassic-late Jurassic rift deposits in northern Cuba contain noticeably different provenance signature than the SFB. Previous U-Pb Detrital Zircon Dating of 19 grains from the San Cayetano Formation by Rojas-Agramonte et al. (2008) contained a mix of signatures, including Paleoproterozoic,

Mesoproterozoic, Neoproterozoic, Ordovician, and Devonian sources. Only one grain consistent with a Pan-African source was identified (561 Ma). The authors interpreted a source from northern South America based on the dominant Mesoproterozoic signature, as well as a possible sediment sources from southern Laurentia or Yucatan. Previous muscovite $^{40}\text{Ar}/^{39}\text{Ar}$ dating from the San Cayetano Formation from Hutson et al. (1998) identified a predominant Paleozoic population which they inferred to have been derived from the Taconic and Alleghenian orogenies. The results from both of these studies suggest that the SFB and syn-rift clastics of Cuba were not derived from the same source, with increased sediment influx from Yucatan or South America toward the south of the early EGOM region.

South Georgia Rift

The presence of both Laurentian and Gondwanan zircons in the SGR implies mixing from multiple sources. The presence of Peri-Gondwanan, Taconic, Acadian, and Alleghenian zircons in SGR syn-rift deposits supports sediment transport from the north. Grenville zircons support at least some sediment transport to the east from the Grenville Terrane. The presence of Acadian and Taconic zircons is unusual for the southern Appalachians. Sources may include the Cat Square or other Peri-Gondwanan Terranes with mixed ages, as well as the Alleghanian clastic wedge, and Acadian plutons present in select Peri-Gondwanan Terrains. Paleozoic zircons are present in greater abundances in SGR samples than previously reported studies of the post-rift Upper Jurassic Norphlet Formation from southern Alabama Lovell (2010), and the Florida panhandle (Lisi, 2013). Paleozoic zircons may have been sourced locally from unroofing of Paleozoic-aged rocks to source sediment deposited in the SGR, followed by later erosion of Grenville-aged rocks to source the Jurassic deposition of the Norphlet Formation.

The abundance of Gondwanan zircons in samples 1854 and 3113 in the Tallahassee graben/Albany subbasin, and lower abundance of Gondwanan zircons in samples 442, 108, 3137, and 619 in the Valdosta sub-basin to the north implies that the Suwannee suture is located somewhere between these two rift basins. Samples 442, 619, 108, and 3137 likely lie along the northern ends of the sub-basin, whereas samples 3113 and 1854 likely lie south of the suture. The presence of Gondwana-aged zircon in the Valdosta sub-basin may indicate that the suture is closer to the northern sub-basin, in the very southern extent of Georgia. The detrital zircon results from this study supports the suture location proposed in Mueller et al., (2014) and Mueller et al. (2014; Fig. 72). Norphlet samples P1004 and P1096 from the Florida panhandle from Lovell (2010), and Lisi (2013) contain a mix of Laurentian and Suwannee derived zircons, implying they may also be located proximal to the suture.

Figure 72. Proposed location of the Suwannee suture, based on work from this study, Lovell, (2010), Lisi (2013), Jesse and Weislogel, (2014) and Heatherington and Mueller, (2014).

Triassic/Jurassic Paleo-Transport Systems of Laurentia

A Paleo-Transport model for drainage systems in Laurentia during the Triassic/Jurassic is displayed in Figure 73. The Appalachians served as a dominant source of sediment throughout North America during the early Mesozoic, and rivers transported sediment as far as the Jurassic dune systems of the west (Navajo, Coconino, etc), where they were then reworked by wind (Rahl et al., 2003; Dickinson and Gehrels, 2009). The Jurassic erg of the western US likely serves as the end of sediment transport from the Appalachians westward. Later, rivers began to drain into

the opening Gulf of Mexico in the Cretaceous (Blum and Pecha, 2014). Even before the Cretaceous, Appalachian and Peri-Gondwanan rocks also supplied sediment into the EGOM, providing sediment for the Norphlet and other Mesozoic clastics. The Suwannee Terrane served as a major source of sediment for Wood River Formation and also contributed sediment to the younger Norphlet Formation in the northern EGOM, although Suwannee influence decreases towards southern Alabama. Yucatan and South America do not appear to have been major sources of sediment in the northern EGOM during rifting, possibly contributing only minor amounts of detritus into the SFB, and may have at least partially supplied sediment to early Norphlet Formation deposits (Gomes et al., 2016). In contrast, Yucatan likely sourced the San Cayetano Formation in the southern EGOM.

Figure 73. Proposed fluvial paleo-transport model for Laurentia during the Triassic Jurassic. The Appalachian shed sediment that was transported to the Gulf of Mexico, and to the Jurassic ergs systems of the western US. Appalachian sediment was also transported to the Inner Cretaceous Seaway, and southern Canada. Peri-Gondwanan terranes were also a major source of sediment into the western EGOM and the Jurassic erg systems. Sediment from Yucatan sourced the San Cayetano Formation, and possibly the South Florida Basin. Modified from Weislogel et al. (2015). Navajo zircon work from Dickinson and Gehrels, (2009), San Cayetano from Rojas-Agramonte et al. (2008).

Stratigraphic Correlation

A proposed stratigraphic correlation for the South Florida Basin, South Georgia Rift, and Eastern Gulf of Mexico is displayed in Figure 74. The minimum age of the Newark Supergroup in the SGR is unknown, but is likely younger than 230 Ma, similar to other Newark Rift Basins (Schlische et al., 2003). The minimum age is constrained by post rift diabase and basalt flows related to CAMP volcanism (200 Ma; Schlische et al., 2003). The Newark Supergroup is overlain by interpreted Cretaceous Cotton Valley and other Cretaceous/Cenozoic post-rift strata

(Chowns and Williams, 1983). A post-rift unconformity separates the Triassic/Jurassic Newark from the Cotton Valley.

The Eagle Mills in the Eastern Gulf of Mexico was likely deposited concurrently with the Newark Supergroup in the South Georgia Rift. An Upper Jurassic, Carnian (~230 Ma) age is suggested by polynomorphs (Moy and Traverse, 1986). Jurassic/Lower Cretaceous strata overlying the Eagle Mills includes the Werner Anhydrite, Louann Salt, Norphlet, Smackover, Buckner Anhydrite, Cotton Valley, Hosston, and Silgo (Goldhammer, 2001; Mancini et al., 1985; Hammes et al., 2011; Cohen et al., 2013). Sea floor spreading began ~160 Ma, following deposition of the Louann Salt (Hudec et al., 2013). Salt deposits are present in northern Yucatan and southern Laurentia, which were initially separated following sea floor spreading. The Norphlet eolian erg was deposited following Louann salt deposition. Based on the age, no correlatable strata are present in the South Georgia Rift. The South Georgia Rift may have partially sourced the Norphlet in the EGOM. Norphlet deposition is followed by anhydrite and carbonate Smackover deposition, which is also not correlated with SGR strata. The Upper Jurassic/Cretaceous Haynesville, Cotton Valley, Hosston, and Silgo likely correlate to Coastal Plain deposits in the SGR (~125-156 Ma).

The deepest wells in the South Florida Basin have penetrated extrusive rhyolite and basalt, dated 175-199 Ma (Applegate et al., 1981; Heatherington and Mueller, 2003). Very few young zircons were dated from this study, but a Maximum Depositional Age of 195-240 Ma is suggested. The Wood River Formation grades into an upper carbonate interval, with an unknown age. The upper age of the Wood River Formation is constrained by the overlying Bone Island Formation (~138 Ma; Applegate et al., 1981). The age of the Wood River correlates chronostratigraphically with the Norphlet-Cotton Valley sequence. Salt deposits are also absent

from the SFB, making correlation difficult. The lower clastic interval was likely deposited concurrently with the Norphlet, while the upper carbonate is correlated with the Smackover. The Lower Cretaceous Pumpkin Bay, Glades Group, and Ocean Reef Group correlate in age to the Cotton Valley, Hosston, Silgo, and other coastal plain deposits in the EGOM and SGR.

Figure 74. Proposed chronostratigraphic correlation between the SGR, EGOM, and SFB. Correlation is based on formation ages and detrital zircon results. SGR ages from Schlische et al. (2003); Chowns and Williams, (1983). EGOM ages from Moy and Traverse, (1986); Goldhammer, (2001); Mancini et al. (1985); Hammes et al. (2001); Cohen et al. (2013). SFB ages from Pollastro et al. (2001); Heatherington and Mueller, (2003); Cohen et al. (2013). Sea floor spreading from Hudec et al. (2013). CAMP ages from Hames et al. (2000).

Chapter 6: Conclusion

1. U-Pb of 552 grains from Triassic/Jurassic South Florida Basin clastics identified a dominant Peri-Gondwanan/Gondwanan Population (525-690 Ma) and Trans-Amazonian/Eburnean population (1900-2200 Ma). The U-Pb age distribution from these samples is consistent with signatures identified in Paleozoic volcanic and metamorphic rocks of Suwannee, indicating the Wood River and other proximal clastics were sourced from local terranes. The uplifted Peninsular Arch likely served as a major sediment source in the Mesozoic before carbonate buildup began. Minor age distributions (12%) from Laurentia sources may indicate sourcing from Yucatan, or long distance transport by fluvial channels across Florida.
2. A Maximum depositional age of 195-227 Ma is proposed for the Wood River Formation based on the age of the youngest detrital zircon grains. The age of Mesozoic detrital zircons is consistent with a South Florida Volcanic source. The Wood River Formation was likely deposited following initial rifting in the EGOM between 174-235 Ma.
3. Thin-section point-counting indicates a cratonic source for basal sediment in the SFB. The basal sandstones are dominated by subrounded, medium-grained quartz grains, which were derived from Ordovician-Devonian clastics of the Suwannee Terrane. Detrital feldspars and perthites were derived from erosion of the Osceola Granite.
4. Metamorphic phyllite sampled from ODP site 0537 yielded zircons with a U-Pb age of 550 Ma. This is consistent with a Pan-African origin of this crust. This age is similar to Paleozoic granites and metamorphic rocks in the Suwannee Terrane of Florida, as well as rocks in Western Africa, and Yucatan. The uplifted block at site 537 is likely attenuated continental crust that is an extension of the Suwannee Terrane.

5. Evaluated wireline logs from the SFB indicate the basin deepens to the south, and the depocenter is likely south of Collier county. V-shale increases to the south, supporting the conclusion that coarse-grained sediment was derived from and deposited proximal to the Peninsular Arch.
6. U-Pb analysis of 567 grains from the Newark Formation within the South Georgia Rift have identified several potential source terranes. These include Appalachian Basin (mixed), Alleghenian (265-330 Ma), Acadian (350-420 Ma), Taconic (430-490 Ma), Gondwanan/Gondwanan Population (525-690 Ma), Mt Rogers (700-760 Ma), Grenville (900-1300 Ma), Granite Rhyolite (1300-1500 Ma), Trans-Amazonian/Eburnean (1900-2200 Ma), and Yavapai Mazatzal (1600-1800 Ma). The South Georgia Rift was sourced primarily from a mix of Laurentian Appalachian, Peri-Gondwanan, and Suwannee sources. This interpretation is supported by thin section petrography, which identified high feldspar and mica content relative to the SFB.
7. Age distributions in the SGR were used to better constrain the location of the Suwannee suture. Samples 619, 108, 3137, and 442 are all dominated by ages consistent with Laurentian sources, and were deposited on the Laurentia side of the suture, while samples 1854 and 3113 contain relatively large Peri-Gondwanan/Gondwanan populations relative to the other SGR samples, and were likely deposited at or near the Suwannee suture.
8. U-Pb age signatures from the SFB and SGR were compared to previous Norphlet Formation provenance studies by Lovell (2010) and Lisi (2013) using the K-S test to identify if the Norphlet may have shared potential sources with syn-rift deposits in the SGR or SFB. Eight major regions with distinct age distributions were identified. Laurentian sources dominate sediment supplied to southern Alabama, Gondwanan

sources dominate sediment supplied to southern Florida, and a mixed source of Laurentia and Suwannee crust supplied sediment to the region between southern Florida and southern Alabama.

9. Age distributions of Triassic Newark sediment from the South Georgia Rift are statistically similar to offshore Jurassic Norphlet samples from the Apalachicola Embayment. The two regions likely shared similar sources, and the SGR/Tallahassee Graben may have served as a potential sediment source into the EGOM.

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Appendix A: U-Pb data

Analysis	U ppm	Th ppm	U/Th	207Pb/2 35U	+/- 2 σ	206Pb/2 38U	+/- 2 σ	207P b/ 206P b	+/- 2 σ	207P b/ 235 U (Ma)	+/- σ Ma	206Pb/2 35U (Ma)	+/- σ Ma	207P b/ 206P b (Ma)	+/- σ Ma	Bes t Ag e Ma	Use d?
3578																	
X3578_1	225	16.3	14.4	0.773	0.0 56	0.0958	0.00 58	0.05 94	0.00 23	589	16	589	17	561	42	589	yes
X3578_2	257	86	3.15	0.913	0.0 68	0.1028	0.00 55	0.06 48	0.00 37	659	18 .5	630	16	740	60	630	yes
X3578_3	38. 7	7.6	8.2	3.46	0.5 9	0.1379	0.00 92	0.16 7	0.02 3	1450	60	831	26	2410	11 0	831	no
X3578_4	129	31.8	3.96	0.8	0.0 49	0.098	0.00 48	0.05 8	0.00 19	593	13 .5	602	14	540	37	602	yes
X3578_5	180	55.6	3.14	0.874	0.0 54	0.094	0.00 48	0.06 72	0.00 3	634	14 .5	579	14	832	48	579	yes
X3578_6	92. 1	33.8	2.63	0.918	0.0 61	0.0977	0.00 46	0.06 74	0.00 31	657	16	601	13 .5	822	48 .5	601	yes
X3578_7	163	77.8	2.13	0.842	0.0 33	0.0974	0.00 3	0.06 21	0.00 21	619	9	599	9	661	35 .5	599	yes
X3578_8	82. 3	47.1	1.78	1.69	0.1 3	0.0997	0.00 71	0.12 19	0.00 64	1012	25 .5	619	20	1975	48 .5	619	yes
X3578_9	72. 5	17.9	4.04	0.773	0.0 36	0.0935	0.00 43	0.05 84	0.00 2	580	10	576	12 .5	556	36 .5	576	yes
X3578_10	195 .5	42.1	4.44	0.877	0.0 45	0.0928	0.00 35	0.06 78	0.00 32	637	12	576	10	870	50	576	yes
X3578_11	89	25.4	3.63	0.803	0.0 94	0.105	0.01 1	0.05 66	0.00 31	597	27 .5	640	32	480	65	640	no
X3578_12	62. 5	25.5	2.56	0.802	0.0 45	0.0918	0.00 44	0.06 24	0.00 24	595	12 .5	565	13	694	41 .5	565	yes
X3578_13	131	86	1.59	0.843	0.0 5	0.0887	0.00 33	0.06 89	0.00 3	617	13 .5	547	9. 5	872	44	547	yes
X3578_14	100 .7	40.8	2.4	0.75	0.0 35	0.0905	0.00 37	0.06 11	0.00 19	566	10	558	11	655	33 .5	558	yes
X3578_15	28. 5	14.2	1.98	1.5	0.1 4	0.1047	0.00 51	0.10 24	0.00 64	924	29	647	14	1650	60	647	yes
X3578_16	91. 6	59	1.76	0.954	0.0 55	0.0998	0.00 35	0.07 07	0.00 38	677	13 .5	613	10	910	55	613	yes
X3578_17	95. 6	11.81	8.4	0.812	0.0 54	0.0978	0.00 53	0.06 04	0.00 25	599	15	601	15 .5	592	47	601	yes
X3578_18	120	32.9	3.61	1.019	0.0 75	0.0985	0.00 55	0.07 37	0.00 42	707	19	605	16	1020	55	605	yes
X3578_19	48. 8	22.7	2.16	1.56	0.2 9	0.1001	0.00 51	0.11 2	0.01 7	910	60	614	15	1570	14 5	614	yes
X3578_20	88	28.4	3.34	0.775	0.0 52	0.0961	0.00 51	0.05 87	0.00 24	584	14 .5	591	15	564	45 .5	591	yes
X3578_21	104	41.8	2.48	1.033	0.0 61	0.1181	0.00 63	0.06 43	0.00 28	716	15 .5	718	18 .5	727	45 .5	718	yes
X3578_22	94. 7	44.4	2.26	0.823	0.0 68	0.0957	0.00 6	0.06 27	0.00 33	603	19	588	17 .5	690	55	588	yes
X3578_24	112 .9	38.3	3.07	5.48	0.4	0.316	0.01 8	0.12 76	0.00 58	1888	32	1762	43	2074	39 .5	207 4	yes
X3578_25	319	99	3.28	1.006	0.0 7	0.1118	0.00 6	0.06 72	0.00 33	714	17 .5	682	17 .5	835	47 .5	682	yes
X3578_26	81. 7	38.7	2.23	1.045	0.0 57	0.0979	0.00 5	0.07 55	0.00 22	731	15	602	14 .5	1076	30	602	yes
X3578_27	40. 8	17.3	2.52	2.67	0.2 4	0.229	0.01 5	0.08 36	0.00 41	1302	32 .5	1327	39	1272	49 .5	132 7	yes
X3578_28	173	53	3.22	1.4	0.1 6	0.139	0.01 6	0.07 57	0.00 37	880	35 .5	832	45 .5	1073	47 .5	832	yes
X3578_29	90. 3	23.3	4.05	0.833	0.0 56	0.097	0.00 54	0.06 29	0.00 34	611	15	596	16	670	55	596	yes
X3578_30	30	10.73	2.88	0.772	0.0 6	0.0958	0.00 61	0.06 08	0.00 38	576	17	589	18	630	65	589	yes

X3578_3 1	167	27	6.67	0.806	0.0 54	0.0998	0.00 57	0.05 98	0.00 23	602	16	613	16 .5	591	44	613	yes
X3578_3 2	154	88.8	1.85	0.792	0.0 75	0.0936	0.00 62	0.06 06	0.00 33	584	20 .5	576	18	630	65	576	yes
X3578_3 3	89. 5	11.68	8.9	0.812	0.0 8	0.0998	0.00 77	0.06 31	0.00 3	612	23 .5	612	22 .5	684	49 .5	612	yes
X3578_3 4	159	17.3	9.4	1.34	0.3 7	0.1026	0.00 57	0.09 1	0.02	763	39	629	16 .5	1170	13 5	629	yes
X3578_3 5	101 .6	53.6	2.05	0.933	0.0 72	0.1017	0.00 5	0.06 73	0.00 34	662	19	624	14 .5	874	47	624	yes
X3578_3 6	34. 2	9.7	3.94	0.758	0.0 57	0.1026	0.00 6	0.05 82	0.00 34	568	16 .5	629	17 .5	490	65	629	yes
X3578_3 7	154	44.4	3.8	0.915	0.0 69	0.1086	0.00 72	0.06 19	0.00 23	654	18	663	21	668	38 .5	663	yes
X3578_3 8	63. 6	14.25	4.6	0.84	0.0 6	0.1005	0.00 53	0.06 26	0.00 42	614	16 .5	617	15 .5	640	70	617	yes
X3578_3 9	95	23.4	4.02	0.757	0.0 58	0.0967	0.00 45	0.05 84	0.00 31	568	16	595	13	530	55	595	yes
X3578_4 0	51	19	2.82	6.86	0.5 9	0.389	0.02 6	0.12 87	0.00 62	2077	39 .5	2110	60	2056	43 .5	205 6	yes
X3578_4 1	204	59.4	3.52	0.817	0.0 53	0.0977	0.00 52	0.06 01	0.00 25	607	14	600	15 .5	614	44	600	yes
X3578_4 2	69. 1	21.9	3.31	12.98	0.7 1	0.531	0.02 4	0.17 86	0.00 46	2675	25	2740	50	2634	21 .5	263 4	yes
X3578_4 3	365	204	1.82	0.812	0.0 43	0.0945	0.00 37	0.06 22	0.00 26	601	12	582	11	672	45 .5	582	yes
X3578_4 4	127	28.6	6.2	0.959	0.0 58	0.0938	0.00 45	0.07 49	0.00 34	684	14 .5	578	13	1059	42 .5	578	yes
X3578_4 5	62. 9	18.2	3.5	0.94	0.1 2	0.0935	0.00 47	0.07 9	0.01 2	659	28	576	13 .5	830	70	576	yes
X3578_4 7	129 .9	37	3.44	0.841	0.0 68	0.0912	0.00 62	0.06 75	0.00 34	621	19	562	18 .5	840	50	562	yes
X3578_4 8	58. 2	16.3	3.97	0.808	0.0 58	0.1006	0.00 72	0.05 95	0.00 28	597	16	617	21	592	47	617	yes
X3578_5 0	233	56	3.03	1.28	0.1 3	0.106	0.01	0.08 78	0.00 53	821	29 .5	646	29 .5	1360	55	646	yes
X3578_5 1	187	44.4	4.68	0.758	0.0 73	0.0902	0.00 76	0.06 08	0.00 27	565	20 .5	555	22 .5	620	50	555	yes
X3578_5 2	293	123	2.35	0.954	0.0 75	0.1064	0.00 78	0.06 54	0.00 32	673	19 .5	658	23 .5	760	50	658	yes
X3578_5 3	91. 3	25.8	3.88	0.834	0.0 75	0.0951	0.00 63	0.06 24	0.00 31	621	20 .5	585	18 .5	670	55	585	yes
X3578_5 5	188	170	1.21	0.863	0.0 67	0.0966	0.00 75	0.06 37	0.00 28	625	18	593	22	705	46	593	yes
X3578_5 6	18. 1	18.7	1	1.63	0.3	0.0995	0.00 85	0.12 1	0.01 8	935	49 .5	610	25	1850	11 5	610	yes
X3578_5 7	74	19.5	4.08	0.735	0.0 69	0.0867	0.00 58	0.05 91	0.00 32	551	20	535	17 .5	600	55	535	yes
X3578_5 8	161	59.5	2.91	0.84	0.0 77	0.0979	0.00 55	0.06 18	0.00 38	610	21	601	16	620	65	601	yes
X3578_5 9	106	13.2	9.3	0.767	0.0 74	0.096	0.00 86	0.05 62	0.00 29	570	21	589	25	430	55	589	yes
X3578_6 0	64. 5	11.6	6.07	0.726	0.0 72	0.0919	0.00 84	0.05 84	0.00 37	556	22	565	24 .5	500	65	565	yes
X3578_6 1	77	21.2	3.98	0.719	0.0 57	0.0903	0.00 58	0.05 86	0.00 28	545	16 .5	556	17	560	55	556	yes
X3578_6 3	148	26	5.94	2.35	0.3 2	0.172	0.01 7	0.09 75	0.00 65	1271	48	1050	55	1520	70	105 0	no
X3578_6 4	38. 4	20.2	1.97	0.773	0.0 61	0.0946	0.00 59	0.05 99	0.00 35	589	18 .5	582	17 .5	610	60	582	yes
X3578_6 5	212	129	1.55	3.03	0.6	0.1141	0.00 72	0.20 9	0.04	1370	75	695	21	2650	16 5	695	yes
X3578_6 6	97. 9	25.3	3.86	0.824	0.0 85	0.0965	0.00 66	0.06 09	0.00 33	600	22 .5	601	20 .5	600	55	601	yes
X3578_6 7	99	54.6	2.29	0.9	0.1	0.0834	0.00 68	0.08 1	0.01 1	640	25 .5	515	20	1080	10 5	515	yes
X3578_6 8	41. 6	15.2	2.76	0.82	0.0 69	0.099	0.00 75	0.06 18	0.00 35	602	19	607	21 .5	650	65	607	yes
X3578_6 9	80. 6	29.9	2.86	1.57	0.1 7	0.1062	0.00 64	0.10 7	0.01	937	32 .5	650	18 .5	1700	85	650	yes
X3578_7 0	185	28.8	7.3	0.812	0.0 56	0.0979	0.00 57	0.06 05	0.00 2	599	15 .5	601	16 .5	605	36	601	yes

X3578_71	199	27.8	8.7	0.817	0.072	0.0975	0.0068	0.0606	0.0033	605	21	606	18.5	610	60	606	yes
X3578_72	90.3	12.8	8.5	0.784	0.053	0.0934	0.0057	0.0618	0.0023	589	15.5	575	17	665	41	575	yes
X3578_73	135	31.9	4.54	1.033	0.098	0.0995	0.0076	0.0746	0.0034	709	24	610	22	1091	47	610	yes
X3578_74	318	103	5.2	0.848	0.069	0.0831	0.0066	0.0751	0.0038	617	19	514	19.5	1060	55	514	yes
X3578_75	156	109	1.6	0.923	0.074	0.102	0.0061	0.0674	0.0038	666	18.5	625	18	830	55	625	yes
X3578_76	24	6.13	4.62	8.17	0.81	0.441	0.038	0.1372	0.0073	2211	44.5	2340	85	2199	46.5	2199	no
X3578_77	65.2	10.1	7.7	1.11	0.15	0.0986	0.0065	0.0781	0.0086	736	35	605	19	1020	105	605	yes
X3578_78	72.1	11	7.19	0.785	0.074	0.0926	0.0058	0.06	0.0052	587	22	576	18	630	85	576	yes
X3578_79	192	78.3	3.02	7.29	0.51	0.4	0.027	0.1373	0.0071	2175	35	2160	60	2200	43	2200	yes
X3578_80	64.9	22.6	3.29	0.869	0.087	0.1	0.0077	0.0612	0.004	625	23	613	22.5	620	70	613	yes
X3578_81	301	71	5.24	0.848	0.095	0.095	0.0095	0.0621	0.0031	612	25	583	28	710	60	583	yes
X3578_82	117	29.9	6.9	1.08	0.15	0.121	0.016	0.0624	0.0038	731	36	732	45.5	700	65	732	no
X3578_84	71.6	10.79	8.1	1	0.11	0.1152	0.008	0.0624	0.0043	688	28	701	23	660	75	701	yes
X3578_85	69.4	16.3	5.09	0.94	0.1	0.0975	0.0076	0.0709	0.0058	670	26.5	598	22.5	970	80	598	yes
X3578_86	169	16.5	27	0.799	0.062	0.0979	0.0058	0.0606	0.0034	591	17.5	601	17	600	65	601	yes
X3578_87	59.8	34	4.5	2.72	0.37	0.143	0.018	0.137	0.011	1300	50	857	49	2170	75	857	no
X3578_88	181	26.8	7.23	1.06	0.17	0.0967	0.0097	0.0752	0.0043	688	25.5	593	27.5	1100	60	593	yes
X3578_89	136	12.3	20.4	0.86	0.076	0.0982	0.0074	0.0599	0.0035	630	20	602	22	640	65	602	yes
X3578_90	190	31.3	5.9	0.91	0.11	0.1025	0.0083	0.0627	0.0046	645	29	627	24	660	80	627	yes
X3578_91	207	26.3	7.6	0.859	0.08	0.1041	0.0078	0.0582	0.0034	621	21	645	23.5	560	70	645	yes
X3578_92	79.9	11.2	8.4	0.799	0.079	0.0952	0.0083	0.0626	0.0043	596	21	584	24	640	70	584	yes
X3578_93	101.8	12.3	8.8	0.92	0.1	0.1082	0.0091	0.0625	0.0041	659	27.5	670	25	640	70	670	yes
X3578_94	90.5	20.8	5.26	1.88	0.23	0.0908	0.0075	0.15	0.015	1072	42.5	559	22	2320	90	559	yes
X3578_95	313	104.5	3.17	0.792	0.074	0.0932	0.0068	0.0614	0.003	585	20	573	20	660	50	573	yes
X3578_96	374	35.8	12.2	11.75	0.93	0.44	0.031	0.1879	0.0093	2560	36	2360	70	2732	40.5	2732	yes
X3578_97	207	22.5	10.8	0.923	0.064	0.1062	0.0066	0.0641	0.0033	659	17.5	650	19.5	730	55	650	yes
X3578_98	187	58	5.02	0.99	0.12	0.0949	0.0093	0.0739	0.0051	685	29	582	27.5	980	70	582	Yes
X3578_99	197	30.8	8.3	1	0.11	0.0928	0.009	0.0754	0.0058	690	28.5	570	26.5	1040	80	570	yes
X3578_100	116.8	56.9	2.17	1.048	0.088	0.0907	0.0059	0.0843	0.0053	735	23	559	17.5	1280	55	559	yes
X3578_101	77	30.9	2.83	0.86	0.14	0.102	0.013	0.0589	0.0041	603	36.5	624	38	540	70	624	no
X3578_102	159	14.1	12.2	1.3	0.12	0.1223	0.0096	0.0765	0.0045	834	26	742	27.5	1060	60	742	yes
X3578_103	84	28.5	3.38	1.64	0.22	0.0998	0.0091	0.122	0.014	966	44	611	26.5	1860	100	611	yes
X3578_104	167	31.1	6.08	6.95	0.7	0.379	0.03	0.1383	0.0086	2121	44.5	2060	70	2210	55	2210	yes
X3578_105	96.6	9.4	12.5	0.792	0.078	0.094	0.0072	0.0596	0.0037	598	22.5	586	22	570	65	586	yes
X3578_106	131	36.8	4.06	7.59	0.68	0.41	0.029	0.1342	0.0076	2194	42	2200	65	2170	55	2170	yes

X3578_108	247	73.2	3.75	4.14	0.35	0.246	0.019	0.1239	0.0063	1650	37	1412	47.5	1986	46.5	1986	yes
X3578_109	256	70	4.22	0.756	0.069	0.0931	0.0065	0.0595	0.0039	564	20.5	572	19	580	70	572	yes
X3578_110	174	48.4	3.85	0.942	0.082	0.1067	0.006	0.0643	0.0044	672	22	653	17.5	710	75	653	yes
X3578_111	165	60.5	3.24	5.5	0.72	0.331	0.045	0.1275	0.0064	1870	55	1810	10.5	2041	43	2041	yes
X3578_113	240	19.5	13.7	2.17	0.19	0.199	0.018	0.0832	0.005	1154	31	1180	50	1230	60	1180	yes
X3578_114	215	42.7	5.32	0.797	0.066	0.095	0.0063	0.0605	0.003	589	18.5	584	18.5	610	50	584	yes
X3578_115	161	38.5	4.9	0.82	0.088	0.096	0.01	0.0628	0.0026	606	23	589	30	678	44	589	no
X3578_116	151	37.3	3.9	0.952	0.089	0.0684	0.0043	0.1023	0.0087	670	22	426	13	1590	75	426	yes
X3578_117	202	137	1.53	0.822	0.078	0.0945	0.0078	0.0641	0.0038	608	22.5	580	23	720	60	580	yes
X3578_118	93.3	19.7	4.86	1.076	0.09	0.0964	0.0077	0.0822	0.004	733	21.5	592	22.5	1239	49	592	yes
X3578_119	67.7	20.7	3.11	0.791	0.065	0.0941	0.0055	0.0594	0.0037	586	18.5	579	16	560	65	579	yes
X3578_120	116.4	78.7	1.48	1.25	0.13	0.0982	0.0058	0.0938	0.0074	821	27	603	17	1470	75	603	yes
X3578_121	184	103	2.03	1.02	0.12	0.107	0.01	0.068	0.0041	700	28	653	29.5	870	60	653	yes
X3578_122	270	84.6	3.51	0.86	0.11	0.097	0.01	0.0634	0.0034	627	30.5	606	28	700	60	606	yes
X3578_123	95	25.7	3.77	0.785	0.073	0.0911	0.0072	0.0633	0.0036	580	21	561	21.5	680	65	561	yes
10566																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Best Age Ma	Used?
X10566_2	291	82.2	3.67	5.52	0.26	0.312	0.011	0.1287	0.0023	1897	20.5	1748	27.5	2078	15.5	2078	yes
X10566_3	358	117.8	3.08	0.882	0.08	0.0797	0.0019	0.0797	0.0062	635	20.5	494	5.5	1120	70	494	yes
X10566_4	83.2	18.4	4.83	0.696	0.031	0.0869	0.003	0.0587	0.0019	535	9.5	537	9	588	33	537	yes
X10566_5	97.1	49.2	1.98	1.28	0.24	0.0944	0.0033	0.099	0.015	812	47	581	9.5	1420	130	581	yes
X10566_6	246	107.5	2.27	0.822	0.042	0.0961	0.0039	0.0635	0.0019	617	13.5	591	11.5	714	31.5	591	yes
X10566_7	84	23.4	3.76	1.76	0.12	0.0986	0.0035	0.1267	0.0056	1022	21	606	10.5	2033	38.5	606	yes
X10566_8	312	152.5	2.08	0.806	0.042	0.0876	0.0032	0.0654	0.0017	598	12	541	9.5	791	25.5	541	yes
X10566_9	128.4	53.3	2.47	1.183	0.1	0.0924	0.0023	0.092	0.0064	791	23.5	569	7	1460	65	569	yes
X10566_10	435	271	1.81	0.763	0.04	0.0741	0.0029	0.0716	0.0029	574	11.5	464	8	988	44	464	yes
X10566_11	54.1	19.4	2.62	0.881	0.081	0.0927	0.0041	0.0684	0.0056	634	21.5	571	12	810	80	571	yes
X10566_12	126.7	80	1.66	0.848	0.046	0.0881	0.0024	0.0715	0.0032	621	12.5	544	7	974	45.5	544	yes
X10566_13	220	101.8	2.148	0.855	0.041	0.0905	0.0022	0.0695	0.0033	626	11	559	6.5	886	48	559	yes
X10566_14	124	34.4	3.46	1.1	0.13	0.0871	0.0037	0.0934	0.0087	762	33	538	11	1410	80	538	yes
X10566_15	70.2	36.3	1.903	0.934	0.05	0.0982	0.0032	0.0716	0.0026	668	13	604	9.5	975	35	604	yes
X10566_17	175	110	2.72	0.878	0.05	0.0968	0.0028	0.066	0.0025	637	13	596	8	789	38.5	596	yes
X10566_18	116.6	85.6	1.324	0.941	0.068	0.0967	0.0044	0.0748	0.0056	668	17.5	595	13	1000	70	595	yes
X10566_19	15.36	13.7	1.14	0.762	0.069	0.0852	0.0049	0.0658	0.0037	581	20	527	14.5	780	55	527	yes

X10566_20	257	238	1.079	1.025	0.044	0.102	0.0027	0.0722	0.0022	715	10.5	626	8	1004	30.5	626	yes
X10566_21	67.1	41.2	1.58	0.827	0.053	0.088	0.0044	0.0654	0.002	613	14	543	13	775	31	543	yes
X10566_22	173.7	60	2.88	0.891	0.043	0.1032	0.0044	0.0613	0.0012	651	11.5	632	13	655	19	632	yes
X10566_23	147	21.7	6.57	0.808	0.031	0.0965	0.003	0.0593	0.0013	603	9	593	9	588	24	593	yes
X10566_24	279	162	1.84	0.874	0.042	0.0975	0.0029	0.0662	0.0024	636	11	600	8.5	794	38	600	yes
X10566_25	57.4	16.2	3.52	1.197	0.086	0.1053	0.0063	0.0819	0.0048	793	19.5	644	18	1230	55	644	yes
X10566_26	129.4	14.09	8.7	3.59	0.15	0.2042	0.0058	0.1246	0.003	1548	16	1197	15.5	2018	21	1197	no
X10566_27	70.5	31.6	2.19	1.49	0.15	0.1004	0.004	0.1081	0.0081	909	29	616	12	1700	70	616	yes
X10566_28	298	190.2	1.54	0.887	0.034	0.105	0.0029	0.061	0.0014	646	9.5	644	8.5	641	26.5	644	yes
X10566_29	604	400	1.96	1.164	0.076	0.1054	0.0054	0.0797	0.0042	778	18	645	15.5	1170	55	645	yes
X10566_30	211	72.9	2.7	0.255	0.02	0.01683	0.00047	0.111	0.0075	230	8	107.6	1.5	1840	55	107.6	yes
X10566_31	229	985	0.234	1.38	0.26	0.0592	0.0031	0.156	0.025	830	55	371	9.5	2270	15.5	371	yes
X10566_32	96.8	17.41	5.47	0.726	0.031	0.0882	0.0023	0.0592	0.0014	553	9	545	7	567	25	545	yes
X10566_33	180	97	1.85	1.045	0.078	0.1043	0.0052	0.0727	0.0036	720	19	639	15	976	48.5	639	yes
X10566_34	34	9.42	3.57	3.55	0.39	0.1355	0.0063	0.181	0.014	1508	43	819	18	2640	60	819	no
X10566_35	109.6	33.3	3.27	0.624	0.044	0.0359	0.0012	0.1231	0.0069	489	13.5	227.4	3.85	2000	50	227.4	yes
X10566_36	82.8	8.24	9.39	1.145	0.075	0.1225	0.0059	0.0658	0.0021	770	17.5	744	17	788	34	744	yes
X10566_37	238	58.5	4.29	5.06	0.25	0.278	0.011	0.1283	0.0032	1824	21	1581	28.5	2071	22	2071	yes
X10566_38	320	102.6	3.28	0.787	0.037	0.0816	0.003	0.0685	0.0024	588	10.5	505	9	878	37	505	yes
X10566_39	212	32.6	6.58	1.1	0.059	0.0949	0.0025	0.0818	0.0039	750	14	584	7.5	1242	46	584	yes
X10566_40	479	166.6	2.99	0.8	0.037	0.0878	0.0036	0.0648	0.0015	602	10.5	542	10.5	762	24	542	yes
X10566_41	130.5	20.46	6.51	7.95	0.38	0.398	0.016	0.1431	0.0029	2218	21.5	2168	39	2266	17.5	2266	yes
X10566_42	184	67.3	2.75	0.903	0.053	0.0841	0.0035	0.0779	0.0027	650	14	520	10.5	1140	35	520	yes
X10566_43	38.7	21.4	1.852	1.74	0.13	0.1016	0.0028	0.1242	0.008	1035	20.5	624	8.5	2037	49	624	yes
X10566_47	82.2	49	1.738	1.201	0.076	0.0927	0.0021	0.0926	0.004	796	17.5	571	6	1473	40	571	yes
X10566_48	191.2	64.8	3.04	0.428	0.041	0.0424	0.0011	0.0714	0.0062	358	14	267.7	3.35	950	90	267.7	yes
ODP																	
ODP_1	28.3	19.9	1.369	2.203	0.15	0.0998	0.0052	0.1606	0.0062	1178	24	613	15.5	2463	30	613	yes
ODP_2	92.3	91.2	0.999	1.144	0.074	0.0893	0.0047	0.0944	0.0021	776	17	551.1	14	1512	21	551.1	yes
ODP_3	76	61.2	1.25	1.293	0.083	0.0934	0.005	0.1016	0.0037	841	18.5	576	14.5	1640	33.5	576	yes
ODP_4	211.2	79.5	2.69	1.104	0.083	0.0867	0.0046	0.0944	0.0034	757	19.5	535.8	13.5	1502	34	535.8	yes
ODP_5	141.3	169.3	0.868	1.081	0.071	0.0897	0.0049	0.0852	0.0024	742	17.5	554	14.5	1322	26.5	554	yes
ODP_6	132.1	170.8	0.795	1.071	0.069	0.0889	0.0048	0.0873	0.0025	738	17	549	14	1359	27	549	yes
ODP_7	104	96	1.104	1.065	0.065	0.0896	0.0046	0.0879	0.0017	735	16	553.3	13.5	1378	18.5	553.3	yes
ODP_8	444	220.1	2.072	1.55	0.18	0.097	0.0054	0.114	0.0096	932	37	597	16	1770	85	597	yes
ODP_9	183	190	0.962	1.865	0.14	0.0952	0.0054	0.1411	0.0053	1075	23.5	586	16	2227	33.5	586	yes

ODP_10	153.3	101.2	1.555	0.909	0.061	0.0799	0.0045	0.0815	0.0027	655	16.5	496	13.5	1221	33	496	yes
ODP_11	285.8	103	2.73	0.812	0.051	0.0841	0.0047	0.07	0.0015	603	14.5	520	14	922	22	520	yes
ODP_12	90.4	14.72	6.09	1.144	0.08	0.0829	0.0045	0.0987	0.0032	777	17.5	513	13.5	1589	30.5	513	yes
ODP_13	142.6	127.9	1.102	1.245	0.086	0.0895	0.0052	0.0993	0.0027	823	19	552	15.5	1612	24.5	552	yes
ODP_14	25.5	13.5	1.97	2.89	0.32	0.1045	0.0064	0.205	0.021	1361	39	641	18.5	2790	80	641	yes
ODP_15	129.4	98.6	1.41	0.976	0.074	0.0841	0.0052	0.0839	0.0028	689	19	520	15.5	1277	32	520	yes
ODP_16	181	41.3	4.52	0.757	0.061	0.0925	0.006	0.0578	0.0022	569	17.5	570	17.5	527	44	570	yes
ODP_17	20.76	3.11	7.19	2.53	0.2	0.099	0.0066	0.188	0.011	1276	29	608	19.5	2703	47	608	yes
ODP_18	9.19	2.26	4.24	4.91	0.4	0.1246	0.008	0.293	0.018	1796	34	756	23	3470	50	756	yes
ODP_19	126.3	46	2.95	1.05	0.075	0.0874	0.0052	0.0862	0.0033	727	18.5	540	15.5	1341	38	540	yes
ODP_20	267	77.2	3.6	0.794	0.051	0.0932	0.0051	0.0607	0.0013	595	15.5	574	15	632	24	574	yes
ODP_21	23.9	2.57	10.11	2.23	0.19	0.0907	0.0063	0.177	0.0088	1181	28	559	18.5	2603	42	559	yes
ODP_22	134.3	114.5	1.26	0.969	0.074	0.0794	0.0054	0.088	0.0035	685	19	492	16	1365	37.5	492	yes
ODP_23	315	43.8	7.64	0.743	0.048	0.088	0.0052	0.0602	0.0014	563	14	543	15.5	604	26	543	yes
ODP_25	131.5	128.8	1.089	1.222	0.09	0.0895	0.0054	0.0982	0.004	807	20.5	553	16	1572	38.5	553	yes
ODP_26	232	71.7	3.37	0.883	0.063	0.0823	0.0051	0.0769	0.0024	641	17	509	15	1117	29.5	509	yes
ODP_28	352	112	3.34	0.943	0.076	0.0889	0.0056	0.0751	0.0028	671	19.5	549	16.5	1081	38	549	yes
ODP_29	101.4	105.3	1.017	1.106	0.081	0.0902	0.0058	0.0886	0.0024	753	19.5	557	17	1396	24.5	557	yes
ODP_30	140.2	138.5	1.071	1.039	0.083	0.0893	0.0058	0.0837	0.003	726	22	551	17	1286	36	551	yes
ODP_31	215	79.5	2.73	0.773	0.058	0.0954	0.0062	0.058	0.0016	583	17	587	18	542	31	587	yes
ODP_32	179	234	0.77	1.06	0.088	0.0924	0.0065	0.0798	0.0022	729	21.5	569	19	1185	26.5	569	yes
ODP_34	55	37.7	1.45	1.546	0.11	0.1015	0.0062	0.1098	0.0051	950	23.5	623	18.5	1789	42.5	623	yes
ODP_35	109.9	109.9	0.972	1.407	0.11	0.0958	0.006	0.1062	0.0034	887	22.5	590	17.5	1748	29.5	590	yes
ODP_36	135.9	94.5	1.4	1.084	0.074	0.095	0.0056	0.0828	0.0026	744	18	585	16.5	1263	29.5	585	yes
ODP_37	107.3	74.3	1.45	1.046	0.089	0.0851	0.0056	0.0881	0.0028	734	22	526	16.5	1385	32	526	yes
ODP_38	260	119.6	2.15	0.851	0.062	0.1	0.0064	0.0615	0.0015	623	17	614	18.5	670	29	614	yes
ODP_39	427	124.1	3.5	0.78	0.054	0.0949	0.0057	0.0612	0.002	584	15.5	584	17	660	37	584	yes
ODP_40	96.6	30.5	3.31	1.237	0.093	0.0973	0.0061	0.0917	0.0037	813	21	602	17.5	1457	35.5	602	yes
ODP_41	71.6	71.7	1.053	1.292	0.094	0.1011	0.0064	0.0963	0.0035	839	21	620	18.5	1540	34.5	620	yes
ODP_42	427	117.3	3.92	0.893	0.063	0.0954	0.0055	0.0683	0.0018	646	17	587	16	885	26.5	587	yes
ODP_43	87.2	135.4	0.71	1.236	0.083	0.0996	0.0062	0.0884	0.0025	819	18	616	19	1393	29	616	yes
ODP_44	119	36.2	3.42	1.17	0.097	0.1026	0.0064	0.083	0.0034	781	22.5	629	18.5	1251	38.5	629	yes
ODP_45	130.8	51	2.59	1.241	0.1	0.1009	0.0067	0.0918	0.0038	814	23	619	19.5	1470	38.5	619	yes
ODP_46	281	68.7	4.2	1.061	0.097	0.1035	0.0074	0.0754	0.0035	735	24.5	634	21.5	1070	47.5	634	yes
ODP_47	90.3	29.2	3.13	1.215	0.086	0.1022	0.006	0.0867	0.0025	809	20.5	627	17.5	1365	30	627	yes
ODP_48	132.3	43.5	2.96	1.209	0.082	0.099	0.0055	0.0879	0.002	802	19	609	16	1382	21	609	yes

ODP_49	88.7	92.8	0.966	1.43	0.14	0.097	0.0064	0.1086	0.0064	892	28	596	19	1760	50	596	yes
ODP_50	145.7	113.9	1.323	1.389	0.11	0.0984	0.0054	0.1029	0.0052	885	22.5	605	16	1694	46.5	605	yes
ODP_51	20.8	5.82	3.5	5.14	0.46	0.1379	0.0086	0.271	0.016	1833	37	832	24.5	3318	40.5	832	yes
ODP_52	44.8	23.5	1.87	1.693	0.13	0.1071	0.0068	0.1181	0.0039	1012	24.5	656	20	1915	30	656	yes
ODP_53	202	59.6	3.34	1.007	0.072	0.0976	0.0057	0.0759	0.0017	705	18.5	600	17	1086	22.5	600	yes
ODP_55	65.1	38.7	1.59	1.469	0.12	0.1045	0.0066	0.1023	0.0062	912	24	640	19.5	1640	50	640	yes
ODP_56	193	69.2	2.83	1.018	0.078	0.0973	0.0064	0.0752	0.0021	710	19.5	598	19	1065	28	598	yes
ODP_57	202	121.2	1.69	1.07	0.077	0.0999	0.0063	0.0774	0.0026	736	18.5	614	18.5	1132	31	614	yes
ODP_58	66	66.4	0.996	1.453	0.1	0.1063	0.006	0.1016	0.0046	919	21	651	17.5	1633	42	651	yes
ODP_59	119.8	154.7	0.796	1.079	0.076	0.0928	0.0054	0.0842	0.0029	744	19	572	16	1284	33.5	572	yes
ODP_60	211.6	156.7	1.39	0.972	0.069	0.0901	0.0056	0.0782	0.0022	691	18.5	556	16.5	1151	28.5	556	yes
ODP_61	207.9	59	3.66	0.928	0.067	0.0905	0.006	0.0742	0.0022	668	18	558	17.5	1038	30	558	yes
ODP_62	194	64.4	3.14	1.089	0.099	0.0972	0.0069	0.0821	0.0041	744	23.5	598	20	1226	47.5	598	yes
ODP_63	33.5	21.3	1.65	1.895	0.14	0.0979	0.0065	0.1428	0.0068	1075	24.5	601	19	2242	40.5	601	yes
ODP_64	104.6	82.4	1.32	1.1	0.084	0.0932	0.0055	0.0845	0.0031	750	20	574	16.5	1290	34.5	574	yes
ODP_65	84.1	71.1	1.232	1.376	0.1	0.0947	0.0059	0.1066	0.0042	875	22	583	17.5	1727	35.5	583	yes
ODP_66	54.9	25.5	2.19	1.596	0.12	0.0955	0.0062	0.1229	0.004	976	24	588	18.5	1997	29.5	588	yes
ODP_67	148.3	66.9	2.22	1.235	0.088	0.0873	0.0052	0.1036	0.004	814	20	539	15.5	1688	36.5	539	yes
ODP_69	111.4	111	1.048	1.118	0.085	0.0807	0.0047	0.101	0.0044	764	19	500	14	1622	39	500	yes
ODP_70	177.7	113.4	1.61	0.929	0.067	0.0798	0.0046	0.0852	0.0031	674	18	495	14	1306	34.5	495	yes
ODP_71	140.1	134.4	1.1	1.072	0.079	0.0774	0.0055	0.1003	0.0043	737	19	480	16.5	1611	38.5	480	yes
ODP_72	114.1	118.5	1	1.121	0.094	0.0838	0.0054	0.095	0.0037	758	22	518	16	1510	36.5	518	yes
ODP_73	376	150.6	2.54	0.761	0.054	0.078	0.0045	0.0699	0.0019	576	15	484	13.5	946	28.5	484	yes
ODP_74	144.7	66.3	2.29	1.012	0.075	0.0819	0.0048	0.0875	0.0034	707	18.5	507	14.5	1354	38.5	507	yes
ODP_75	243	62.2	4.01	0.873	0.067	0.0806	0.0049	0.0778	0.0033	634	18	499	14.5	1100	34.5	499	yes
ODP_76	80.3	28.9	2.8	1.284	0.098	0.0844	0.0055	0.1136	0.0055	841	23.5	522	16.5	1848	42	522	yes
ODP_78	51.5	23.5	2.25	1.87	0.16	0.0942	0.0053	0.1393	0.007	1064	28	580	15.5	2197	43	580	yes
ODP_79	132.6	49.5	2.8	1.163	0.084	0.0869	0.0052	0.095	0.0032	781	19.5	537	15.5	1528	29.5	537	yes
ODP_83	101.5	70.3	1.433	1.579	0.13	0.0915	0.0054	0.1266	0.006	963	26	564	16	2045	41	564	yes
ODP_85	151.2	120.5	1.223	1.014	0.071	0.0854	0.0048	0.0854	0.0032	709	17.5	528	14.5	1310	35	528	yes
ODP_86	136	112.7	1.173	1.36	0.13	0.0885	0.0052	0.1128	0.0076	862	27	547	15	1800	60	547	yes
ODP_88	297	86.5	3.29	0.858	0.061	0.0828	0.0051	0.0751	0.0018	627	17	513	15	1066	23.5	513	yes
ODP_89	265	59.4	4.32	0.869	0.058	0.0799	0.0045	0.0767	0.0027	633	16	495	13.5	1111	33.5	495	yes
ODP_90	100.8	98.4	1.008	1.174	0.1	0.09	0.005	0.0944	0.0057	783	22.5	555	15	1500	55	555	yes
ODP_91	262	192	1.418	0.893	0.058	0.0849	0.0047	0.0757	0.0018	647	15.5	525	14	1091	21.5	525	yes
ODP_92	131	94	1.47	1.85	0.19	0.0935	0.0055	0.1394	0.0091	1058	32.5	580	15	2200	55	580	yes

ODP_93	137.9	142.1	1.005	0.965	0.07	0.0824	0.005	0.0833	0.0031	683	18	513	15.5	1261	36	513	yes
ODP_94	155.6	157.6	1.102	0.913	0.06	0.079	0.0045	0.0826	0.002	660	16.5	490	13.5	1254	24	490	yes
ODP_96	152.4	118	1.36	1.208	0.085	0.0888	0.0053	0.0974	0.0031	802	19	548	15.5	1563	30.5	548	yes
ODP_97	167.5	151.9	1.224	0.897	0.061	0.0789	0.0043	0.0822	0.0024	652	17	489	13	1239	29.5	489	yes
ODP_98	32.3	16.28	2.21	2.71	0.22	0.0938	0.0054	0.204	0.011	1321	30.5	577	16	2838	42.5	577	yes
ODP_99	166.2	159.4	1.135	0.978	0.08	0.0797	0.0046	0.0871	0.0038	688	20.5	494	14	1367	40.5	494	yes
ODP_100	178	59.9	3.14	1.015	0.065	0.0826	0.0045	0.0887	0.003	710	16	512	13	1370	27	512	yes
ODP_101	588	175	3.4	0.829	0.067	0.0848	0.0055	0.0684	0.0031	610	18.5	525	16.5	858	44.5	525	yes
ODP_102	123.7	121.7	1.014	0.967	0.07	0.0762	0.0047	0.091	0.0041	684	18	473	14	1423	41.5	473	yes
ODP_103	353	106.5	3.36	0.669	0.046	0.0824	0.0051	0.0594	0.0017	522	14.5	510	15	581	32	510	yes
ODP_104	225	131.2	1.64	0.866	0.064	0.0798	0.0046	0.0783	0.0022	631	17	495	14	1146	28.5	495	yes
ODP_105	111.2	76	1.45	1.45	0.13	0.0873	0.0053	0.1215	0.0062	901	26	539	15.5	1984	43.5	539	yes
ODP_107	206	225	0.856	1.064	0.078	0.0831	0.0048	0.0922	0.0032	733	19	514	14.5	1458	32.5	514	yes
ODP_108	268	145.4	1.77	1.19	0.084	0.0829	0.0047	0.1071	0.0034	801	18	513	14	1740	29.5	513	yes
ODP_109	178.1	122.3	1.417	1.036	0.075	0.0809	0.0051	0.0925	0.0032	719	18.5	501	15	1465	33	501	yes
778																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Best Age Ma	Used?
X778_2	141.4	95.8	1.492	0.805	0.051	0.0893	0.0029	0.0652	0.0035	596	14	551	8.5	750	55	551	yes
X778_3	157	46.2	3.4	0.712	0.031	0.0897	0.003	0.0583	0.0016	551	7	554	9	530	31.5	554	yes
X778_4	69	33.9	1.79	0.819	0.074	0.098	0.0044	0.0625	0.0039	611	18.5	603	13	650	65	603	yes
X778_5	58.9	152.2	0.389	0.88	0.1	0.0872	0.0027	0.0715	0.0073	629	25	539	8	890	100	539	yes
X778_6	90	30.56	2.96	0.737	0.04	0.0868	0.0031	0.0625	0.0032	565	12.5	536	9.5	660	50	536	yes
X778_8	199	25.3	7.69	2.01	0.11	0.1491	0.0058	0.0996	0.0029	1126	18.5	896	16	1619	26.5	896	no
X778_9	60.8	73.8	0.811	0.971	0.071	0.0926	0.0031	0.0745	0.0052	684	17.5	570	9	1060	70	570	yes
X778_10	271	109	2.545	0.682	0.023	0.0822	0.0028	0.0592	0.0014	527	7	509	8.5	575	25.5	509	yes
X778_11	262.8	73.4	3.59	0.676	0.026	0.0641	0.0022	0.0765	0.0025	524	7.5	400.6	7	1098	32.6	400.6	yes
X778_12	62.6	42	1.529	0.738	0.036	0.0888	0.003	0.0618	0.0025	559	10.5	548	8.5	659	44.5	548	yes
X778_13	125.1	746	1.62	0.536	0.03	0.052	0.0027	0.077	0.0028	435	9.5	326	8.5	1115	37	326	yes
X778_14	117	21.7	4.93	0.849	0.049	0.0941	0.0043	0.0647	0.0026	621	13	579	12.5	746	43	579	yes
X778_15	667	159	5.8	0.688	0.035	0.0777	0.0042	0.0661	0.004	537	12.5	482	12.5	780	55	482	yes
X778_16	137.6	74.2	1.946	0.715	0.026	0.0845	0.0025	0.0614	0.002	547	7.5	522.7	7.5	642	33.5	522.7	yes
X778_17	165.4	154.2	1.088	0.742	0.032	0.0902	0.0032	0.0593	0.0023	562	9.5	557	9.5	598	42.5	557	yes
X778_18	20.89	24.65	0.852	1.15	0.2	0.0884	0.0037	0.093	0.015	727	37.5	546	11	1240	13.5	546	yes
X778_19	320.7	186.4	1.727	0.928	0.045	0.0929	0.0028	0.0728	0.0034	665	11.5	572.5	8	984	45.5	572.5	yes
X778_20	540	404	1.41	2.49	0.22	0.1353	0.0058	0.133	0.012	1259	32	818	16.5	2100	75	818	no

X778_21	152 .4	17.64	8.5	0.738	0.0 25	0.0866	0.00 29	0.06 16	0.00 18	560	7. 5	535	8. 5	649	31 .5	535	yes
X778_22	40. 6	30.15	1.351	2.546	0.0 84	0.2166	0.00 79	0.08 58	0.00 32	1283	12	1263	21	1320	35 .5	132 0	yes
X778_23	120 .5	24.29	5.01	0.935	0.0 33	0.0903	0.00 3	0.07 49	0.00 25	669	8. 5	557	9	1053	33 .5	557	yes
X778_24	227	201	1.118	0.896	0.0 36	0.0912	0.00 28	0.07 13	0.00 29	648	9. 5	563	8. 5	975	44	563	yes
X778_25	269	283	1.002	0.829	0.0 32	0.0988	0.00 4	0.06 1	0.00 16	616	9. 5	607	11 .5	631	28	607	yes
X778_26	102 .5	34.4	2.97	0.788	0.0 42	0.0906	0.00 32	0.06 21	0.00 3	588	12	559	9. 5	651	50	559	yes
X778_27	144	53.4	2.604	0.717	0.0 22	0.0893	0.00 3	0.05 8	0.00 17	548	6. 5	554	9. 5	517	33	554	yes
X778_28	156 .8	53.4	2.93	0.705	0.0 31	0.0833	0.00 3	0.06 07	0.00 28	540	9. 5	515	9	622	47	515	yes
X778_29	195	36.6	5.28	0.853	0.0 37	0.0906	0.00 34	0.06 85	0.00 28	630	11	559	10	865	41	559	yes
X778_30	32	18.1	1.809	0.719	0.0 46	0.0885	0.00 32	0.05 97	0.00 36	547	13	547	9. 5	550	60	547	yes
X778_31	107 .4	28.33	3.82	0.892	0.0 42	0.101	0.00 39	0.06 35	0.00 25	645	11	620	11 .5	709	39 .5	620	yes
X778_32	59. 8	45.2	1.362	0.865	0.0 61	0.0914	0.00 38	0.07 07	0.00 46	628	16	564	11	900	65	564	yes
X778_33	83	53.7	1.61	0.707	0.0 29	0.0801	0.00 26	0.06 35	0.00 26	542	8. 5	497	8	723	39 .5	497	yes
X778_34	99. 6	39.89	2.54	0.744	0.0 43	0.0873	0.00 33	0.06 15	0.00 19	563	7	539	9. 5	647	32 .5	539	yes
X778_36	121	75	1.78	0.75	0.0 44	0.0929	0.00 43	0.05 93	0.00 28	565	12 .5	573	12 .5	551	50	573	yes
X778_37	177 .1	66	2.73	0.718	0.0 26	0.0857	0.00 3	0.06 18	0.00 26	549	7. 5	530	9	646	42	530	yes
X778_38	212	30.5	6.67	0.954	0.0 35	0.1117	0.00 39	0.06 16	0.00 17	679	9	683	11 .5	662	31	683	yes
X778_39	525	114	5.4	0.752	0.0 23	0.0892	0.00 36	0.06 18	0.00 14	569	6. 5	551	10 .5	671	23 .5	551	yes
X778_40	91. 1	32.03	2.94	0.699	0.0 32	0.0861	0.00 3	0.05 89	0.00 22	537	9. 5	532	9	547	40	532	yes
X778_41	755	508	1.542	0.642	0.0 17	0.0582	0.00 2	0.07 88	0.00 18	502. 9	5. 5	364.9	6	1163	23	364 .9	yes
X778_42	61. 3	18.17	3.5	0.719	0.0 35	0.0855	0.00 32	0.06 13	0.00 24	549	10	528	9. 5	649	39	528	yes
X778_43	353	25.9	14.9	0.715	0.0 22	0.0878	0.00 36	0.05 98	0.00 17	547	6. 5	542	10 .5	585	30	542	yes
X778_44	166	102	1.608	0.826	0.0 29	0.0907	0.00 32	0.06 64	0.00 2	610	8	560	9. 5	807	31	560	yes
X778_45	357	196	1.787	0.694	0.0 18	0.082	0.00 26	0.06 06	0.00 15	535	5. 5	507.9	7. 5	617	26 .5	507 .9	yes
X778_46	153 .5	67.1	2.306	0.89	0.0 43	0.0933	0.00 37	0.06 88	0.00 27	644	11 .5	575	11	890	41	575	yes
X778_47	69	27	2.7	1.166	0.0 9	0.087	0.00 29	0.09 74	0.00 81	778	20	538	8. 5	1510	75	538	yes
X778_48	153 .1	59.9	2.62	0.78	0.0 4	0.0878	0.00 33	0.06 25	0.00 27	583	11 .5	546	10 .5	670	46	546	yes
X778_49	116	128.2	0.96	0.727	0.0 29	0.0857	0.00 3	0.06 06	0.00 24	554	8. 5	530	9	604	41 .5	530	yes
X778_50	216	74	2.96	6.57	0.1 8	0.3668	0.01 2	0.13	0.00 21	2057	12	2013	28 .5	2097	14	209 7	yes
X778_51	185	33.5	8.2	6.94	0.2	0.374	0.01 4	0.13 37	0.00 28	2101	12 .5	2045	33	2144	17 .5	214 4	yes
X778_52	109 .7	111.5	0.998	1.35	0.1 2	0.0938	0.00 39	0.10 82	0.00 81	869	27 .5	578	11 .5	1740	60	578	yes
X778_53	80. 2	59.1	1.61	0.382	0.0 69	0.0317	0.00 13	0.09	0.01 6	318	23 .5	200.9	4. 05	1160	14 5	200 .9	yes
X778_54	251	115.6	2.35	0.754	0.0 3	0.0912	0.00 31	0.05 92	0.00 18	569	9	563	9	564	32	563	yes
X778_55	81. 7	49.5	1.69	1.11	0.1 4	0.0946	0.00 38	0.08 8	0.01 1	740	33 .5	583	11 .5	1230	11 5	583	yes
X778_56	337	215	1.619	4.83	0.2 1	0.2388	0.00 99	0.14 43	0.00 34	1790	17 .5	1379	26	2276	20 .5	227 6	no
X778_57	203 .4	79.8	2.7	0.842	0.0 3	0.0982	0.00 34	0.06 19	0.00 2	619	8. 5	604	10	659	33 .5	604	yes

X778_58	766	51.2	15.3	0.819	0.023	0.0998	0.0031	0.0604	0.0014	607	6.5	613	9	613	24.5	613	yes
X778_59	29.2	14.77	1.992	1.33	0.26	0.0918	0.0037	0.1	0.018	820	50	566	11	1490	180	566	yes
X778_60	253	54.8	4.81	4.53	0.16	0.2645	0.0091	0.1254	0.0028	1737	14.5	1512	23	2030	20	2030	yes
X778_61	56.6	23.8	2.46	0.905	0.091	0.0933	0.0035	0.0715	0.0075	644	23	575	10	850	100	575	yes
X778_62	69.3	17.64	4	0.904	0.063	0.0936	0.0034	0.0721	0.0056	649	16	577	10	920	75	577	yes
X778_64	64.9	32.8	2.027	13.19	0.49	0.526	0.022	0.182	0.0035	2694	17	2722	45.5	2673	15.5	2673	yes
X778_65	64.9	15.8	5.7	1.423	0.092	0.1044	0.0034	0.101	0.0062	892	19.5	640	10	1640	55	640	yes
X778_66	54.8	27.1	2.066	0.884	0.097	0.0941	0.0031	0.0674	0.0069	632	24.5	580	9	830	115	580	yes
X778_67	410	85.8	4.94	0.832	0.038	0.0884	0.0024	0.0693	0.0036	613	10.5	545.9	7	853	46	545.9	yes
X778_68	105.5	62.3	1.734	0.888	0.074	0.092	0.0042	0.0715	0.0055	639	19	567	12.5	910	75	567	yes
X778_69	53.2	11.88	4.63	0.93	0.1	0.0968	0.0034	0.0692	0.0083	653	25.5	595	10	770	105	595	yes
X778_70	90.9	31.4	3.06	6.17	0.22	0.348	0.014	0.128	0.003	2004	16.5	1922	34.5	2074	21.5	2074	yes
X778_71	74.9	64.1	1.183	0.938	0.077	0.1067	0.0034	0.0643	0.0049	665	19.5	653	10	680	75	653	yes
X778_72	193	52.3	3.69	1.714	0.06	0.172	0.0058	0.0733	0.0017	1012	11	1023	16	1017	24	1023	yes
X778_73	157	43.1	3.62	0.757	0.032	0.0938	0.0033	0.0593	0.0024	578	9.5	578	10	557	44	578	yes
X778_74	121.1	68	1.775	6.12	0.22	0.3505	0.011	0.1255	0.0029	1989	15	1936	27	2032	20.5	2032	yes
X778_75	112	50.4	2.318	0.905	0.06	0.0914	0.0028	0.0716	0.0049	650	16	563.8	8	940	70	563.8	yes
X778_76	68.8	32.3	2.15	0.806	0.078	0.0917	0.0039	0.0645	0.0059	592	20.5	566	11.5	670	90	566	yes
X778_77	130.6	60.9	2.22	0.72	0.034	0.089	0.0036	0.0607	0.003	549	10	549	10.5	630	50	549	yes
X778_78	12.5	10.84	1.135	2.18	0.29	0.1203	0.0067	0.128	0.016	1155	44.5	722	16.5	1970	130	722	yes
X778_79	137	53.2	2.49	1.051	0.056	0.0978	0.0036	0.0793	0.0039	726	13.5	602	10.5	1170	50	602	yes
X778_80	110.8	42.1	2.594	0.908	0.037	0.1035	0.0036	0.0634	0.0026	654	9.5	635	10.5	718	44	635	yes
X778_81	58.3	48.3	1.266	0.865	0.09	0.0959	0.003	0.0669	0.0068	623	23.5	590	9	730	100	590	yes
X778_82	81.1	33.2	2.552	0.848	0.062	0.0909	0.0028	0.068	0.0047	619	16.5	561	8.5	820	70	561	yes
X778_83	374	196	1.967	0.747	0.026	0.0795	0.0032	0.0677	0.0022	565	7.5	493	9.5	862	32	493	yes
X778_84	79.1	25.9	3.23	0.789	0.034	0.095	0.0029	0.0611	0.002	589	9.5	585	8.5	632	35	585	yes
X778_85	101.5	78.4	1.282	0.78	0.035	0.0886	0.003	0.0635	0.002	584	9.5	547	9	715	33	547	yes
X778_87	169.4	91	2.11	0.766	0.037	0.0877	0.0033	0.0639	0.0026	575	10.5	542	10	718	41.5	542	yes
X778_88	89.3	61.9	1.51	0.764	0.034	0.086	0.0031	0.0644	0.0027	575	9.5	532	9.5	735	43.5	532	yes
X778_89	95.4	33.6	2.78	0.776	0.023	0.0912	0.0025	0.0618	0.0018	582	6.5	562.3	7.5	668	32	562.3	yes
X778_90	210	84.7	2.47	0.832	0.032	0.0887	0.0029	0.0689	0.0022	613	9	548	8.5	884	33	548	yes
X778_91	158	83.2	1.945	0.767	0.027	0.0896	0.0031	0.0639	0.0018	577	7.5	553	9	728	29.5	553	yes
X778_93	247	118	52	0.787	0.026	0.0846	0.0034	0.0695	0.0034	589	7.5	523	10	887	48	523	yes
X778_94	116.7	53.8	2.119	6.57	0.12	0.3672	0.011	0.1313	0.0022	2055	8.5	2016	25.5	2118	15.5	2118	yes
X778_95	226.2	102.9	2.206	5.504	0.11	0.3222	0.0094	0.1247	0.0017	1900	9	1800	23	2031	13.5	2031	yes
X778_96	212	83	4.1	0.742	0.02	0.0884	0.0025	0.0618	0.0017	563	5.5	545.9	7.5	657	29.5	545.9	yes

X778_97	73.3	52.1	1.54	0.83	0.052	0.0945	0.0028	0.0643	0.0035	610	13.5	582	8.5	720	50	582	yes
X778_98	122	61.1	2.09	0.795	0.035	0.0934	0.0028	0.0638	0.0035	593	9.5	575.5	8	676	43	575.5	yes
X778_99	204.8	83	2.477	0.733	0.018	0.0881	0.0025	0.0608	0.0014	558.2	5.5	544.4	7.5	627	25	544.4	yes
X778_100	164.5	30.3	5.5	1.424	0.05	0.1309	0.004	0.0804	0.002	897	10.5	793	11.5	1200	24	793	yes
X778_101	88.8	25.3	3.62	1.129	0.062	0.0977	0.0031	0.0827	0.0043	769	14	601	9	1320	65	601	yes
X778_102	50	40.7	1.298	2.68	0.1	0.2165	0.0058	0.0902	0.0031	1321	14	1263	15.5	1418	31.5	1418	yes
X778_103	705	549	1.332	0.8	0.033	0.0736	0.0033	0.0808	0.0028	595	9	458	10	1204	34	458	yes
X778_104	897	290	3.01	0.622	0.03	0.0508	0.0016	0.0875	0.0034	490	9.5	319.7	5	1373	35	319.7	yes
X778_105	223	286	0.764	1.259	0.06	0.0893	0.0031	0.1055	0.005	839	13.5	551	9.5	1711	45	551	yes
X778_106	45	30.5	1.491	1.079	0.081	0.0896	0.0026	0.0862	0.0057	737	19	552.9	7.5	1300	60	552.9	yes
X778_107	74.6	17.7	4.34	1.23	0.12	0.0965	0.0033	0.0919	0.0077	800	26	594	10	1400	75	594	yes
X778_108	166	33.63	4.82	0.825	0.037	0.0995	0.0036	0.0601	0.0019	609	10	611	10.5	594	34	611	yes
X778_109	631	99.1	6.3	1.029	0.019	0.1162	0.0033	0.06434	0.001	718.2	4.9	708.7	9.5	751	17	708.7	yes
X778_110	103.2	54.2	1.871	1.406	0.07	0.105	0.003	0.0975	0.0046	888	14.5	643.6	9	1555	42.5	643.6	yes
X778_111	52.8	35.3	1.516	0.798	0.032	0.0935	0.0026	0.062	0.003	594	9	576.1	8	667	49	576.1	yes
X778_112	49.9	18.91	2.605	0.235	0.025	0.0327	0.0011	0.0511	0.0053	213	10	207.4	3.5	200	95	207.4	yes
X778_113	102.4	28.24	3.67	0.772	0.025	0.0943	0.0025	0.0592	0.002	580	7	580.8	7.5	571	36.5	580.8	yes
15095																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Best Age Ma	Used?
X15095_2	178	180	1.12	0.655	0.19	0.0893	0.0067	0.058	0.014	505	60	550	19.5	524	25.5	550	yes
X15095_3	127	39.1	3.16	0.706	0.21	0.0893	0.0052	0.0605	0.015	539	60	551	15.5	624	29.0	551	yes
X15095_4	185	87.7	2.1	0.684	0.2	0.0926	0.0056	0.0578	0.014	525	60	570	16.5	513	26.0	570	yes
X15095_5	91.3	15.9	5.53	0.691	0.2	0.0919	0.0051	0.0598	0.015	535	60	566	15	568	26.5	566	yes
X15095_7	87	33.5	2.55	0.647	0.19	0.0925	0.0073	0.0581	0.014	501	60	569	21.5	540	28.5	569	yes
X15095_8	305	108.7	2.69	0.605	0.18	0.0846	0.0044	0.0587	0.015	478	55	523	13	554	25.0	523	yes
X15095_9	106	25.3	5.7	0.742	0.23	0.0931	0.008	0.0647	0.016	550	65	573	23.5	750	26.0	573	yes
X15095_10	119	20.7	12.2	0.716	0.22	0.0995	0.0094	0.0583	0.015	534	65	609	27.5	510	26.5	609	yes
X15095_11	310	19.3	18.6	1.25	0.37	0.1321	0.0084	0.0755	0.019	835	80	805	24.5	1081	23.5	805	yes
X15095_12	489	74.4	6.2	0.669	0.2	0.0891	0.007	0.0575	0.014	514	60	549	21	513	25.5	549	yes
X15095_13	325	140	2.69	6.36	1.9	0.378	0.028	0.1286	0.032	2005	13.5	2060	65	2071	22.5	2071	no
X15095_14	480	399	1.15	0.759	0.24	0.0872	0.0085	0.0603	0.015	562	65	537	25	591	26.5	537	yes
X15095_15	77.5	26.1	3.41	1.23	0.38	0.1055	0.0081	0.0889	0.023	827	80	645	23.5	1360	24.0	645	yes
X15095_16	178	66.7	2.75	0.788	0.23	0.0962	0.0067	0.0585	0.014	589	70	591	19.5	558	25.0	591	yes
X15095_17	311	45.5	8.9	6.61	2.1	0.361	0.034	0.124	0.031	2000	13.0	1970	80	2027	24.0	2027	no
X15095_18	105	30.6	4.09	6.78	2.2	0.377	0.03	0.124	0.032	2080	15.0	2050	70	2000	23.5	2000	no

X15095_19	263	108	2.34	0.917	0.28	0.11	0.0081	0.0584	0.015	657	70	672	23.5	533	265	672	yes
X15095_20	139	14.3	8.7	0.829	0.25	0.1	0.007	0.0587	0.015	603	70	613	20.5	520	265	613	yes
X15095_21	611	59.8	10.5	6.9	2.2	0.356	0.043	0.1346	0.034	2040	145	1940	100	2140	215	2140	yes
X15095_22	71.2	26.8	2.61	0.919	0.27	0.1096	0.007	0.0605	0.015	655	70	670	20.5	616	280	670	yes
X15095_23	112	34.2	3.55	0.9	0.28	0.1051	0.0083	0.0595	0.015	635	75	642	24	560	275	642	yes
X15095_24	125	48.6	2.5	0.811	0.24	0.0993	0.0062	0.0603	0.015	598	65	610	18.5	595	265	610	yes
X15095_25	195	63	3.31	0.812	0.25	0.0944	0.0085	0.065	0.015	598	70	580	25	570	270	580	yes
X15095_26	224	28.9	7.6	0.868	0.26	0.1039	0.0078	0.0594	0.015	625	70	636	22.5	574	275	636	yes
X15095_27	180	98	1.76	0.797	0.23	0.0944	0.0052	0.062	0.015	596	65	581	15	669	270	581	yes
X15095_28	85.5	14.5	5.98	0.754	0.22	0.0983	0.0067	0.0588	0.015	566	65	603	19.5	537	270	603	yes
X15095_29	216	50.6	3.86	0.821	0.24	0.097	0.0059	0.0612	0.015	608	65	603	18.5	623	255	603	yes
X15095_30	87.7	104.2	0.82	2.11	0.63	0.1918	0.011	0.0777	0.019	1136	100	1129	30.5	1159	250	1129	yes
X15095_31	209	12.7	16.3	0.755	0.23	0.094	0.0066	0.0576	0.014	571	60	578	19.5	495	275	578	yes
X15095_34	76.2	40.2	1.96	0.863	0.26	0.0981	0.0068	0.0644	0.016	645	65	602	20	760	280	602	yes
X15095_35	346	44.7	8.9	0.94	0.31	0.115	0.016	0.0575	0.014	642	75	674	40	500	280	674	no
X15095_36	194	39.8	4.67	7.79	2.4	0.433	0.037	0.1278	0.032	2160	135	2300	80	2062	215	2062	no
X15095_38	250	167	1.83	3.44	1.1	0.266	0.023	0.0919	0.023	1501	115	1520	60	1469	225	1469	no
X15095_39	48.6	32.8	1.61	0.926	0.28	0.1058	0.0076	0.0636	0.016	656	70	647	22	680	250	647	yes
X15095_40	128.7	82	1.48	0.846	0.26	0.0933	0.0064	0.0629	0.016	618	70	574	19	650	260	574	yes
X15095_41	34.1	15.5	2.21	0.93	0.32	0.099	0.012	0.0638	0.017	654	80	605	34	650	265	605	no
X15095_42	126	24	5.4	0.81	0.25	0.103	0.0085	0.0564	0.014	597	70	630	24.5	450	285	630	yes
X15095_43	141	50.5	2.62	0.79	0.24	0.0991	0.0073	0.0582	0.014	590	65	608	21.5	547	250	608	yes
X15095_44	157	50.1	3.8	0.76	0.24	0.097	0.011	0.0564	0.014	568	70	595	30.5	460	255	595	no
X15095_45	161	65	4.2	0.8	0.26	0.0987	0.0099	0.0585	0.015	578	70	604	29	540	285	604	yes
X15095_46	146	147	1.24	0.84	0.28	0.0945	0.0087	0.0619	0.016	580	60	580	25.5	600	250	580	yes
X15095_47	386	51.7	10.1	6.42	2.1	0.335	0.037	0.135	0.034	1950	140	1840	85	2180	220	2180	no
X15095_48	69.4	29.4	2.25	1.218	0.36	0.129	0.0069	0.0681	0.017	801	80	781	19.5	840	250	781	yes
X15095_49	471	142	3.9	0.753	0.23	0.0901	0.0063	0.065	0.015	561	65	555	18.5	610	255	555	yes
X15095_50	95.5	57.5	1.67	0.781	0.23	0.0984	0.0066	0.0621	0.016	577	65	604	19.5	640	250	604	yes
X15095_51	266	31.8	8.8	0.679	0.21	0.089	0.0093	0.0573	0.014	521	65	548	27	508	265	548	yes
X15095_52	38.8	13.7	2.69	0.649	0.19	0.0777	0.0041	0.065	0.016	504	60	482	12	775	265	482	yes
X15095_53	72.9	53.7	1.38	0.591	0.17	0.0839	0.0048	0.0563	0.014	472	55	519	14	445	270	519	yes
X15095_54	14.5	8.4	1.64	1.09	0.52	0.0855	0.008	0.085	0.029	537	50	527	23.5	930	220	527	yes
X15095_55	148	67.9	1.95	0.617	0.18	0.0863	0.0055	0.0569	0.014	483	55	533	16.5	499	275	533	yes
X15095_56	72.8	39	2.13	0.59	0.17	0.079	0.0053	0.0615	0.015	466	55	490	15.5	586	195	490	yes
X15095_57	121.4	26.4	4.55	0.586	0.17	0.0855	0.0054	0.056	0.014	469	55	528	16	453	285	528	yes

X15095_58	77.8	64	1.25	0.553	0.16	0.0819	0.0053	0.0548	0.014	449	55	507	16	386	280	507	yes
X15095_59	307	302	0.939	3.05	0.88	0.2196	0.011	0.1132	0.028	1412	110	1278	28	1854	210	1278	no
X15095_60	86.2	49.6	1.51	0.577	0.17	0.0778	0.0037	0.0621	0.015	465	55	483	11	648	265	483	yes
X15095_61	527	1330	0.366	0.546	0.16	0.0739	0.0043	0.0631	0.016	441	50	459	12.5	692	260	459	yes
X15095_62	63	15.7	3.81	0.645	0.2	0.0935	0.0079	0.0575	0.014	496	60	575	23.5	506	260	575	yes
X15095_63	27.1	11.8	2.58	0.687	0.21	0.0806	0.0052	0.0693	0.018	520	60	499	15.5	750	195	499	yes
X15095_64	419	93	4.4	0.652	0.19	0.0946	0.0047	0.0569	0.014	511	55	582	14	484	280	582	yes
X15095_65	88.4	44.6	2.2	0.616	0.19	0.0845	0.0081	0.0575	0.014	478	55	522	24	536	285	522	yes
X15095_67	77	28	2.82	0.696	0.22	0.0906	0.0087	0.0579	0.015	530	65	558	25.5	490	270	558	yes
X15095_68	533	338	1.52	0.756	0.22	0.0943	0.0051	0.0621	0.015	572	65	581	15	699	270	581	yes
X15095_69	210	70.4	3.19	0.653	0.19	0.0889	0.0055	0.0565	0.014	506	60	548	16.5	473	260	548	yes
X15095_70	346	116	3.03	0.638	0.19	0.079	0.0048	0.0605	0.015	490	50	495	15	599	260	495	yes
X15095_71	49.7	14.2	3.36	0.794	0.23	0.1005	0.0049	0.059	0.015	589	65	617	14.5	516	220	617	yes
X15095_72	57.3	23	2.5	0.689	0.2	0.0889	0.0054	0.0556	0.014	528	60	554	16.5	410	270	554	yes
X15095_73	211	58.7	3.45	0.701	0.21	0.0897	0.0053	0.0566	0.014	540	65	553	15.5	490	250	553	yes
X15095_74	132	25.9	4.85	0.71	0.21	0.0944	0.0059	0.0562	0.014	545	65	581	17.5	454	285	581	yes
X15095_75	595	166	3.67	0.644	0.19	0.0813	0.0041	0.0595	0.015	507	60	504	12	572	270	504	yes
X15095_76	60.8	51.1	1.35	0.94	0.28	0.0864	0.0057	0.0839	0.022	659	70	534	17	1240	255	534	yes
X15095_77	123	71.5	1.61	6.3	1.8	0.371	0.023	0.1285	0.032	2021	135	2029	55	2066	220	2066	no
X15095_78	158.2	59.4	2.47	0.679	0.2	0.0833	0.0043	0.0614	0.015	522	60	515	12.5	639	265	515	yes
X15095_79	41.4	23.4	1.77	1.03	0.32	0.1005	0.008	0.0712	0.018	707	75	617	23.5	940	260	617	yes
X15095_80	243	199	1.34	3.87	1.1	0.2519	0.01	0.1148	0.028	1602	115	1454	27.5	1876	215	1876	no
X15095_81	81	37.4	1.88	0.639	0.19	0.0854	0.0051	0.0576	0.014	502	60	528	15	500	280	528	yes
X15095_82	97	57.8	1.41	0.687	0.21	0.0911	0.0066	0.0557	0.014	523	60	561	19.5	421	265	561	yes
X15095_83	217	73.2	2.92	0.704	0.2	0.0808	0.0028	0.0672	0.017	539	60	500.7	8.5	810	240	500.7	yes
X15095_84	590	311	2.39	1.24	0.37	0.096	0.0071	0.0959	0.024	804	85	590	21	1533	235	590	yes
X15095_85	194	46.2	4.23	7.26	2.1	0.368	0.018	0.149	0.037	2137	130	2014	43	2321	215	2321	yes
X15095_86	190	114	1.93	0.696	0.2	0.0878	0.0054	0.0598	0.015	542	60	542	16	591	265	542	yes
X15095_87	143	74.1	1.81	0.642	0.19	0.0838	0.0048	0.0586	0.014	500	55	518	14.5	537	270	518	yes
X15095_88	165	19.1	9.4	0.623	0.19	0.0857	0.0056	0.0557	0.014	485	60	529	16.5	429	275	529	yes
X15095_89	141	35.7	4.01	0.685	0.2	0.0794	0.0044	0.067	0.017	527	60	492	13	800	250	492	yes
X15095_90	102.7	123.7	0.799	0.643	0.19	0.0843	0.0049	0.0574	0.014	506	60	521	14.5	507	285	521	yes
X15095_91	224	59.1	3.85	5.15	1.5	0.307	0.016	0.1275	0.031	1835	125	1724	41	2052	220	2052	no
X15095_92	229	123	1.85	0.242	0.072	0.0306	0.0016	0.058	0.015	219	29	194.2	5	500	270	194.2	yes
X15095_93	147	34.2	4.47	0.65	0.19	0.0825	0.0045	0.0586	0.014	509	55	511	13.5	536	265	511	yes
X15095_94	674	495	1.19	0.882	0.26	0.0931	0.0063	0.0667	0.016	638	70	573	18.5	819	260	573	yes

X15095_96	642	127	4.78	2.9	0.86	0.214	0.013	0.0934	0.023	1363	110	1249	34	1493	240	1249	yes
X15095_97	69.5	60.8	1.17	0.62	0.19	0.0727	0.0057	0.0591	0.015	489	55	457	16.5	560	275	457	yes
X15095_98	24.7	9.67	2.52	0.776	0.23	0.0876	0.0055	0.0617	0.015	576	65	540	16	630	270	540	yes
X15095_99	136.6	91	1.56	0.92	0.27	0.0809	0.0045	0.0797	0.02	663	65	501	13.5	1190	230	501	yes
X15095_100	260	53.3	4.83	0.734	0.22	0.0845	0.0058	0.0601	0.015	558	65	522	17	605	260	522	yes
X15095_101	134	18.8	7.7	0.721	0.21	0.0852	0.0062	0.0579	0.014	544	60	526	18.5	508	270	526	yes
X15095_102	596	41.9	14.4	0.716	0.21	0.0854	0.0059	0.0581	0.014	548	60	528	17.5	554	260	528	yes
X15095_103	307	7.41	39.3	0.668	0.19	0.0818	0.004	0.0562	0.014	517	60	506	12	458	270	506	yes
X15095_104	87.1	35.7	2.55	0.731	0.22	0.0854	0.0056	0.0587	0.015	559	65	528	16.5	533	270	528	yes
X15095_105	372	232	1.54	0.77	0.23	0.0828	0.0047	0.063	0.016	575	65	513	14	703	250	513	yes
X15095_106	55.9	19.6	2.77	1.15	0.34	0.0907	0.0059	0.0888	0.023	775	85	559	17.5	1340	220	559	yes
X15095_107	293	145	2.38	0.81	0.27	0.099	0.013	0.056	0.014	591	75	608	36.5	400	260	608	no
X15095_108	360	134	2.78	4.55	1.4	0.264	0.019	0.1251	0.031	1733	130	1505	49.5	2019	220	2019	no
X15095_109	31.9	17.3	1.91	5.38	1.6	0.33	0.018	0.1136	0.028	1863	125	1834	43.5	1842	225	1842	no
X15095_110	189	24.8	7.5	0.775	0.23	0.0941	0.0065	0.0592	0.015	590	65	579	19	572	260	579	yes
2012																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Best Age Ma	Used?
X2012_2	345	136.8	2.557	1.01	0.091	0.1164	0.0056	0.06343	0.0035	708.1	23	709.6	16	717	60	709.6	yes
X2012_3	415	20.6	20.48	16.75	1.5	0.5568	0.027	0.2233	0.012	2927	40	2856	55	3002	44.5	3002	yes
X2012_4	166.6	30.5	5.61	6.603	0.59	0.3689	0.017	0.137	0.0071	2060	39	2024	41	2096	48	2096	yes
X2012_5	85.1	14.53	5.77	7.03	0.64	0.3815	0.019	0.1358	0.0076	2116	41	2081	44	2173	48	2173	yes
X2012_6	318	200	1.662	0.868	0.079	0.1042	0.0049	0.06086	0.0034	635	21.5	638.9	14.5	628	60	638.9	yes
X2012_7	882	91.5	9.49	0.4011	0.037	0.03631	0.0018	0.0797	0.0046	342	13.5	229.9	5.5	1180	55	229.9	yes
X2012_8	85.6	29.4	2.9	0.803	0.074	0.0944	0.0046	0.061	0.0038	597	21	581.4	13.5	643	65	581.4	yes
X2012_9	155.3	55.3	2.778	0.775	0.076	0.0914	0.0053	0.0614	0.0042	581	22	563	16	633	75	563	yes
X2012_10	409	110.3	3.71	0.733	0.066	0.08984	0.0042	0.05958	0.0033	557.6	19.5	554.5	12.5	585	60	554.5	yes
X2012_11	105	18.3	6.19	6.956	0.63	0.3858	0.019	0.1315	0.0073	2104	40	2102	43.5	2123	49.5	2123	yes
X2012_13	144.8	76.8	1.899	0.826	0.075	0.0991	0.0048	0.0602	0.0035	610.4	21	608.8	14	630	60	608.8	yes
X2012_14	329	96.7	3.503	1.905	0.18	0.1011	0.0049	0.1378	0.0083	1080	31.5	620.6	14.5	2184	55	620.6	yes
X2012_15	229	54.2	4.516	0.723	0.066	0.0892	0.0043	0.0588	0.0034	551.6	19.5	550.8	13	548	60	550.8	yes
X2012_16	602	322.7	1.898	0.612	0.056	0.0734	0.0037	0.0602	0.0034	484.4	17.5	458.3	11	606	60	458.3	yes
X2012_17	1270	363	3.8	0.539	0.052	0.0439	0.0026	0.0875	0.0053	436	17.5	276.6	8	1360	60	276.6	yes
X2012_18	68.6	27.1	2.762	0.732	0.07	0.0905	0.0044	0.0584	0.0038	555	20.5	559.5	13.5	536	70	559.5	yes
X2012_19	172.1	26.2	6.87	0.729	0.066	0.0886	0.0043	0.0591	0.0034	555.4	19.5	547.4	12.5	576	60	547.4	yes
X2012_20	287.2	128.6	2.343	5.97	0.54	0.3238	0.016	0.1322	0.0073	1972	39.5	1807	38.5	2125	48.5	2125	yes

X2012_2_1	75.7	43.8	2.026	0.712	0.066	0.0926	0.0047	0.0557	0.0034	545	19.5	571	14	438	70	571	yes
X2012_2_2	246	30.6	7.75	1.081	0.099	0.1178	0.0057	0.0659	0.0039	744	24.5	718	16.5	794	60	718	yes
X2012_2_3	5.42	-3.8675E-06	-1341000	1.75	0.2	0.1739	0.011	0.0751	0.0065	1011	36.5	1030	31	1000	90	1030	yes
X2012_2_4	85	20.77	3.919	6.62	0.6	0.3672	0.018	0.1275	0.0072	2062	38.5	2018	41.5	2064	49	2064	yes
X2012_2_5	94.6	19.08	4.7	0.724	0.067	0.088	0.0043	0.0588	0.0036	553.3	19	543.8	12.5	550	65	543.8	yes
X2012_2_6	44.5	25.6	1.61	15.7	1.4	0.567	0.028	0.1983	0.011	2858	42.5	2895	60	2816	46.5	2816	yes
X2012_2_7	128.6	45.9	2.646	0.867	0.08	0.1044	0.005	0.0591	0.0035	632	21.5	639.8	14.5	567	65	639.8	yes
X2012_2_8	81.3	43.9	1.7	0.819	0.076	0.098	0.0048	0.059	0.0036	606	21.5	602	14	547	65	602	yes
X2012_2_9	136	35.1	3.591	0.827	0.077	0.0994	0.005	0.0585	0.0035	610	21.5	611	14.5	561	65	611	yes
X2012_3_0	278	134.8	1.929	6.573	0.59	0.3684	0.018	0.1271	0.007	2055	39.5	2021	41.5	2056	49	2056	yes
X2012_3_1	400	195	1.94	0.729	0.066	0.0905	0.0044	0.05716	0.0032	556.4	19	558.1	13	500	60	558.1	yes
X2012_3_2	116.8	75.8	1.456	0.943	0.086	0.1124	0.0057	0.0604	0.0037	676	22.5	686	16.5	600	65	686	yes
X2012_3_3	44.8	10.23	3.99	0.872	0.084	0.1069	0.0054	0.0583	0.0038	644	23	654	15.5	521	70	654	yes
X2012_3_4	252	14.9	15.63	0.817	0.075	0.0997	0.0048	0.0581	0.0033	605.4	21	612.6	14	527	65	612.6	yes
X2012_3_5	103.1	39.4	2.547	7.163	0.64	0.384	0.018	0.1318	0.0073	2131	40	2094	42.5	2124	48.5	2124	yes
X2012_3_6	149.1	35.3	4.04	0.721	0.066	0.0892	0.0043	0.0575	0.0034	554	20	550.9	12.5	520	65	550.9	yes
X2012_3_7	703	290	2.455	0.3641	0.033	0.05044	0.0025	0.052	0.003	315.1	12.5	317.2	7.5	275	65	317.2	yes
X2012_3_8	107.9	25.7	4.204	7.531	0.68	0.3976	0.019	0.1354	0.0075	2178	40	2157	43.5	2165	48.5	2165	yes
X2012_4_0	249	63.7	3.87	0.663	0.063	0.0767	0.0041	0.0603	0.0036	515	19	476	12.5	603	65	476	yes
X2012_4_1	123	107	1.388	0.377	0.036	0.0516	0.0026	0.0535	0.0037	324	13.5	324.5	8	327	75	324.5	yes
X2012_4_2	319.8	197.8	1.608	4.094	0.37	0.2831	0.014	0.1044	0.006	1654	36	1606	36	1706	55	1706	yes
X2012_4_3	85.5	65.5	1.448	0.687	0.065	0.0862	0.0042	0.057	0.0036	529	19.5	532.6	12.5	478	70	532.6	yes
X2012_4_4	293	107.8	2.83	6.212	0.56	0.354	0.017	0.1252	0.0069	2005.2	39	1958	40.5	2029	48.5	2029	yes
X2012_4_5	41.3	31.8	1.325	0.72	0.069	0.0872	0.0043	0.0597	0.0039	554	20	539	13	565	70	539	yes
X2012_4_6	94.1	41	2.261	0.858	0.08	0.097	0.0049	0.0629	0.0038	628	22	596	14.5	701	65	596	yes
X2012_4_7	442	95.4	4.674	5.59	0.53	0.2777	0.014	0.1471	0.0083	1911	41.5	1579	35	2309	49.5	2309	no
X2012_4_8	112.6	55.6	2.23	0.865	0.08	0.1029	0.0053	0.0602	0.0037	632	22	631	15.5	608	65	631	yes
X2012_4_9	798	130.7	6.41	0.719	0.066	0.0888	0.0045	0.05886	0.0033	551	20	548	13.5	558	60	548	yes
X2012_5_0	332	249	1.55	0.772	0.071	0.094	0.0045	0.0595	0.0034	579.6	20	578.8	13.5	588	60	578.8	yes
X2012_5_1	74.5	29.5	2.61	0.679	0.063	0.0838	0.0042	0.0599	0.0037	527	19.5	518.6	12.5	582	70	518.6	yes
X2012_5_2	121.4	87.2	1.428	0.924	0.091	0.1031	0.005	0.0646	0.0043	660	23.5	633	15	715	70	633	yes
X2012_5_3	462	230	2.109	0.632	0.057	0.0799	0.0039	0.058	0.0033	496.8	18	495.2	11.5	522	60	495.2	yes
X2012_5_4	666	288	2.43	0.706	0.065	0.0804	0.0044	0.063	0.0036	543	19	498	13	717	55	498	yes
X2012_5_5	255.8	225.7	1.176	0.84	0.076	0.099	0.0048	0.061	0.0035	618.1	21	608.6	14	653	65	608.6	yes
X2012_5_6	185.4	45	4.334	0.775	0.071	0.0935	0.0045	0.0597	0.0035	585.4	19.5	575.8	13	599	60	575.8	yes
X2012_5_7	238	7.8	39.7	0.75	0.068	0.0922	0.0044	0.0593	0.0035	568.6	20	568.2	13	581	65	568.2	yes

X2012_58	534	20.22	27.11	4.8	0.43	0.3135	0.015	0.1103	0.0061	1783	38	1757	36.5	1805	49	1805	yes
X2012_59	301	186.8	1.669	14.11	1.3	0.525	0.026	0.1961	0.011	2755	43.5	2715	55	2792	45	2792	yes
X2012_60	140.2	47.3	3.015	2.549	0.23	0.2118	0.013	0.0868	0.0049	1286	33.5	1238	27	1361	55	1238	yes
X2012_61	335	89.9	3.49	0.716	0.065	0.0893	0.0043	0.0582	0.0034	548.8	18.5	551.3	12.5	541	60	551.3	yes
X2012_62	382	104.8	3.73	7.14	0.64	0.3871	0.019	0.1342	0.0074	2127	40	2114	43	2152	47.5	2152	yes
X2012_63	75.1	48.3	1.553	0.696	0.066	0.0862	0.0043	0.0589	0.0039	536	19.5	533	12.5	549	70	533	yes
X2012_64	488	244	2.015	0.696	0.063	0.0875	0.0042	0.0581	0.0033	536.7	19	540.6	12.5	534	60	540.6	yes
X2012_65	361	173	2.079	11.49	1	0.4604	0.022	0.1803	0.0099	2562	42.5	2441	48.5	2659	46	2659	yes
X2012_66	39.1	25.67	1.519	0.777	0.078	0.0938	0.0048	0.0600	0.0045	585	22.5	577	14	570	80	577	yes
X2012_68	226	127	1.802	0.732	0.068	0.0882	0.0043	0.0609	0.0036	558	19.5	545	12.5	617	65	545	yes
X2012_69	179.8	68.4	2.569	0.731	0.068	0.0907	0.0043	0.0589	0.0036	556	20	559.8	13	538	65	559.8	yes
X2012_70	845	212	3.983	0.775	0.07	0.0906	0.0045	0.06265	0.0035	582.7	20.5	561	13	695	60	561	yes
X2012_71	582	721	0.804	0.745	0.068	0.0927	0.0045	0.0585	0.0033	564.3	20	571.2	13.5	547	65	571.2	yes
X2012_72	590	31	19.27	6.566	0.59	0.374	0.018	0.1283	0.0071	2058	42	2047	43	2076	47.5	2076	yes
X2012_73	272	97.4	2.703	7.51	0.68	0.4006	0.019	0.1367	0.0076	2174	39.5	2171	44	2182	48.5	2182	yes
X2012_74	359	107.7	3.342	7.84	0.71	0.391	0.019	0.1464	0.0082	2215	39.5	2126	43	2306	46	2306	yes
X2012_75	324	210.2	1.529	0.801	0.074	0.097	0.0049	0.0601	0.0037	597	21.5	596	14.5	619	65	596	yes
X2012_76	21.5	10.77	1.981	0.757	0.088	0.0953	0.0056	0.0593	0.0058	569	25	586	16.5	520	100	586	yes
X2012_77	233	96.5	2.385	0.69	0.063	0.0853	0.0042	0.0593	0.0035	534.3	19	527.8	12.5	574	65	527.8	yes
X2012_78	743	175	4.22	0.459	0.045	0.0562	0.0032	0.0600	0.0038	383	16	352	10	589	70	352	yes
X2012_79	1165	803	1.511	4.94	0.46	0.1974	0.01	0.1818	0.01	1809	38.5	1161	28	2667	46	1161	no
X2012_80	293	112.1	2.702	0.473	0.044	0.0624	0.003	0.0553	0.0034	394.3	15	390.3	9	412	65	390.3	yes
X2012_81	323	101.3	3.208	0.803	0.075	0.0959	0.0047	0.0607	0.0036	600	21	590	14	617	65	590	yes
X2012_82	180	89.7	2.035	0.703	0.066	0.0875	0.0044	0.0587	0.0037	539	20	540	13	555	70	540	yes
X2012_83	252	188.6	1.357	0.725	0.067	0.0907	0.0044	0.0595	0.0036	554	20	559.4	13	584	60	559.4	yes
X2012_84	322	150	2.6	6.92	0.62	0.3789	0.018	0.1345	0.0075	2100	40	2070	42.5	2157	49.5	2157	yes
X2012_85	546	521	1.24	0.679	0.063	0.0743	0.0038	0.0661	0.0041	527	19	462	11.5	804	65	462	yes
X2012_86	578	360.6	1.591	0.703	0.064	0.0857	0.0042	0.0597	0.0035	539.9	19	529.7	12.5	586	60	529.7	yes
X2012_87	216	103.5	2.128	0.711	0.067	0.0877	0.0044	0.0595	0.0038	544	20	542	13	583	70	542	yes
X2012_88	240	90.9	2.652	0.728	0.068	0.0904	0.0045	0.0597	0.0037	554	20	558	13	598	70	558	yes
X2012_89	279	113.3	2.451	0.831	0.076	0.1013	0.0051	0.0613	0.0037	613	21	621	15	643	65	621	yes
X2012_90	1342	537	2.581	4.413	0.4	0.2534	0.013	0.1288	0.0073	1714	38	1455	34	2078	50	2078	yes
X2012_91	2600	1472	1.82	0.48	0.047	0.057	0.0035	0.0621	0.0035	397	16	357	10.5	683	60	357	yes
X2012_92	343	147.2	2.353	0.723	0.066	0.0899	0.0044	0.0601	0.0035	554	19.5	554.6	13	602	65	554.6	yes
X2012_93	497	402	1.247	0.874	0.08	0.1042	0.0051	0.0619	0.0036	638	22	638.9	15	672	65	638.9	yes
X2012_94	108.3	56.5	1.992	0.724	0.069	0.0911	0.0046	0.0578	0.004	553	20	562	13.5	525	75	562	yes

X2012_95	1015	395	2.672	0.731	0.066	0.0902	0.0044	0.0604	0.0034	557.7	19	556.8	13	607	60	556.8	yes
X2012_97	352	56.5	6.46	0.748	0.07	0.0887	0.0043	0.0628	0.0039	567	20	547.9	13	675	65	547.9	yes
X2012_98	260	161.7	1.596	0.709	0.065	0.0891	0.0044	0.0602	0.0037	543	19.5	550	13	614	65	550	yes
X2012_99	499	247	2.179	0.728	0.066	0.0898	0.0044	0.0616	0.0035	554.4	19.5	554.1	13	651	60	554.1	yes
X2012_100	23.9	15.97	1.54	0.821	0.12	0.103	0.007	0.0592	0.0082	599	33.5	631	20.5	530	135	631	yes
X2012_101	401	153.4	2.624	6.683	0.6	0.3657	0.018	0.1347	0.0074	2069	39.5	2008	41	2157	48.5	2157	yes
X2012_102	116.8	33.5	3.398	0.822	0.08	0.0953	0.0049	0.0654	0.0044	613	23.5	586	14.5	780	70	586	yes
X2012_103	871	352	2.485	0.83	0.076	0.1	0.005	0.063	0.0036	614	21.5	614	15	708	60	614	yes
X2012_104	194.7	109.1	1.787	0.964	0.089	0.1118	0.0055	0.0651	0.0039	683	23	683	16	769	65	683	yes
X2012_105	452	182	2.528	6.896	0.62	0.3752	0.018	0.1383	0.0077	2098	39.5	2053	42.5	2205	48.5	2205	yes
X2012_106	248	191	1.399	0.735	0.069	0.0918	0.0045	0.0613	0.0037	560	20	566.2	13.5	639	65	566.2	yes
108																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Best Age Ma	Used?
X108Kory2	3.03	0.0000001	3.03	1.06	0.29	0.0643	0.0059	0.116	0.028	680	65	401	17.5	1550	195	401	yes
X108Kory3	341	36.8	9.9	0.384	0.033	0.0536	0.0046	0.054	0.0025	328	12.5	336	14	348	50	336	yes
X108Kory4	118	89.1	1.33	0.573	0.054	0.0739	0.0062	0.0572	0.0032	461	17	459	18.5	510	50	459	yes
X108Kory5	65.7	44.6	1.63	0.737	0.086	0.0597	0.0045	0.0879	0.007	549	24	373	13.5	1310	75	373	yes
X108Kory6	213	67	5.1	0.52	0.042	0.0684	0.0045	0.0549	0.0028	421	13.5	426	13.5	440	55	426	yes
X108Kory7	126	37.7	3.63	0.427	0.035	0.0574	0.0044	0.0545	0.0024	358	12	359	13.5	367	49	359	yes
X108Kory8	216	180	1.29	1.34	0.21	0.0655	0.0049	0.146	0.018	829	43	408	14.5	2210	105	408	yes
X108Kory9	202	54.5	3.95	1.91	0.17	0.187	0.015	0.0752	0.0035	1079	29.5	1101	41	1065	44	1101	yes
X108Kory10	970	151	10.2	0.678	0.068	0.0684	0.0054	0.069	0.0041	524	20.5	426	17	930	60	426	yes
X108Kory11	39.9	20.3	2.04	2.4	0.19	0.192	0.013	0.0918	0.0056	1238	29	1128	34.5	1440	55	1128	yes
X108Kory12	549	681	0.84	1.21	0.12	0.0798	0.0063	0.1115	0.0073	792	25.5	494	18.5	1800	60	494	yes
X108Kory13	760	580	7.8	2.63	0.28	0.0904	0.0072	0.2119	0.0098	1311	35	557	21.5	2918	39.5	557	yes
X108Kory14	620	201	3	0.448	0.047	0.0596	0.0052	0.053	0.0023	371	16	372	15.5	312	47.5	372	yes
X108Kory15	151	61	2.55	0.406	0.04	0.0564	0.0041	0.054	0.0022	343	14	353	12.5	367	46	353	yes
X108Kory16	138	153	1.02	0.389	0.037	0.0522	0.004	0.0568	0.0026	331	14	327	12.5	480	55	327	yes
X108Kory17	159	28.8	6.02	0.679	0.063	0.0847	0.0074	0.0591	0.0031	519	18.5	523	22	530	55	523	yes
X108Kory19	201	153	1.67	1.24	0.16	0.139	0.016	0.0615	0.0041	798	33.5	831	43.5	630	70	831	no
X108Kory20	228	51.6	4.74	0.43	0.039	0.058	0.0043	0.0534	0.0022	360	14	363	13	323	45	363	yes
X108Kory21	434	39.8	12.8	0.526	0.054	0.0675	0.0058	0.0548	0.0024	423	17.5	420	17.5	399	49.5	420	yes
X108Kory22	181	41.5	4.25	0.546	0.024	0.0706	0.0023	0.0553	0.0015	441	7.5	439	7	416	30.5	439	yes
X108Kory23	71.1	10.4	7.2	0.613	0.057	0.0692	0.0054	0.0619	0.0034	479	18.5	430	15.5	640	55	430	yes
X108Kory24	41.3	27.1	1.62	1.79	0.19	0.157	0.015	0.0825	0.0055	1019	33.5	935	40.5	1210	60	935	yes

X108Kory_25	1690	112.9	15.8	1.36	0.14	0.0784	0.0055	0.1299	0.0081	878	31.5	486	17	2060	55	486	yes
X108Kory_26	390	164	3.68	0.728	0.067	0.0785	0.007	0.0679	0.0032	548	19	486	21	890	55	486	yes
X108Kory_27	55.4	51.5	1.19	2.52	0.27	0.193	0.017	0.0912	0.0036	1252	39	1133	45.5	1435	38.5	1133	yes
X108Kory_28	367	162	2.56	0.504	0.035	0.064	0.0032	0.0562	0.0024	412	11.5	399	10	452	48	399	yes
X108Kory_29	460	171	3.02	0.809	0.087	0.0919	0.0077	0.0617	0.0035	591	23.5	565	22.5	620	60	565	yes
X108Kory_30	86.6	15.7	5.9	2.34	0.2	0.204	0.014	0.08	0.0032	1207	29.5	1194	37.5	1207	39	1194	yes
X108Kory_31	138	44.1	3.39	1.16	0.11	0.1239	0.009	0.0666	0.0024	771	24	751	25.5	809	38.5	751	yes
X108Kory_32	392	270	1.56	0.503	0.062	0.0634	0.0064	0.0546	0.0026	405	21	395	19.5	400	55	395	yes
X108Kory_33	129	17.8	8.2	1.07	0.1	0.1067	0.0092	0.0717	0.0032	725	25.5	651	27	971	43.5	651	yes
X108Kory_34	320	46.7	6.89	0.886	0.032	0.1072	0.0035	0.0589	0.0013	646	8.5	656	10	557	25	656	yes
X108Kory_35	57	23.6	2.68	3.4	0.81	0.272	0.057	0.0892	0.0083	1450	95	1530	14.5	1380	85	1380	no
X108Kory_36	168	92	2.06	0.609	0.067	0.0743	0.0065	0.0576	0.0026	475	20.5	460	19.5	504	50	460	yes
X108Kory_37	189	58.1	3.33	3.1	0.28	0.234	0.016	0.0966	0.0053	1434	35	1348	42.5	1545	50	1348	yes
X108Kory_38	403	68.6	6.02	2.73	0.24	0.231	0.015	0.0841	0.0055	1314	33.5	1335	38	1310	65	1335	yes
X108Kory_39	143	70.8	2.09	0.509	0.058	0.0619	0.0061	0.0576	0.003	411	19.5	393	18.5	480	55	393	yes
X108Kory_40	545	148	3.56	0.535	0.029	0.0683	0.0035	0.0565	0.0016	433	9.5	425	10.5	472	33.5	425	yes
X108Kory_41	239	116.8	2.26	0.988	0.085	0.1105	0.0082	0.0642	0.003	689	22	674	24	720	55	674	yes
X108Kory_42	102	0.285	385	0.636	0.058	0.081	0.0054	0.055	0.0023	494	18	507	16	406	48.5	507	yes
X108Kory_43	437	97.3	4.97	3.68	0.3	0.282	0.02	0.0936	0.0039	1548	32	1600	50	1509	38	1509	no
X108Kory_44	121	74.3	1.79	0.662	0.08	0.086	0.0087	0.057	0.0032	516	23.5	530	25.5	450	60	530	yes
X108Kory_45	205	132	1.54	0.512	0.031	0.0681	0.0031	0.0546	0.0024	425	10	424	9.5	371	49.5	424	yes
X108Kory_46	187	30.6	6.5	0.578	0.053	0.074	0.0059	0.0557	0.0029	457	17	460	17.5	410	55	460	yes
X108Kory_48	286	79.4	4.13	0.77	0.16	0.0589	0.0048	0.088	0.014	534	36.5	368	14.5	1250	120	368	yes
X108Kory_49	157	149	1.18	0.563	0.05	0.0748	0.0061	0.0547	0.0025	449	17.5	464	18	400	50	464	yes
X108Kory_50	230	67.4	3.43	0.553	0.04	0.0731	0.0047	0.055	0.002	443	13	454	14	407	38	454	yes
X108Kory_51	440	78.1	6.31	2.76	0.21	0.222	0.015	0.0921	0.0038	1329	29	1287	40.5	1483	39	1287	yes
X108Kory_52	1170	530	2.2	0.95	0.16	0.0518	0.0045	0.155	0.032	678	44	325	13.5	2010	185	325	yes
X108Kory_53	200	48.4	4.12	0.58	0.048	0.0705	0.0055	0.0591	0.0026	460	15.5	438	16.5	567	46	438	yes
X108Kory_54	51.1	34	1.57	0.548	0.062	0.0672	0.0053	0.0592	0.0053	436	20	418	16	500	90	418	yes
X108Kory_55	440	138	3.47	2.31	0.15	0.213	0.013	0.0794	0.0031	1206	23.5	1253	33.5	1227	43	1253	yes
X108Kory_56	623	279	2.52	0.483	0.033	0.0582	0.0037	0.0624	0.0024	401	11	364	11.5	680	43	364	yes
X108Kory_57	291	111.3	2.72	0.405	0.027	0.0562	0.0031	0.0539	0.0017	347	10	352	9.5	379	35	352	yes
X108Kory_58	1460	29.8	49.9	0.362	0.021	0.0514	0.0021	0.0524	0.0018	313	8	323	6.5	291	38	323	yes
X108Kory_59	137	38.6	3.74	0.746	0.05	0.0969	0.0054	0.0591	0.0022	562	14.5	595	16	553	42.5	595	yes
X108Kory_60	227	61.2	4.51	0.9	0.13	0.11	0.016	0.0609	0.0029	633	31.5	666	45	600	50	666	no
X108Kory_61	91.3	24.5	3.66	2.43	0.14	0.2217	0.0099	0.0805	0.0031	1250	20.5	1289	26	1192	37.5	1289	no

X108Kory 62	114 .4	31.4	3.56	1.84	0.1	0.1849	0.00 82	0.07 22	0.00 31	1055	18 .5	1092	22	981	46	109 2	no
X108Kory 63	61. 5	28.3	2.14	0.586	0.0 53	0.0703	0.00 48	0.06 36	0.00 37	463	17	437	14 .5	690	65	437	yes
X108Kory 64	103 .1	21.3	5.18	2.29	0.2 2	0.186	0.01 1	0.09 07	0.00 53	1193	31	1094	29 .5	1406	50	109 4	yes
X108Kory 65	22. 9	7.5	3.22	0.494	0.0 58	0.0559	0.00 4	0.06 42	0.00 68	388	19 .5	350	12	630	10 0	350	yes
X108Kory 66	294	158	1.88	0.425	0.0 37	0.0555	0.00 42	0.05 45	0.00 22	356	13 .5	348	13	374	45 .5	348	yes
X108Kory 67	556	53.5	11.6	0.671	0.0 44	0.0672	0.00 34	0.07 27	0.00 3	518	13 .5	419	10 .5	987	41 .5	419	yes
X108Kory 68	134	53.4	2.55	0.574	0.0 56	0.0711	0.00 52	0.05 67	0.00 26	454	18	442	15 .5	475	47 .5	442	yes
X108Kory 69	250	323	0.8	0.542	0.0 49	0.0624	0.00 5	0.06 04	0.00 21	435	16	389	15	619	35 .5	389	yes
X108Kory 70	712	176	4.13	0.471	0.0 24	0.0524	0.00 26	0.06 41	0.00 31	391	8. 5	329	8	732	49 .5	329	yes
X108Kory 71	129	98	1.34	0.784	0.0 91	0.0665	0.00 41	0.08 55	0.00 74	578	21 .5	415	12 .5	1270	80	415	yes
X108Kory 72	221 .9	130.2	1.71	0.561	0.0 28	0.0708	0.00 23	0.05 61	0.00 22	451	9	441	7	449	44 .5	441	yes
X108Kory 73	732	487	1.54	0.471	0.0 29	0.0534	0.00 23	0.06 23	0.00 38	390	10	335	7	640	60	335	yes
X108Kory 74	157 .1	79.8	1.96	0.749	0.0 54	0.092	0.00 46	0.05 84	0.00 24	563	16	572	13 .5	555	45	572	yes
X108Kory 76	57. 5	14.9	3.87	1.93	0.1 6	0.17	0.01 4	0.08 05	0.00 43	1077	27 .5	1005	38 .5	1190	50	100 5	yes
X108Kory 77	290	39.4	7.38	1.68	0.1 6	0.166	0.01 1	0.07 51	0.00 38	996	29 .5	987	31 .5	1040	50	987	yes
X108Kory 78	893	177.2	4.86	3.93	0.2 1	0.295	0.01 1	0.09 48	0.00 41	1621	21	1662	28	1533	43 .5	153 3	no
X108Kory 79	145	60.8	2.38	1.84	0.1 5	0.179	0.01 2	0.07 58	0.00 31	1064	28	1067	32	1086	40	106 7	yes
X108Kory 80	278	57.4	4.6	2.14	0.2 1	0.1563	0.01	0.09 73	0.00 56	1139	35	934	28	1610	60	934	no
X108Kory 81	770	197	3.6	0.82	0.0 89	0.088	0.00 69	0.06 8	0.00 47	605	26	543	20 .5	830	70	543	yes
X108Kory 82	505	73.2	7.6	1.11	0.1 6	0.0773	0.00 46	0.10 2	0.01 1	745	39	479	14	1540	11 0	479	yes
X108Kory 83	52. 1	17.3	3.14	0.942	0.0 7	0.1096	0.00 77	0.06 39	0.00 29	668	19 .5	669	22 .5	749	48	669	yes
X108Kory 84	821	308	2.7	0.661	0.0 44	0.0577	0.00 28	0.08 34	0.00 34	512	13	362	8. 5	1288	39 .5	362	yes
X108Kory 85	226	64.1	3.36	2.15	0.1 3	0.2001	0.01 1	0.08 18	0.00 26	1172	21	1174	27 .5	1230	31 .5	117 4	yes
X108Kory 86	766	187	4.24	2.8	0.1 7	0.239	0.01 5	0.08 58	0.00 32	1345	25 .5	1377	38	1320	36	137 7	yes
X108Kory 87	357	150	2.46	0.731	0.0 55	0.0918	0.00 55	0.05 84	0.00 25	553	15 .5	565	16	534	44	565	yes
X108Kory 88	873	62.7	14.4	0.52	0.0 32	0.0685	0.00 34	0.05 47	0.00 23	423	10 .5	427	10 .5	408	46	427	yes
X108Kory 89	195	272	0.78	0.534	0.0 41	0.0628	0.00 39	0.06 04	0.00 26	431	13 .5	392	11 .5	596	44 .5	392	yes
X108Kory 90	358	130.7	2.89	0.498	0.0 41	0.0665	0.00 44	0.05 37	0.00 19	407	14	415	13 .5	345	40	415	yes
X108Kory 91	526	21.3	24.7	0.419	0.0 35	0.0582	0.00 44	0.05 3	0.00 22	357	12 .5	364	13 .5	311	46	364	yes
X108Kory 92	345	71	6.7	0.938	0.0 68	0.0744	0.00 42	0.09 35	0.00 35	672	16 .5	462	12 .5	1433	35	462	yes
X108Kory 93	133	26	5.43	1.81	0.1 7	0.178	0.01 4	0.07 23	0.00 25	1031	30	1053	37 .5	995	34	105 3	no
X108Kory 94	477	14.2	69	0.417	0.0 51	0.0567	0.00 62	0.05 14	0.00 23	348	17 .5	354	19	242	48 .5	354	no
X108Kory 95	607	520	1.21	0.56	0.0 34	0.0712	0.00 38	0.05 62	0.00 21	453	10 .5	443	11 .5	445	40	443	yes
X108Kory 96	297	52.3	6.05	2.32	0.1 6	0.189	0.01 1	0.08 66	0.00 29	1206	23	1116	30 .5	1351	33	111 6	yes
X108Kory 97	283	166	1.69	0.435	0.0 23	0.0548	0.00 31	0.05 7	0.00 21	365	8	344	9. 5	474	40 .5	344	yes
X108Kory 98	65. 1	17.4	3.94	0.78	0.0 97	0.0767	0.00 71	0.07 23	0.00 65	570	26	475	21	920	95	475	yes

X108Kory_99	47.1	29.1	1.57	2.4	0.44	0.199	0.012	0.086	0.01	1198	45.5	1165	31	1190	60	1165	yes
X108Kory_100	75	34.4	2.58	2.06	0.35	0.0884	0.0087	0.165	0.018	1080	55	544	25.5	2460	95	544	yes
X108Kory_101	260	66	3.86	2.04	0.3	0.0779	0.0055	0.174	0.017	1080	49	483	16.5	2620	85	483	yes
X108Kory_102	86.9	85	1.01	0.45	0.042	0.0556	0.0042	0.0575	0.0024	373	14.5	348	13	490	47	348	yes
X108Kory_104	747	234	25	0.479	0.032	0.0525	0.0027	0.0661	0.0038	395	10.5	330	8.5	770	55	330	yes
X108Kory_105	120	83.8	1.47	2.76	0.26	0.237	0.019	0.0834	0.0029	1334	35.5	1362	48	1267	34	1362	no
X108Kory_106	94	50.7	1.8	0.641	0.045	0.0778	0.0043	0.0601	0.0033	499	14	482	13	570	60	482	yes
X108Kory_107	289	165	1.75	0.668	0.046	0.0575	0.0026	0.0834	0.0034	516	14.5	360	8	1295	36.5	360	yes
X108Kory_108	960	73.3	13.7	1.58	0.084	0.1561	0.0065	0.072	0.0024	957	17	934	18	975	33	934	yes
X108Kory_109	326	374	0.847	0.513	0.036	0.055	0.003	0.071	0.0058	417	12	345	9	880	80	345	yes
X108Kory_110	110.5	53.4	2.1	1.3	0.13	0.0746	0.0035	0.121	0.01	828	29	463	10.5	1920	85	463	yes
X108Kory_111	228	247	0.976	0.4	0.021	0.054	0.0022	0.0545	0.002	341	7.5	339	6.5	378	40	339	yes
X108Kory_112	670	195	3.64	1.42	0.48	0.0646	0.0074	0.125	0.014	731	40	403	22	1950	90	403	no
X108Kory_113	118.9	41.8	3.06	0.636	0.046	0.0761	0.0041	0.0607	0.0027	496	14	472	12.5	602	49	472	yes
X108Kory_114	188.3	27.4	7.5	2.38	0.13	0.2031	0.0091	0.0813	0.0026	1228	19.5	1190	24.5	1242	31.5	1190	yes
X108Kory_115	394	184	2.23	2.58	0.15	0.226	0.001	0.0809	0.0023	1302	21.5	1310	30	1221	29	1310	no
X108Kory_116	407	305	1.51	0.514	0.026	0.0568	0.0019	0.0633	0.0019	425	9	356	6	735	32.5	356	yes
X108Kory_117	80.1	36.5	2.43	3.52	0.77	0.1185	0.0085	0.192	0.033	1390	80	720	24.5	2540	140	720	yes
X108Kory_118	587	197	3.26	0.837	0.06	0.098	0.0061	0.0613	0.0022	612	16.5	609	18	644	38	609	yes
3113																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Best Age Ma	Used?
X3113_3	209	238	0.842	2.463	0.07	0.2155	0.0065	0.0827	0.0019	1259	10	1257	17.5	1265	21	1257	yes
X3113_5	213	361	0.597	0.479	0.048	0.0514	0.00097	0.0677	0.0065	393	15.5	323.1	3	770	85	323.1	yes
X3113_6	185	96.9	1.81	0.819	0.027	0.099	0.0031	0.0593	0.0017	607	7.5	609	9	570	31	609	yes
X3113_7	402	362	1.068	0.349	0.013	0.0465	0.0013	0.0549	0.002	306	5	293	4.05	392	40	293	yes
X3113_8	281	171	1.717	1.105	0.05	0.0913	0.0032	0.0875	0.0041	754	12	563	9.5	1350	45	563	yes
X3113_9	260	65.8	3.93	0.903	0.047	0.0715	0.0018	0.0908	0.0052	651	12.5	445	5.5	1410	55	445	yes
X3113_11	213	112.7	1.887	1.34	0.19	0.076	0.002	0.122	0.015	836	38	472	6	1920	115	472	yes
X3113_13	18.9	11.02	1.728	7.38	0.26	0.406	0.012	0.1314	0.0048	2155	15	2194	27.5	2105	32	2105	yes
X3113_14	115.3	53.6	2.19	0.536	0.042	0.0531	0.0015	0.0744	0.0068	433	13.5	333.5	4.45	980	80	333.5	yes
X3113_16	145	93	1.77	0.672	0.069	0.0548	0.0017	0.0918	0.0097	515	20	344	5	1390	95	344	yes
X3113_18	315	141	2.28	0.615	0.037	0.0681	0.0018	0.0661	0.0041	485	11.5	425	5.5	770	60	425	yes
X3113_19	127.2	159	0.821	0.78	0.15	0.0548	0.002	0.106	0.018	568	39	344	6	1530	155	344	yes
X3113_20	523	117	4.61	1.31	0.13	0.1047	0.0048	0.0938	0.0075	874	31.5	642	14	1470	75	642	yes
X3113_21	221.9	126.8	1.759	0.58	0.04	0.0554	0.0017	0.0764	0.0049	462	12.5	347	5.5	1090	60	347	yes

X3113_22	282	109.2	2.67	1.651	0.086	0.0807	0.0027	0.1491	0.0054	991	17	500	8	2325	29.5	500	yes
X3113_23	113.9	77.4	1.428	2.98	0.24	0.1533	0.0068	0.144	0.011	1386	31	918	19	2270	65	918	no
X3113_24	352	416	0.923	1.095	0.062	0.1038	0.0034	0.0773	0.0051	747	15	636	10	1100	70	636	yes
X3113_25	811	504	1.7	0.456	0.015	0.0498	0.0015	0.066	0.002	381	5	313.3	4.6	820	28	313.3	yes
X3113_26	327	239	1.392	1.293	0.052	0.1093	0.0024	0.0876	0.0034	841	11.5	668	7	1359	35.5	668	yes
X3113_28	416	522	0.844	1.21	0.11	0.0778	0.0029	0.1126	0.0085	802	26	486	8.5	1780	70	486	yes
X3113_29	30.6	37.6	0.9	5.74	0.25	0.2995	0.0094	0.1346	0.0048	1931	18.5	1687	23.5	2147	30	2147	yes
X3113_32	187.5	288	0.664	0.94	0.042	0.071	0.0024	0.0952	0.0027	675	11.5	442	7	1525	27	442	yes
X3113_36	114.4	33.9	3.43	6.04	0.17	0.3664	0.0085	0.124	0.004	1985	12.5	2011	20	1945	29.5	1945	yes
X3113_37	439	292	1.558	0.729	0.032	0.0716	0.0012	0.0734	0.0026	554	9	445.9	3.7	1013	35	445.9	yes
X3113_38	232	89.1	2.67	1.506	0.077	0.1139	0.0029	0.0945	0.0043	929	15.5	698	8.5	1498	42.5	698	yes
X3113_39	215	178	1.123	1.363	0.095	0.1197	0.004	0.083	0.0045	875	21	729	11.5	1240	50	729	yes
X3113_40	85.5	71.2	1.209	1.24	0.073	0.062	0.0017	0.1437	0.0074	814	16.5	388	5.5	2282	43	388	yes
X3113_41	217.9	182	1.255	10.32	0.29	0.416	0.011	0.1804	0.0036	2461	13	2242	24.5	2653	17	2653	yes
X3113_42	350	33.4	10.64	0.826	0.018	0.095	0.0021	0.0635	0.0016	611	5	585	6	727	24.5	585	yes
X3113_43	48.9	22.01	2.2	3.99	0.14	0.235	0.0062	0.1238	0.0034	1628	14	1360	16	2005	24	1360	no
X3113_44	335	154.7	2.12	0.656	0.024	0.0694	0.0021	0.0684	0.003	511	7.5	432	6.5	875	46.5	432	yes
X3113_45	191	158.4	1.225	0.73	0.1	0.0646	0.0017	0.082	0.011	544	27	404	5	1100	110	404	yes
X3113_46	82.4	38.8	2.177	0.578	0.027	0.0728	0.0015	0.0575	0.0029	462	8.5	452.7	4.5	480	50	452.7	yes
X3113_47	109.6	36.7	2.99	3.74	0.11	0.2681	0.007	0.103	0.0023	1582	11.5	1530	18	1674	21	1674	yes
X3113_48	85.4	39	2.25	1.12	0.11	0.1095	0.0036	0.0729	0.006	752	24	670	10.5	950	75	670	yes
X3113_49	372	225	1.94	1.94	0.31	0.1049	0.0058	0.133	0.016	1060	50	642	17	2110	110	642	yes
X3113_52	372	30.2	13.2	1.151	0.039	0.1073	0.0027	0.0797	0.0015	776	9	657	8	1185	18.5	657	yes
X3113_53	531	500	1.094	0.572	0.027	0.0462	0.001	0.0931	0.0048	458	8.5	290.8	3.2	1461	46.5	290.8	yes
X3113_54	80.7	38.6	2.12	7.67	0.27	0.42	0.012	0.1349	0.0037	2189	15.5	2256	27.5	2156	24	2156	yes
X3113_55	346	365	0.972	0.525	0.045	0.04748	0.00095	0.0824	0.0073	424	14.5	299	2.95	1190	90	299	yes
X3113_56	794	92.8	8.84	1.578	0.047	0.1466	0.0041	0.0787	0.0022	960	9	882	11.5	1157	27	882	yes
X3113_57	259.4	21.6	12.34	0.897	0.041	0.1033	0.0028	0.065	0.0028	642	9	633	8	711	28	633	yes
X3113_58	318	210	1.64	0.93	0.11	0.0543	0.0018	0.123	0.013	654	29	341	5.5	1900	90	341	yes
X3113_59	736	575	1.36	0.774	0.093	0.0499	0.0014	0.111	0.012	578	27.5	314.1	4.2	1750	110	314.1	yes
X3113_60	89.6	28.2	3.19	2.093	0.065	0.1807	0.0049	0.0872	0.0036	1145	10.5	1070	13.5	1348	37.5	1070	yes
X3113_61	427	175	2.69	0.946	0.029	0.1077	0.0029	0.0643	0.0014	678	7	659	8.5	747	23.5	659	yes
X3113_62	301	109.2	2.75	0.55	0.016	0.069	0.0022	0.0577	0.0013	444	5.5	430	7	512	24	430	yes
X3113_63	179.3	152.1	11.92	1.652	0.043	0.1698	0.0037	0.0714	0.0011	989	8.5	1011	10.5	970	16.5	1011	yes
X3113_64	161	60.7	2.63	1.31	0.13	0.0961	0.0034	0.0975	0.0071	837	27	591	10	1570	75	591	yes
X3113_65	713	115	6.6	3.94	0.2	0.2104	0.0056	0.1342	0.0051	1617	20	1231	15	2145	33	1231	no

X3113_66	545	13.7	44.2	0.544	0.018	0.0687	0.0017	0.0566	0.0016	441	5.5	428	5	467	31	428	yes
X3113_67	194	116.1	1.619	1.643	0.049	0.1126	0.0024	0.1057	0.0024	985	9.5	688	7	1722	21.5	688	yes
X3113_68	232	127.4	1.87	2.143	0.073	0.1926	0.0063	0.0792	0.0024	1160	11.5	1135	17	1167	30.5	1135	yes
X3113_69	334	283	1.204	5.44	0.51	0.1402	0.0062	0.287	0.015	1909	41	845	17.5	3389	40.5	845	no
X3113_70	229	80.4	2.9	0.927	0.021	0.1098	0.003	0.061	0.0011	666	5.5	671	8.5	642	19.5	671	yes
X3113_71	151	82.1	1.927	0.952	0.032	0.0973	0.0022	0.0703	0.0024	678	8.5	599	6.5	923	34.5	599	yes
X3113_72	69	28.7	2.64	1.394	0.046	0.1336	0.0028	0.0738	0.0028	885	10	808	8	1062	40.5	808	yes
X3113_73	520	480	1.112	2.24	0.13	0.0975	0.0023	0.1634	0.007	1185	21	600	7	2488	35.5	600	yes
X3113_74	294	35.9	8.6	3.18	0.13	0.2181	0.0057	0.1045	0.005	1450	15	1271	15	1688	41	1271	yes
X3113_75	423	272	1.584	1.155	0.045	0.1158	0.003	0.0693	0.002	778	10.5	706	8.5	911	32	706	yes
X3113_76	234	148.2	1.573	0.704	0.036	0.0726	0.002	0.0717	0.0047	539	10.5	452	6	930	60	452	yes
X3113_77	423	254	1.672	1.227	0.027	0.1021	0.0017	0.0858	0.0023	812	6	626.7	4.5	1337	24	626.7	yes
X3113_78	100.5	59.2	1.77	0.934	0.041	0.104	0.0024	0.0657	0.0031	673	9.5	638	7	773	46.5	638	yes
X3113_80	180.2	11.62	15.98	7.63	0.19	0.4177	0.0085	0.132	0.002	2187	11.5	2249	19.5	2122	13.5	2122	no
X3113_82	890	225	4.13	0.969	0.052	0.0617	0.0015	0.1159	0.0053	690	12.5	385.8	4.65	1887	40	385.8	yes
X3113_83	159	76.6	2.05	1.35	0.15	0.0983	0.0033	0.096	0.0078	853	29.5	604	9.5	1490	70	604	yes
X3113_84	740	371	1.94	1.06	0.1	0.0598	0.0017	0.132	0.011	733	26	374	5.5	2060	75	374	yes
X3113_85	259.8	306	0.868	2.78	0.1	0.1873	0.0038	0.1068	0.0032	1346	14	1106	10	1738	27.5	1106	no
X3113_86	407	115	3.67	2.97	0.33	0.1173	0.0049	0.181	0.015	1379	45.5	715	14	2640	70	715	yes
X3113_87	839	676	1.266	1.316	0.085	0.0974	0.0023	0.0984	0.0046	853	19	599	6.5	1569	46	599	yes
X3113_88	63.6	51.7	1.244	1.59	0.19	0.0796	0.0024	0.143	0.015	955	36.5	494	7	2210	85	494	yes
X3113_89	622	142	4.41	0.595	0.018	0.0693	0.0019	0.0624	0.0022	473	6	432	5.5	673	37	432	yes
X3113_90	240.1	132.1	1.848	0.933	0.023	0.1106	0.0024	0.0614	0.001	668	6	676	7	651	17.5	676	yes
X3113_92	239	92.6	2.54	1.034	0.045	0.0706	0.0019	0.1069	0.0035	731	11.5	442	5.5	1749	31	442	yes
X3113_95	800	322	2.35	0.614	0.044	0.0621	0.0016	0.072	0.0043	483	13	388.4	4.75	950	55	388.4	yes
X3113_96	551	31.3	17.2	0.626	0.021	0.0655	0.0019	0.0686	0.0018	493	6.5	409	6	878	27	409	yes
X3113_97	240	138	1.81	0.438	0.012	0.0554	0.0013	0.0572	0.0015	370.4	3.85	347.8	4.1	502	29	347.8	yes
X3113_98	389	175.2	2.28	6.96	0.18	0.3851	0.0083	0.1304	0.002	2108	11	2099	19.5	2107	13	2107	yes
X3113_99	182.6	109.5	1.698	1.38	0.064	0.1261	0.0033	0.0805	0.0033	877	13.5	765	9.5	1192	38.5	765	yes
X3113_100	584	532	1.156	0.532	0.014	0.0574	0.0016	0.0677	0.0014	432.4	4.75	359.5	4.8	854	22	359.5	yes
X3113_101	183.1	126.5	1.46	6.19	0.46	0.33	0.0064	0.134	0.0096	1985	32	1838	15.5	2120	60	2120	yes
X3113_102	108.5	52.5	2.043	1.244	0.058	0.1106	0.0024	0.0815	0.0037	818	13	676	7	1212	42	676	yes
X3113_103	183.6	155.4	1.177	0.715	0.023	0.0809	0.0025	0.0668	0.0021	547	7	501	7.5	836	30.5	501	yes
X3113_104	337	346	0.968	0.582	0.034	0.0601	0.0019	0.0705	0.0032	464	11	376	5.5	924	43	376	yes
X3113_105	224	288	0.766	0.457	0.033	0.0539	0.0015	0.0612	0.0042	380	11	338.2	4.65	600	65	338.2	yes
X3113_106	147.5	50.4	2.9	1.048	0.025	0.1218	0.0028	0.0625	0.0014	727	6	741	8	685	24	741	yes

X3113_107	82.6	67.2	1.188	2.81	0.11	0.2254	0.0089	0.0911	0.0022	1360	14	1309	23.5	1444	22	1309	yes
X3113_108	224	291	0.77	4.04	0.35	0.1077	0.0034	0.269	0.015	1631	36.5	659	10	3295	43	659	yes
X3113_110	52.1	9.6	5.31	2.152	0.06	0.195	0.0047	0.08	0.0021	1168	10.5	1148	12.5	1198	25	1148	yes
X3113_111	134.5	62.6	2.138	0.997	0.023	0.1064	0.0032	0.0693	0.0024	702	6	651	9	893	35.5	651	yes
X3113_112	87.7	45.2	1.98	1.749	0.057	0.1746	0.0054	0.0733	0.0018	1025	10.5	1042	15	1015	25	1042	yes
X3113_114	176	75.8	2.18	0.48	0.023	0.0617	0.0017	0.0552	0.0018	401	7.5	386	5	428	39.5	386	yes
X3113_115	213	181.4	1.129	0.973	0.027	0.1078	0.0024	0.0652	0.0015	691	7	660	7	783	25.5	660	yes
X3113_116	74.2	27.5	2.79	10.67	0.25	0.479	0.01	0.1627	0.0034	2496	11.5	2520	23	2487	16.5	2487	yes
X3113_117	54.2	79.2	0.674	0.578	0.076	0.0539	0.0021	0.0742	0.0078	453	22.5	338	6.5	980	100	338	yes
X3113_118	99.7	107.2	0.907	16.3	2.4	0.354	0.012	0.348	0.049	2910	70	1954	27.5	3690	105	3690	no
619																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Bes t Age Ma	Use d?
X619_2	45.3	31.28	1.564	1.658	0.081	0.1525	0.0076	0.0742	0.0021	988	15.5	915	21	1048	28.5	915	yes
X619_3	351	145.2	2.89	1.301	0.082	0.0646	0.0033	0.1433	0.0049	840	19	406	9.5	2266	29	406	yes
X619_4	95.3	45.5	2.23	1.63	0.12	0.1556	0.011	0.0754	0.0019	973	22	930	31.5	1072	25.5	930	yes
X619_5	104.1	48.4	2.19	1.44	0.056	0.1365	0.0071	0.0715	0.0017	903	11.5	825	20	968	24.5	825	yes
X619_6	281	120	2.22	0.844	0.035	0.0961	0.0049	0.05969	0.0012	620	9.5	592	14.5	589	22.5	592	yes
X619_7	64.7	61.9	0.992	0.459	0.026	0.0576	0.003	0.0542	0.0023	385	8.5	360.9	9	360	46.5	360.9	yes
X619_8	405	191	2.06	0.309	0.01	0.0396	0.0021	0.0536	0.0018	273.4	3.95	250.4	6.5	341	37.5	250.4	yes
X619_10	104	21.6	4.56	0.549	0.025	0.0658	0.0033	0.0569	0.0027	443	8	411	10	464	48.5	411	yes
X619_11	255	182.4	1.26	0.628	0.037	0.0739	0.0039	0.0585	0.0016	492	12	459	11.5	552	28	459	yes
X619_12	731	123	5.58	1.92	0.062	0.1675	0.0084	0.0799	0.0019	1095	12	998	23	1188	24.5	998	yes
X619_13	121.8	23.8	4.66	2.59	0.12	0.1687	0.0082	0.1026	0.0029	1292	17.5	1004	22.5	1673	28	1004	no
X619_14	193.7	81.8	2.19	1.444	0.072	0.1041	0.0053	0.0969	0.0044	903	15	638	15.5	1571	44.5	638	yes
X619_15	60.1	16.47	3.42	0.505	0.03	0.059	0.0029	0.0587	0.0028	408	8.5	369.8	9	529	50	369.8	yes
X619_16	610	132	4.25	2.031	0.085	0.1787	0.0092	0.0782	0.0017	1122	14.5	1059	25	1148	22	1059	yes
X619_17	122.9	30.5	3.92	0.599	0.02	0.0587	0.0028	0.0707	0.0024	476	6.5	367.5	8.5	938	34	367.5	yes
X619_19	33.6	11.32	3.03	2.02	0.12	0.2106	0.01	0.0749	0.0019	1113	21	1236	26	1059	25	1236	no
X619_20	163.4	119.2	1.39	0.492	0.016	0.0639	0.003	0.0565	0.0018	406	5.5	399.1	9	464	34	399.1	yes
X619_21	202.7	70.3	2.87	1.818	0.056	0.1785	0.0084	0.075	0.0014	1050	10	1058	23	1067	18	1058	yes
X619_22	32.9	15.3	2.133	0.677	0.049	0.0924	0.0046	0.063	0.003	526	14.5	570	13.5	570	55	570	yes
X619_23	264	39.1	6.86	2.159	0.085	0.2003	0.0096	0.0816	0.0015	1164	14	1176	26	1234	18	1176	yes
X619_25	72	44.9	1.675	3.89	0.23	0.2354	0.011	0.1189	0.0035	1621	22	1362	28.5	1933	26	1362	yes
X619_26	802	43	19.45	0.46	0.021	0.06126	0.0028	0.056	0.0013	383	7.5	383.2	8.5	447	25.5	383.2	yes
X619_27	106.7	313	3.41	7.44	0.3	0.3307	0.017	0.1545	0.0031	2160	19	1841	39.5	2394	17	2394	yes

X619_28	301	275.9	1.091	1.075	0.0 48	0.1196	0.00 56	0.06 446	0.00 11	739	12	728	16	754	18 .5	728	yes
X619_29	128 .2	134.8	0.98	0.656	0.0 19	0.0802	0.00 41	0.05 81	0.00 14	512	6	497	12	529	26	497	yes
X619_30	590	303	2.13	1.43	0.1 2	0.0603	0.00 28	0.16 03	0.00 93	891	26 .5	377.3	8. 5	2430	50	377 .3	yes
X619_31	346	124	2.83	3.22	0.1 3	0.2339	0.01 1	0.09 18	0.00 2	1458	16 .5	1355	29 .5	1459	20 .5	135 5	yes
X619_32	182 .4	144	1.267	1.09	0.0 52	0.0796	0.00 37	0.09 95	0.00 35	746	12 .5	493.6	11	1605	32 .5	493 .6	yes
X619_33	296	68	4.89	0.451	0.0 18	0.05187	0.00 24	0.06 25	0.00 18	377	6. 5	326	7	709	31	326	yes
X619_34	120 .1	37.1	3.14	1.727	0.0 6	0.164	0.00 76	0.07 42	0.00 16	1016	11 .5	979	21	1042	22	979	yes
X619_35	517	139.1	3.7	1.79	0.1	0.167	0.00 83	0.07 81	0.00 15	1034	20	999	23 .5	1148	19 .5	999	yes
X619_36	310	207.5	1.52	0.632	0.0 28	0.05694	0.00 27	0.08 39	0.00 71	505	10	356.9	8	1240	80	356 .9	yes
X619_37	367	54	7.05	0.436	0.0 18	0.057	0.00 3	0.05 43	0.00 12	367	6. 5	357.1	9	379	24 .5	357 .1	yes
X619_40	229	82.9	2.45	1.1	0.1 1	0.0922	0.00 44	0.08 8	0.01 3	740	23 .5	570	13 .5	1260	12 0	570	yes
X619_41	84. 9	26	2.96	2.65	0.1 7	0.2185	0.01 1	0.08 45	0.00 26	1303	24 .5	1273	29	1296	28	127 3	yes
X619_42	14. 7	10.5	1.28	0.555	0.0 69	0.0697	0.00 47	0.05 36	0.00 75	449	24	434	14	370	13 0	434	yes
X619_43	152 .8	53.9	2.69	0.884	0.0 29	0.0973	0.00 47	0.06 28	0.00 22	642	8	598	14	688	36	598	yes
X619_44	252 .2	62.1	4.14	9.37	0.5 2	0.309	0.01 7	0.20 66	0.00 8	2374	25	1734	42	2880	32	288 0	no
X619_45	48. 2	25.4	1.94	2.057	0.0 99	0.1839	0.00 92	0.07 78	0.00 27	1130	17	1088	25	1140	35 .5	108 8	yes
X619_46	117 2	193	6.3	0.577	0.0 37	0.0693	0.00 34	0.06 33	0.00 25	465	11 .5	431.9	10	697	40 .5	431 .9	yes
X619_47	367	58.3	7.36	2.01	0.1 2	0.18	0.00 89	0.08 07	0.00 17	1109	22	1067	24	1216	19	106 7	yes
X619_48	229 .4	103.5	2.39	0.422	0.0 26	0.0529	0.00 27	0.05 98	0.00 19	363	9. 5	332.1	8. 5	582	34 .5	332 .1	yes
X619_49	175 .5	106.9	1.736	2.05	0.1 2	0.1874	0.00 99	0.08 06	0.00 22	1126	21 .5	1106	27	1220	26	110 6	yes
X619_50	302	72.6	4.32	0.99	0.1	0.0505	0.00 26	0.14 14	0.00 65	709	24 .5	317.8	8	2238	46	317 .8	yes
X619_51	77. 9	66.8	1.27	1.38	0.1 7	0.1099	0.00 57	0.09 31	0.00 64	863	35 .5	672	16 .5	1430	65	672	yes
X619_52	58. 5	15	3.79	2.72	0.2 2	0.2302	0.01 2	0.08 76	0.00 3	1312	34 .5	1335	30 .5	1360	33 .5	133 5	yes
X619_54	366	214	1.6	0.389	0.0 31	0.0526	0.00 28	0.05 83	0.00 23	335	11	330.4	8. 5	522	43	330 .4	yes
X619_61	139 .4	53.6	2.68	0.792	0.0 55	0.0947	0.00 49	0.06 08	0.00 2	588	16	583	14 .5	618	37	583	yes
X619_62	158	43.3	4.17	2.24	0.1 5	0.1981	0.01 1	0.07 69	0.00 27	1191	24	1164	30	1108	35	116 4	no
X619_63	113 .3	30.2	4.14	1.98	0.1 3	0.1833	0.00 96	0.07 78	0.00 24	1098	23 .5	1084	26	1132	29 .5	108 4	yes
X619_65	66. 7	40.2	1.92	0.517	0.0 46	0.0561	0.00 29	0.06 95	0.00 54	418	15	352	9	840	75	352	yes
X619_66	117 .5	44.6	2.98	0.455	0.0 21	0.0558	0.00 31	0.05 91	0.00 38	380	7	350	9. 5	530	65	350	yes
X619_67	82. 6	12.6	7.38	0.814	0.0 32	0.0799	0.00 43	0.06 97	0.00 29	607	8. 5	495	13	903	43	495	yes
X619_68	177	92.6	2.13	0.406	0.0 19	0.0504	0.00 29	0.05 44	0.00 29	345	7	317	9	360	55	317	yes
X619_69	174	199	0.956	0.384	0.0 24	0.0497	0.00 29	0.05 32	0.00 27	329	8. 5	313	9	310	55	313	yes
X619_70	142	27.7	5.19	1.436	0.0 88	0.135	0.00 79	0.07 09	0.00 19	898	18 .5	815	22 .5	964	28 .5	815	yes
X619_71	105 .1	28.4	3.7	0.944	0.0 62	0.1026	0.00 57	0.06 64	0.00 41	670	15 .5	629	16 .5	770	60	629	yes
X619_72	204 .9	78.6	2.49	1.996	0.0 66	0.1771	0.00 93	0.07 68	0.00 22	1112	11 .5	1051	25 .5	1126	29	105 1	yes
X619_73	338	242	1.364	0.534	0.0 44	0.066	0.00 44	0.05 46	0.00 17	430	14 .5	411	13	409	31 .5	411	yes

X619_74	177	25.6	6.58	1.992	0.084	0.1781	0.0088	0.075	0.0016	1109	14.5	1056	24.5	1064	22.5	1056	yes
X619_75	98.6	36.9	2.69	0.42	0.026	0.04327	0.0021	0.0654	0.005	355	9.5	273	6.5	720	80	273	yes
X619_76	99.5	31.9	3.1	0.646	0.04	0.0764	0.0042	0.0576	0.003	508	13	475	12.5	480	55	475	yes
X619_77	21.9	6.67	3.36	1.77	0.11	0.1649	0.0089	0.0739	0.0036	1027	19.5	983	24.5	1008	49	983	yes
X619_78	114.3	13.3	10	0.414	0.023	0.0548	0.0029	0.0535	0.0022	350	8.5	344	9	350	42.5	344	yes
X619_79	799	23.6	33.7	2.301	0.072	0.1724	0.009	0.0918	0.0045	1210	11	1025	24.5	1467	44	1025	no
X619_80	210.9	138	1.61	0.501	0.059	0.0602	0.0033	0.0642	0.0042	405	20	377	10	700	65	377	yes
X619_81	225.1	26.9	8.44	0.689	0.041	0.0756	0.0039	0.066	0.0018	541	12	470	11.5	799	28	470	yes
X619_82	148	20.8	7.28	1.8	0.12	0.1746	0.0098	0.0746	0.0024	1038	22.5	1036	27	1046	32	1036	yes
X619_83	253	80	3.47	0.733	0.097	0.0756	0.0038	0.0713	0.0055	561	30	470	11.5	950	80	470	yes
X619_84	136	85	1.55	0.845	0.084	0.095	0.005	0.0646	0.0029	619	22.5	585	15	749	49	585	yes
X619_85	29.3	12.14	2.51	1.76	0.12	0.1789	0.009	0.0755	0.004	1021	23.5	1061	24.5	1050	50	1061	yes
X619_86	299	13.7	25.4	0.509	0.022	0.0641	0.0034	0.0575	0.0018	420	7	400	10.5	522	37.5	400	yes
X619_87	703	20.9	37.1	2.95	0.3	0.2027	0.011	0.1089	0.0025	1384	39	1189	29	1778	21	1189	no
X619_88	51.5	51.3	0.992	0.635	0.058	0.0737	0.0041	0.0662	0.0052	499	17.5	458	12.5	710	70	458	yes
X619_90	167	51.4	3.18	1.57	0.15	0.1545	0.0088	0.0765	0.0022	971	28	926	24.5	1110	27.5	926	yes
X619_91	81.8	17.1	4.93	4.83	0.29	0.0718	0.0043	0.49	0.016	1799	25.5	447	13	4222	24	447	yes
X619_92	235.8	83.5	2.85	0.862	0.071	0.1007	0.0053	0.0607	0.002	632	19	618	15.5	639	35	618	yes
X619_93	30.1	13.25	2.25	1.62	0.15	0.1702	0.01	0.0706	0.0035	973	29.5	1012	27.5	930	50	1012	no
X619_94	88.9	34.3	2.81	0.792	0.081	0.102	0.0064	0.0628	0.0037	586	23.5	626	18.5	680	60	626	yes
X619_95	361	28.7	12.61	1.75	0.12	0.1739	0.0098	0.0721	0.0018	1018	24.5	1033	27	983	25	1033	no
X619_96	48.9	19	2.64	0.42	0.038	0.0595	0.0035	0.0555	0.0041	359	15	372	10.5	390	75	372	yes
X619_97	248	164	1.63	0.49	0.029	0.0616	0.0033	0.0574	0.0019	403	10	385	10	507	35.5	385	yes
X619_98	510	137	3.99	0.541	0.037	0.0647	0.0036	0.0614	0.0021	436	12.5	404	11	664	33.5	404	yes
X619_99	96	70.2	1.366	0.393	0.04	0.0536	0.0028	0.0553	0.0029	343	13.5	336.8	8.5	390	55	336.8	yes
X619_100	142.7	82.3	1.78	0.752	0.047	0.0794	0.004	0.069	0.0025	566	14	492	12	896	36	492	yes
X619_101	123.5	14.9	8.59	2.45	0.13	0.1896	0.0097	0.0949	0.003	1252	19.5	1118	26.5	1518	29	1118	yes
X619_102	597	59.5	10.16	0.564	0.035	0.0662	0.0032	0.0628	0.0014	452	11.5	413.1	10	704	25	413.1	yes
X619_103	230	80.8	3.03	0.51	0.044	0.0698	0.0036	0.0565	0.0024	425	13.5	435	11	449	44.5	435	yes
X619_104	348	99	3.83	0.547	0.044	0.0637	0.0032	0.063	0.0019	444	15	398.1	9.5	717	34	398.1	yes
X619_105	599	173	3.45	0.97	0.031	0.0798	0.0038	0.0909	0.0062	687	8	495.1	11	1470	70	495.1	yes
3137																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Best Age Ma	Used?
X3137_2	1370	256	5.06	3.43	0.43	0.0746	0.005	0.331	0.026	1498	49.5	463	15	3587	60	463	yes
X3137_3	353	8.82	39.4	6.89	0.6	0.1904	0.01	0.262	0.016	2078	36.5	1123	28	3247	46.5	1123	no

X3137_4	203	174.9	1.174	5.28	0.59	0.1378	0.008	0.275	0.021	1829	46	831	22.5	3300	60	831	no
X3137_5	1432	767	1.93	0.671	0.037	0.0518	0.0023	0.095	0.005	520	11	325.2	7	1522	49	325.2	yes
X3137_6	435	340	1.254	5.39	0.33	0.0921	0.0041	0.4215	0.022	1879	25.5	568	12	3984	38.5	568	yes
X3137_7	622	301	2.061	0.739	0.051	0.0647	0.0026	0.0842	0.0058	560	14.5	404.1	8	1268	65	404.1	yes
X3137_8	670	169	4.17	1.248	0.11	0.0658	0.0037	0.1345	0.008	822	25.5	411	11	2146	55	411	yes
X3137_9	405	124.2	3.36	0.99	0.17	0.0521	0.0031	0.138	0.019	688	42	327	9.5	2080	120	327	yes
X3137_10	490	142.2	3.53	1.78	0.15	0.0989	0.0045	0.13	0.0093	1031	25	608	13	2089	65	608	yes
X3137_11	387	127.1	3.09	1.85	0.19	0.0592	0.003	0.229	0.021	1049	33	370	9	3010	70	370	yes
X3137_13	441	349	1.295	12.06	0.88	0.1498	0.0095	0.592	0.03	2628	38.5	898	26.5	4490	35.5	898	no
X3137_14	417	410	1.035	7.45	0.52	0.1215	0.0059	0.449	0.025	2176	29	739	17	4083	39.5	739	yes
X3137_15	131	57.7	2.25	0.83	0.15	0.0591	0.0029	0.1	0.017	588	38.5	370	9	1440	150	370	yes
X3137_16	189.5	58.9	3.33	2.643	0.15	0.1061	0.0046	0.1794	0.0096	1310	21	650	13.5	2641	44	650	yes
X3137_17	62.3	44.9	1.425	0.93	0.16	0.049	0.0028	0.131	0.021	644	42.5	309	8.5	2090	155	309	yes
X3137_18	568	35.7	18.3	0.555	0.049	0.0687	0.0046	0.058	0.0034	445	16	428	14	512	65	428	yes
X3137_19	494	275	1.819	2.08	0.18	0.0613	0.0029	0.249	0.018	1138	31.5	383	8.5	3159	60	383	yes
X3137_20	273.2	85.8	3.28	2.007	0.1	0.1778	0.0078	0.0817	0.0044	1117	17.5	1055	21.5	1231	50	105.5	yes
X3137_21	690	492	1.419	2.24	0.25	0.1125	0.0048	0.142	0.013	1171	38	687	14	2190	80	687	yes
X3137_22	101.5	61.7	1.759	1.283	0.099	0.0694	0.0032	0.1329	0.01	833	21	433	9.5	2150	65	433	yes
X3137_23	686	113.9	6.14	2.195	0.14	0.1011	0.0042	0.154	0.0087	1175	22	620.7	12.5	2398	48.5	620.7	yes
X3137_24	197	46.2	4.29	12.8	2.6	0.283	0.026	0.307	0.037	2560	90	1590	65	3470	90	3470	no
X3137_25	171.9	139.3	1.264	0.695	0.063	0.06	0.0027	0.0835	0.0072	531	18.5	375.7	8	1330	80	375.7	yes
X3137_26	422	301	1.456	4.48	0.75	0.0876	0.0079	0.345	0.035	1640	70	540	23.5	3640	80	540	yes
X3137_27	710	476	1.551	4.05	0.31	0.0783	0.0036	0.361	0.026	1633	33.5	486	11	3749	60	486	yes
X3137_28	292	42.7	6.91	2.924	0.17	0.2226	0.01	0.095	0.0051	1385	21.5	1295	26.5	1521	48.5	129.5	yes
X3137_29	259.9	175.9	1.607	4.4	0.4	0.0817	0.0048	0.378	0.022	1694	36	506	14	3812	44.5	506	yes
X3137_30	363	268	1.49	0.51	0.038	0.04733	0.0021	0.0769	0.0055	416	12.5	298.1	6.5	1100	75	298.1	yes
X3137_36	240	81	3.39	0.79	0.12	0.0514	0.0024	0.114	0.017	575	31	322.8	7.5	1670	130	322.8	yes
X3137_37	560	126.9	5	1.5	0.2	0.0677	0.003	0.162	0.02	904	37.5	422.4	9	2370	95	422.4	yes
X3137_38	488	300	1.629	1.211	0.075	0.1011	0.0044	0.087	0.006	803	17.5	621	13	1332	65	621	yes
X3137_39	263.3	53	9.1	0.413	0.032	0.0503	0.0022	0.0586	0.0048	349	11	316.5	7	500	75	316.5	yes
X3137_40	118.7	39.1	3.14	0.822	0.091	0.087	0.0043	0.0687	0.007	599	20.5	538	13	800	95	538	yes
X3137_41	443	392	1.17	1.75	0.14	0.063	0.0031	0.196	0.013	1018	25.5	394	9.5	2789	50	394	yes
X3137_42	202.3	74.3	2.93	0.825	0.065	0.0927	0.0048	0.0639	0.0042	615	15.5	576	15.5	709	65	576	yes
X3137_45	987	155	8.6	1.75	0.18	0.0727	0.0033	0.169	0.013	1010	31	453	10	2540	65	453	yes
X3137_46	389	297	1.327	0.958	0.065	0.0511	0.0023	0.1366	0.0092	680	16.5	322.6	7.5	2146	50	322.6	yes
X3137_48	547	129	4.35	0.965	0.075	0.0649	0.0032	0.1087	0.0099	683	18.5	406	9.5	1740	75	406	yes

X3137_49	579	202	2.83	1.32	0.12	0.075	0.0032	0.1296	0.011	867	28.5	466	9.5	2090	80	466	yes
X3137_50	263	201	1.53	0.469	0.026	0.0556	0.0023	0.0604	0.0038	390	9	349	7	612	65	349	yes
X3137_51	72.3	7.9	9.04	2.149	0.13	0.1785	0.0074	0.0881	0.0062	1161	21.5	1059	20	1352	65	1059	yes
X3137_52	70.8	10.12	6.85	2.106	0.11	0.1967	0.0083	0.077	0.0042	1149	18.5	1157	22.5	1111	55	1157	yes
X3137_53	252	296	0.888	0.659	0.053	0.0514	0.0023	0.0915	0.0071	511	16	322.9	7	1480	75	322.9	yes
X3137_54	340	288	1.22	0.566	0.035	0.0608	0.0026	0.0686	0.0043	454	11.5	380.6	8	877	65	380.6	yes
X3137_55	145.9	9.92	15	1.576	0.095	0.1543	0.0066	0.0737	0.0043	958	18.5	925	18.5	1019	55	925	yes
X3137_56	62.6	39.5	1.71	0.92	0.13	0.0668	0.0033	0.097	0.012	643	32.5	417	10	1470	125	417	yes
X3137_57	247	89	2.8	1.5	0.13	0.104	0.0053	0.1033	0.0079	931	23	637	15.5	1651	60	637	yes
X3137_59	631	346	1.92	0.826	0.062	0.0721	0.003	0.0807	0.0053	608	17	449	9	1221	65	449	yes
X3137_60	70.8	24.8	2.94	0.668	0.073	0.0691	0.003	0.0699	0.0083	513	21	431	9	760	95	431	yes
X3137_61	68	40.7	1.729	0.742	0.068	0.0699	0.0032	0.0761	0.0067	558	19.5	436	9.5	1060	90	436	yes
X3137_62	277	181	1.68	0.62	0.12	0.0529	0.0027	0.079	0.012	455	29	332	8.5	1060	135	332	yes
X3137_63	290	47.1	6.36	1.93	0.17	0.1585	0.0074	0.0862	0.0063	1089	29	948	20.5	1340	70	948	yes
X3137_64	170	32.2	5.68	2.028	0.12	0.1754	0.0077	0.0836	0.0046	1122	21	1042	21	1273	50	1042	yes
X3137_65	154.4	93.7	1.726	0.861	0.089	0.065	0.0028	0.095	0.0093	624	23	405.7	8.5	1470	85	405.7	yes
X3137_66	166	31.8	5.39	3.06	0.19	0.228	0.012	0.0939	0.0049	1417	24	1323	30.5	1501	49	1323	yes
X3137_67	195	92.3	2.203	0.512	0.035	0.0604	0.0026	0.0622	0.0046	418	11	377.9	8	660	75	377.9	yes
X3137_68	879	96.2	9.21	0.819	0.046	0.0681	0.003	0.086	0.0054	606	13	424.6	9	1316	60	424.6	yes
X3137_69	1410	674	2.035	1.42	0.13	0.0681	0.003	0.153	0.014	904	29.5	424.5	9	2370	80	424.5	yes
X3137_70	51	14.91	3.45	1.779	0.12	0.1627	0.0069	0.08	0.0062	1033	21.5	972	19	1128	60	972	yes
X3137_71	960	192	5.71	1.36	0.16	0.0741	0.0042	0.134	0.012	856	32	461	12.5	2090	70	461	yes
X3137_73	219	85.9	2.6	0.593	0.054	0.0661	0.0029	0.0672	0.0065	469	15.5	412.5	8.5	770	85	412.5	yes
X3137_74	111.8	25.8	4.51	2.45	0.22	0.1863	0.0082	0.0932	0.0076	1257	31.5	1101	22.5	1500	80	1101	yes
X3137_75	1150	370	3.17	0.776	0.045	0.0764	0.0033	0.0746	0.0047	582	12.5	474.4	10	1034	65	474.4	yes
X3137_76	390	89	4.61	2.544	0.13	0.2142	0.0093	0.0863	0.0043	1283	19	1251	24.5	1340	47	1251	yes
X3137_77	207	9.2	27.2	0.886	0.098	0.0807	0.0042	0.0773	0.007	633	25.5	500	12.5	1160	95	500	yes
X3137_79	259	48.6	5.34	1.951	0.13	0.1701	0.0069	0.0835	0.0055	1095	21	1012	19	1236	50	1012	yes
X3137_80	519	158.2	3.36	0.556	0.038	0.0573	0.0024	0.071	0.0047	447	12	359.2	7.5	933	60	359.2	yes
X3137_81	291	142	2.111	4.81	0.37	0.0886	0.0046	0.396	0.023	1771	33	547	13.5	3882	45	547	yes
X3137_83	145.3	24.13	6.1	2.263	0.13	0.1828	0.0082	0.0909	0.005	1199	20	1082	22.5	1436	55	1082	yes
X3137_84	409.3	342	1.243	1.033	0.092	0.0637	0.003	0.121	0.01	714	23	398	9	1950	80	398	yes
X3137_85	780	32.7	24.4	0.402	0.028	0.0507	0.0024	0.0575	0.0036	342	10	318.9	7	493	65	318.9	yes
X3137_86	183	45.3	3.96	0.69	0.064	0.0685	0.0031	0.0743	0.0076	528	18.5	427	9.5	960	90	427	yes
X3137_87	251.2	18.1	142.5	0.474	0.037	0.0492	0.0021	0.0704	0.0054	392	12.5	309.6	6.5	920	80	309.6	yes
X3137_88	447	103	4.33	1.49	0.087	0.1273	0.0059	0.0853	0.0045	928	18	772	17	1317	49.5	772	yes

X3137_89	400	163	2.62	0.917	0.093	0.0831	0.0039	0.0809	0.0077	653	23.5	514	11.5	1150	85	514	yes
X3137_90	1002	179	5.58	1.526	0.078	0.1497	0.0064	0.0744	0.0039	940	15.5	899	18	1063	47	899	yes
X3137_91	94	32.9	2.845	0.828	0.098	0.0679	0.0029	0.0888	0.01	602	25.5	423.5	8.5	1290	100	423.5	yes
X3137_92	370	175	2.259	0.506	0.04	0.0515	0.0024	0.0727	0.0063	414	13.5	323.8	7	950	80	323.8	yes
X3137_93	85.2	54.2	1.544	0.62	0.11	0.056	0.0027	0.077	0.011	473	31	351	8	1050	145	351	yes
X3137_94	176.9	92.1	1.874	0.404	0.028	0.0475	0.0022	0.0621	0.0047	343	10	299.2	6.5	630	80	299.2	yes
X3137_95	742	269	2.94	1.793	0.12	0.1062	0.0051	0.1232	0.0066	1039	21.5	650	14.5	1996	47	650	yes
X3137_96	274.6	97.5	2.85	0.829	0.067	0.0632	0.0027	0.0967	0.0074	608	18.5	395	8.5	1530	80	395	yes
X3137_98	1120	522	2.144	0.769	0.08	0.0603	0.0028	0.093	0.0079	571	22	378	8.5	1450	80	378	yes
X3137_99	98	43.8	2.31	1.17	0.22	0.0728	0.0035	0.115	0.02	739	49.5	453	10.5	1650	160	453	yes
X3137_100	154	60.6	2.5	0.917	0.062	0.0945	0.0041	0.0721	0.0047	658	16	582	12	964	65	582	yes
X3137_101	98	51	1.898	0.748	0.069	0.0883	0.004	0.0625	0.0059	562	18	545	12	620	60	545	yes
X3137_102	179.6	24.2	7.47	1.817	0.11	0.1723	0.0075	0.0775	0.0042	1049	19	1024	20.5	1125	55	1024	yes
X3137_103	236	50.2	5.5	1.006	0.11	0.0821	0.0039	0.091	0.011	698	25	508	11.5	1330	105	508	yes
X3137_104	250	26.3	9.65	0.847	0.055	0.0848	0.0041	0.0728	0.0044	621	15	524	12	992	60	524	yes
X3137_105	321	40.8	8.4	1.708	0.099	0.1548	0.0081	0.0806	0.0041	1009	19	927	22.5	1217	46	927	yes
X3137_107	112.7	47.1	2.293	0.823	0.062	0.0904	0.0039	0.0659	0.005	598	12.5	558	11.5	790	65	558	yes
X3137_108	140	62.6	2.153	7.66	0.47	0.361	0.02	0.1562	0.0077	2191	28.5	1983	46.5	2413	41.5	2413	yes
X3137_112	2340	912	2.39	0.466	0.035	0.04664	0.002	0.075	0.0059	387	12	293.8	6	1020	85	293.8	yes
442																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Best Age Ma	Used?
X442_2	889	432	2.09	1.243	0.085	0.1258	0.0068	0.0719	0.0025	816	19	763	19.5	969	36.5	763	yes
X442_3	870	650	1.412	1.31	0.073	0.122	0.0049	0.0778	0.0021	852	16	742	14	1143	29.5	742	yes
X442_4	119.2	79.4	1.57	0.633	0.055	0.0544	0.0024	0.0841	0.0048	494	17	341.2	7	1350	60	341.2	yes
X442_5	299	276	1.109	0.533	0.048	0.054	0.0025	0.0725	0.0049	431	15.5	339	7.5	980	70	339	yes
X442_6	165	217	0.766	0.403	0.032	0.0476	0.0028	0.0613	0.0041	342	11.5	299	8.5	560	55	299	yes
X442_7	101.8	40.1	2.55	0.708	0.041	0.0878	0.0041	0.0597	0.0022	545	12	542	12	600	43.5	542	yes
X442_8	46.7	16.94	2.8	1.25	0.41	0.0982	0.0063	0.096	0.025	740	65	603	18.5	1120	170	603	yes
X442_9	472	176	2.63	2.373	0.13	0.1817	0.0093	0.0945	0.0024	1237	19	1075	26.5	1510	25.5	1075	yes
X442_10	792	487	1.634	1.129	0.072	0.0603	0.0026	0.14	0.006	769	16	377.7	8	2206	39.5	377.7	yes
X442_11	142.4	108.1	1.373	0.801	0.054	0.0624	0.0026	0.0933	0.0044	594	15	390	8	1468	48	390	yes
X442_12	350	411	0.872	0.498	0.031	0.0602	0.0028	0.0598	0.0027	409	10.5	377	8.5	569	50	377	yes
X442_13	869	64	15.1	0.56	0.037	0.0661	0.0029	0.0624	0.0036	450	12	413	9	710	60	413	yes
X442_14	156	57.8	2.74	1.06	0.16	0.1089	0.006	0.076	0.011	718	32.5	666	17.5	830	85	666	yes
X442_15	730	94.2	8.5	1.075	0.07	0.1082	0.0051	0.0716	0.0026	738	16	662	15	970	41	662	yes

X442_16	733	451	1.602	0.646	0.045	0.0557	0.0023	0.0836	0.004	504	13	349.2	7	1259	44.5	349.2	yes
X442_17	407	440	1.02	0.411	0.031	0.0474	0.002	0.063	0.0029	348	11	298.4	6	678	49	298.4	yes
X442_18	164	70	2.91	0.648	0.063	0.0499	0.0023	0.0927	0.0062	508	19	314.1	7	1470	65	314.1	yes
X442_19	507	660	0.796	0.63	0.1	0.0535	0.0028	0.085	0.01	483	28	336	8	1200	100	336	yes
X442_20	275	159	1.83	0.609	0.083	0.0495	0.0035	0.0884	0.0086	479	27	311	10.5	1420	90	311	yes
X442_22	1150	700	1.68	0.392	0.034	0.0446	0.0021	0.0641	0.004	334	12	280.9	6.5	700	65	280.9	yes
X442_24	45.4	19	2.61	0.974	0.048	0.1038	0.0045	0.0681	0.0024	689	13	637	13	854	38	637	yes
X442_25	499	124	4.47	0.763	0.042	0.0682	0.0032	0.0814	0.0039	574	12	425	9.5	1200	50	425	yes
X442_26	418	88	4.81	4.8	0.28	0.306	0.014	0.1124	0.0027	1787	23.5	1720	34.5	1833	23	1833	yes
X442_27	500	61.1	8.42	0.931	0.044	0.1023	0.0041	0.065	0.0016	667	11.5	628	12	784	27	628	yes
X442_28	45	21.6	2.02	1.55	0.18	0.0588	0.0032	0.187	0.016	937	35	368	9.5	2720	75	368	yes
X442_30	132	41	3.21	2.6	0.16	0.2181	0.0095	0.0853	0.0029	1294	21.5	1271	25	1310	33.5	1271	yes
X442_31	226	104	2.28	0.568	0.053	0.0523	0.0025	0.0782	0.0059	452	16.5	329	7.5	1090	70	329	yes
X442_32	696	112	6.32	1.72	0.15	0.1456	0.0065	0.0875	0.0066	1009	24.5	876	18.5	1295	44	876	no
X442_33	146	105.2	1.335	0.8	0.038	0.1006	0.0043	0.059	0.0012	598	11	617	12.5	563	22.5	617	yes
X442_34	221	77.1	2.97	27.8	1.8	0.331	0.017	0.618	0.022	3413	33	1840	40.5	4545	28.5	4545	no
X442_35	288.6	26.6	10.93	2.3	0.19	0.1703	0.0087	0.1017	0.0095	1212	30	1013	24	1590	90	1013	no
X442_36	108.4	54.9	2.023	0.96	0.16	0.0537	0.0025	0.124	0.016	672	40	337	7.5	1930	120	337	yes
X442_37	200	143	1.39	2.07	0.39	0.0676	0.0041	0.222	0.028	1110	60	422	12	2860	115	422	yes
X442_38	302	72	5.07	1.72	0.19	0.0868	0.0042	0.142	0.011	1002	34	536	12	2210	70	536	yes
X442_39	281	81	3.52	8.05	0.92	0.2371	0.011	0.255	0.028	2209	49	1370	27.5	3120	85	1370	yes
X442_40	824	540	2.51	2.3	0.27	0.0754	0.0038	0.216	0.017	1186	38.5	468	11.5	2920	70	468	yes
X442_41	153	27.6	5.5	0.533	0.026	0.0726	0.0032	0.0543	0.0014	433.1	8.5	452	9.5	397	29	452	yes
X442_42	17.21	3.75	4.72	2.15	0.14	0.1972	0.009	0.0797	0.0031	1168	22	1160	24	1171	39	1160	yes
X442_43	447	517	0.875	1.53	0.28	0.0639	0.0034	0.159	0.023	900	55	399	10	2330	145	399	yes
X442_44	435	162.1	2.67	0.879	0.051	0.092	0.0041	0.0696	0.0022	639	13.5	567	12	917	34.5	567	yes
X442_46	515	230	2.22	0.786	0.044	0.04737	0.002	0.1179	0.005	591	12	298.3	6	1905	38.5	298.3	yes
X442_47	374	269	1.51	0.467	0.024	0.0522	0.0021	0.0642	0.0022	388	8.5	328.1	6.5	734	35.5	328.1	yes
X442_48	436	179	2.425	0.345	0.02	0.04684	0.0019	0.0533	0.0019	301	7.5	295.1	6	325	39	295.1	yes
X442_49	326	115.1	2.89	0.84	0.048	0.102	0.0044	0.0605	0.0022	618	14	626	13	604	40.5	626	yes
X442_50	116.4	17	7.02	1.313	0.11	0.0958	0.0039	0.0987	0.0064	851	24	590	11.5	1570	65	590	yes
X442_51	533	27.1	21.9	0.67	0.078	0.0631	0.003	0.0768	0.0063	513	21.5	394	9	1050	70	394	yes
X442_52	529	24.4	21.65	0.783	0.066	0.0653	0.0032	0.0859	0.0056	601	17.5	408	9.5	1320	60	408	yes
X442_53	62.6	44	1.43	1.58	0.13	0.0749	0.0038	0.1499	0.0093	955	25.5	465	11.5	2380	55	465	yes
X442_54	800	68.2	11.3	2.59	0.22	0.1842	0.01	0.1003	0.0058	1303	31	1089	27	1610	55	1089	no
X442_55	748	62	12.61	0.643	0.053	0.0675	0.0037	0.0665	0.0046	500	16.5	421	11	890	75	421	yes

X442_57	234	91.1	2.63	1.69	0.19	0.1168	0.0066	0.1021	0.0086	996	36.5	711	19	1640	80	711	yes
X442_58	493	188	2.56	0.757	0.058	0.05057	0.002	0.1105	0.006	579	15.5	318	6	1818	47	318	yes
X442_60	1410	409	3.23	3	0.26	0.0693	0.0035	0.322	0.016	1412	32.5	432	10.5	3559	41	432	yes
X442_61	282	43.2	6.7	0.381	0.023	0.0507	0.0023	0.0553	0.0017	327	8.5	318.7	7	440	39.5	318.7	yes
X442_62	412	94.7	4.09	1.594	0.12	0.1481	0.0089	0.0805	0.0033	962	22.5	889	25	1206	42.5	889	yes
X442_63	568	311	1.92	9.87	0.5	0.1372	0.0063	0.526	0.019	2419	31	828	18	4313	28	828	no
X442_64	279	150	1.865	1.066	0.063	0.0996	0.0043	0.0789	0.0028	738	16	612	12.5	1155	35.5	612	yes
X442_65	279	227	1.212	0.93	0.071	0.0585	0.0025	0.1135	0.0054	663	18	366.4	7.5	1869	45.5	366.4	yes
X442_66	650	258	2.73	22.1	1.8	0.405	0.021	0.396	0.017	3168	39	2205	47.5	3894	34.5	3894	no
X442_67	111.8	60	2.1	49.2	4	0.482	0.032	0.722	0.018	3954	40.5	2530	75	4786	20.5	4786	no
X442_68	1230	984	1.294	0.464	0.028	0.0442	0.0019	0.0743	0.0027	386	10	278.9	6	1060	37	278.9	yes
X442_69	1030	319	3.249	0.628	0.047	0.04536	0.0019	0.0995	0.0068	492	14.5	286	6	1570	65	286	yes
X442_70	36.2	20.47	1.758	1.86	0.13	0.1131	0.0045	0.1199	0.0072	1061	22.5	691	13	1960	55	691	yes
X442_71	13	6.19	2.103	4.81	0.39	0.0893	0.004	0.372	0.017	1781	34.5	551	12	3800	32.5	551	yes
X442_72	73.1	41	1.79	3.64	0.39	0.2158	0.0096	0.121	0.011	1534	41	1259	24	1900	75	1259	no
X442_73	189	58.4	3.48	7.33	0.33	0.368	0.015	0.1423	0.0024	2158	20.5	2016	36	2253	14.5	2253	yes
X442_74	99.1	42.8	2.424	3.34	0.17	0.2552	0.011	0.0941	0.0026	1488	19.5	1464	27.5	1508	27	1508	yes
X442_76	117	93	1.247	4.44	0.7	0.1347	0.0073	0.228	0.027	1660	70	814	20.5	2980	10.5	814	no
X442_77	253	97.9	2.63	3.02	0.19	0.2126	0.0091	0.1041	0.0037	1407	22.5	1242	24	1686	31.5	1242	yes
X442_78	442	196.9	2.28	3.82	0.37	0.21	0.011	0.135	0.012	1575	37.5	1228	30	2140	85	1228	no
X442_79	661	423	1.97	5.53	0.63	0.09	0.0044	0.448	0.042	1880	50	556	13	4020	80	556	yes
X442_81	687	117.8	5.92	0.984	0.099	0.0718	0.0032	0.1031	0.0095	706	25	447	9.5	1640	85	447	yes
X442_82	1040	26.27	39.9	0.863	0.064	0.0683	0.0026	0.0938	0.0063	627	17	426.1	8	1480	65	426.1	yes
X442_83	333	104.4	3.26	4.02	0.21	0.2697	0.012	0.1094	0.0043	1634	21.5	1539	29.5	1772	37	1772	yes
X442_84	97.2	36.5	2.69	0.639	0.051	0.0647	0.0029	0.0716	0.0034	498	15.5	404	8.5	950	50	404	yes
X442_85	313	95.2	3.24	0.615	0.037	0.0553	0.0022	0.0808	0.0038	485	11.5	347.1	7	1221	46.5	347.1	yes
X442_86	187	160.9	1.149	0.881	0.072	0.0686	0.0031	0.0946	0.0065	644	20	428	9.5	1500	65	428	yes
X442_87	81	59.8	1.337	0.888	0.054	0.1098	0.0045	0.0603	0.002	643	14.5	671	13	599	38.5	671	yes
X442_88	125.6	94.7	1.266	4.1	0.41	0.0828	0.0046	0.351	0.019	1631	40.5	513	13.5	3690	42	513	yes
X442_89	889	230	3.93	1.348	0.1	0.1161	0.0057	0.0837	0.0042	868	22.5	720	16.5	1310	50	720	yes
X442_91	284	154	2.13	1.66	0.26	0.0633	0.0036	0.198	0.025	987	49	400	11	2700	95	400	yes
X442_92	1079	95.9	11.5	1.357	0.073	0.1115	0.0045	0.0869	0.0028	872	16	681	13	1347	31.5	681	yes
X442_93	337	175	1.98	2.27	0.11	0.197	0.0084	0.0831	0.0024	1200	18.5	1159	22.5	1262	28	1159	yes
X442_94	264	290	1.008	0.514	0.027	0.062	0.0025	0.0599	0.0021	421	9	387.5	7.5	594	40	387.5	yes
X442_95	212.6	97.6	2.19	0.971	0.069	0.0761	0.0032	0.0904	0.0053	691	18.5	473	9.5	1440	55	473	yes
X442_96	477	154	3.47	1.4	0.15	0.0787	0.0032	0.129	0.012	872	32	488	9.5	2020	85	488	yes

X442_97	273	135.8	2.001	0.63	0.035	0.0774	0.0032	0.0583	0.0015	495	11	482	9.5	541	28	482	yes
X442_98	608	799	0.741	1.15	0.19	0.0575	0.0028	0.144	0.02	758	47	360	8.5	2110	130	360	yes
X442_99	154.4	36.5	4.26	17.39	1	0.588	0.028	0.2149	0.007	2955	30.5	2978	60	2934	27.5	2934	yes
X442_100	327	107.6	3.09	0.867	0.047	0.1086	0.0046	0.0581	0.0017	640	14	664	13.5	565	34.5	664	yes
X442_101	298	101	3.6	0.77	0.061	0.0946	0.0053	0.06	0.0027	582	17.5	582	15.5	598	48	582	yes
X442_102	212	99.7	2.14	3.04	0.35	0.1498	0.0091	0.1441	0.0094	1402	45	899	25.5	2250	60	899	no
X442_103	440	397	1.25	1.55	0.15	0.058	0.0024	0.188	0.015	938	32	363.6	7.5	2710	70	363.6	yes
X442_104	562	273	2.09	1.9	0.12	0.1627	0.007	0.0838	0.0039	1076	23	971	19.5	1263	45	971	yes
X442_105	394	313	1.41	0.38	0.024	0.0508	0.0025	0.0536	0.0023	326	8.5	319	7.5	348	48.5	319	yes
X442_106	545	450	1.27	1.72	0.16	0.1231	0.0065	0.1026	0.0063	1005	27	753	18.5	1640	55	753	yes
X442_107	113.9	47.3	2.35	0.708	0.038	0.0825	0.0034	0.0615	0.0021	545	11	511	10.5	654	37	511	yes
X442_108	560	201	2.54	0.612	0.071	0.0573	0.0034	0.0738	0.0055	480	21.5	359	10.5	990	75	359	yes
X442_110	60.8	22.6	2.654	0.454	0.043	0.0455	0.0022	0.0711	0.0058	377	15	286.8	7	880	80	286.8	yes
X442_111	97.4	69	1.38	1.067	0.07	0.1059	0.0049	0.0726	0.003	734	16.5	649	14	1013	44	649	yes
X442_112	282	167	1.63	0.945	0.052	0.1095	0.0052	0.0627	0.002	674	13.5	669	15	694	35.5	669	yes
1854																	
Analysis	U ppm	Th ppm	U/Th	207Pb/235U	+/- 2σ	206Pb/238U	+/- 2σ	207Pb/206Pb	+/- 2σ	207Pb/235U (Ma)	+/- σ Ma	206Pb/235U (Ma)	+/- σ Ma	207Pb/206Pb (Ma)	+/- σ Ma	Best Age Ma	Used?
X1854_2	71	49.5	1.536	0.801	0.055	0.0926	0.0025	0.0641	0.0045	594	14.5	571	7.5	658	55	571	yes
X1854_3	205	88.2	2.395	0.2463	0.015	0.0311	0.00081	0.0557	0.003	223.1	6	197.4	2.55	432	55	197.4	yes
X1854_4	192	81.4	2.351	1.641	0.087	0.1627	0.0036	0.07336	0.0027	986.2	17	972	10	1022	37	972	yes
X1854_5	490	77.6	6.68	0.745	0.04	0.0911	0.0021	0.05948	0.0023	564.8	11.5	561.7	6.5	582	41.5	561.7	yes
X1854_7	98.5	36.2	2.766	0.826	0.045	0.0991	0.0024	0.0606	0.0025	612	12.5	609.1	7	618	45	609.1	yes
X1854_8	786	90.5	9.33	0.3142	0.017	0.04452	0.00088	0.05139	0.0019	277.6	6.5	280.8	2.75	251	43.5	280.8	yes
X1854_9	467	94	5.46	0.5196	0.028	0.06822	0.0015	0.05512	0.0021	424.5	9.5	425.3	4.5	413	42	425.3	yes
X1854_10	160.4	51.8	3.081	0.542	0.03	0.0684	0.0015	0.0579	0.0026	439	9.5	426.5	4.4	511	47.5	426.5	yes
X1854_11	221	45.4	4.803	0.834	0.044	0.1001	0.0022	0.05982	0.0022	615	12	615.9	6	595	40	615.9	yes
X1854_12	127.6	23.01	5.53	2.136	0.11	0.1964	0.0047	0.0795	0.0031	1161	18	1155	12.5	1184	37.5	1155	yes
X1854_13	246	57.9	4.31	2.07	0.11	0.1886	0.0044	0.0804	0.003	1140	19.5	1113	12	1207	37	1113	yes
X1854_14	262.9	45.4	6.08	2.109	0.11	0.1958	0.0044	0.0786	0.003	1151	18	1152	12	1164	37.5	1152	yes
X1854_15	130.8	42.6	3.2	0.723	0.04	0.0873	0.002	0.0601	0.0026	551.5	12	539.7	6	601	47.5	539.7	yes
X1854_16	103.9	18.7	5.61	2.223	0.13	0.2046	0.006	0.0793	0.0033	1193	21	1200	16	1180	43.5	1200	yes
X1854_17	468	23.5	27	2.095	0.12	0.1859	0.0043	0.0821	0.0031	1147	20	1099	11.5	1247	35.5	1099	yes
X1854_18	173	35.2	4.744	1.72	0.09	0.1703	0.0038	0.07325	0.0027	1016	17	1013	10.5	1017	37.5	1013	yes
X1854_19	44.8	47.1	0.941	0.785	0.053	0.0853	0.0027	0.0673	0.0042	584	14.5	527	8	780	60	527	yes
X1854_20	59.3	60.5	0.944	0.657	0.044	0.0683	0.0019	0.0708	0.0044	508	13	426.7	5.5	960	65	426.7	yes

X1854_2 1	90	16.3	5.192	7.183	0.3 7	0.3876	0.00 86	0.13 35	0.00 48	2134 .7	22 .5	2114	19 .5	2142	31 .5	214 2	yes
X1854_2 2	333	147.9	2.19	0.398	0.0 24	0.04964	0.00 11	0.05 76	0.00 26	339. 2	9	312.9	3. 4	517	50	312 .9	yes
X1854_2 3	502	109.3	4.62	0.5394	0.0 29	0.06976	0.00 15	0.05 594	0.00 22	438. 5	9. 5	434.6	4. 4	469	42 .5	434 .6	yes
X1854_2 4	67. 5	31.3	2.117	1.638	0.0 89	0.164	0.00 37	0.07 26	0.00 3	983	16 .5	979	10	996	41	979	yes
X1854_2 5	71. 3	20.71	3.361	0.81	0.0 48	0.0964	0.00 22	0.06 15	0.00 29	601	13	593.1	6. 5	643	48	593 .1	yes
X1854_2 6	119 .2	45.2	2.84	0.726	0.0 4	0.0874	0.00 21	0.06 26	0.00 26	554. 3	12	539.9	6. 5	595	47	539 .9	yes
X1854_2 7	509	295.7	1.66	0.6629	0.0 34	0.0807	0.00 17	0.06 021	0.00 22	516. 1	10 .5	500.2	5	607	40	500 .2	yes
X1854_2 8	19. 7	7.68	2.581	0.751	0.0 59	0.0881	0.00 28	0.06 2	0.00 42	570	18	544	8. 5	680	65	544	yes
X1854_2 9	124 .3	57	3.15	0.723	0.0 41	0.0884	0.00 21	0.05 89	0.00 25	551. 4	12	545.8	6. 5	555	47	545 .8	yes
X1854_3 0	39. 7	21.8	1.962	1.84	0.1 2	0.17	0.00 44	0.07 86	0.00 41	1053	19 .5	1012	12	1124	48 .5	101 2	yes
X1854_3 1	164	63	3.23	12.66	0.6 6	0.5057	0.01 1	0.18 11	0.00 66	2656	24 .5	2636	24 .5	2661	30	266 1	yes
X1854_3 2	237	110.9	2.137	6.069	0.3 1	0.3489	0.00 75	0.12 67	0.00 46	1985	21 .5	1931	17 .5	2052	32 .5	205 2	yes
X1854_3 3	34. 6	21.7	1.525	3.202	0.1 7	0.2474	0.00 6	0.09 36	0.00 38	1455	21	1424	15 .5	1499	39	149 9	yes
X1854_3 5	73. 7	20.6	3.614	5.062	0.2 6	0.3294	0.00 67	0.11 13	0.00 41	1828	22 .5	1835	16	1820	33	182 0	yes
X1854_3 6	225	128	1.704	0.839	0.0 45	0.0984	0.00 21	0.06 18	0.00 26	617	12 .5	604.9	6	662	45	604 .9	yes
X1854_3 7	54. 8	23.76	2.338	15.13	0.7 8	0.5417	0.01 2	0.20 07	0.00 74	2821	25	2789	26	2834	30 .5	283 4	yes
X1854_3 8	192 .8	123.2	1.607	0.837	0.0 44	0.0981	0.00 21	0.06 27	0.00 24	616. 7	12	603.4	6	695	42	603 .4	yes
X1854_3 9	114 .5	20.15	5.732	2.698	0.1 4	0.2318	0.00 47	0.08 45	0.00 32	1327	19	1343	12 .5	1299	36 .5	134 3	yes
X1854_4 0	47. 1	15.36	3.018	1.726	0.0 97	0.1722	0.00 42	0.07 31	0.00 31	1020	17	1024	11 .5	1033	39	102 4	yes
X1854_4 1	44. 8	8.66	5.111	1.83	0.0 98	0.1756	0.00 41	0.07 53	0.00 31	1056	18	1045	11 .5	1078	43	104 5	yes
X1854_4 2	202 .6	10.8	144	7.55	0.4 4	0.3938	0.01 42	0.14 04	0.00 53	2175	26 .5	2139	24	2232	32 .5	223 2	yes
X1854_4 3	187 .8	60.1	3.112	2.167	0.1 1	0.1994	0.00 42	0.07 886	0.00 29	1169 .7	18	1173	11	1168	36	117 3	yes
X1854_4 4	51. 4	22.3	2.389	0.779	0.0 5	0.0882	0.00 25	0.06 23	0.00 34	583	14	545	7. 5	704	60	545	yes
X1854_4 5	68. 5	29.5	2.325	0.906	0.0 53	0.1002	0.00 25	0.06 5	0.00 3	655	14 .5	616	7. 5	769	47	616	yes
X1854_4 6	8.9 7	0.772	11.95	0.72	0.0 78	0.0852	0.00 33	0.06 38	0.00 7	551	23	527	9. 5	630	10 5	527	yes
X1854_4 7	81	15.1	3.6	2.065	0.1 3	0.1941	0.00 64	0.07 69	0.00 36	1131	21	1142	17	1118	46	114 2	yes
X1854_4 8	142	123.3	1.141	3.483	0.1 8	0.2675	0.00 57	0.09 35	0.00 35	1522	20 .5	1530	14	1497	36	149 7	yes
X1854_4 9	57. 2	28.6	2.025	0.752	0.0 45	0.091	0.00 23	0.05 95	0.00 28	570	13	562.4	7	565	50	562 .4	yes
X1854_5 0	787	12.52	63.43	0.7498	0.0 39	0.09212	0.00 18	0.05 886	0.00 21	567. 9	11 .5	568	5. 5	562	39	568	yes
X1854_5 1	229	102.1	2.32	0.5047	0.0 27	0.06585	0.00 14	0.05 49	0.00 22	414. 4	9	411	4. 35	403	44 .5	411	yes
X1854_5 2	54. 9	21.4	2.632	0.704	0.0 41	0.0866	0.00 23	0.05 91	0.00 28	541	12	537	7	546	50	537	yes
X1854_5 3	164	43.7	3.739	3.27	0.1 8	0.2155	0.00 72	0.10 81	0.00 4	1473	22	1260	19 .5	1764	33 .5	126 0	yes
X1854_5 4	122 .2	30.7	3.84	0.874	0.0 48	0.1017	0.00 23	0.06 19	0.00 25	639	13	624.5	6. 5	656	44	624 .5	yes
X1854_5 5	96	34.6	2.882	0.815	0.0 45	0.0964	0.00 23	0.06 06	0.00 27	604	13	593.2	6. 5	605	47 .5	593 .2	yes
X1854_5 6	172 .5	102.3	1.694	1.12	0.0 61	0.1226	0.00 29	0.06 537	0.00 25	763	14 .5	747	8. 5	783	41 .5	747	yes
X1854_5 7	164	89.1	1.785	5.847	0.3 1	0.351	0.00 76	0.12 03	0.00 44	1952	23	1938	18	1960	33 .5	196 0	yes

X1854_58	178	45.14	3.9	6.796	0.35	0.3837	0.0082	0.1291	0.0047	2085	23	2093	19	2084	32.5	2084	yes
X1854_59	86	48.2	1.792	7.798	0.4	0.4109	0.0091	0.1372	0.005	2208	23	2218	20.5	2193	31	2193	yes
X1854_60	48.6	12.65	3.794	0.778	0.046	0.0964	0.0026	0.0586	0.0028	582	13.5	593	7.5	540	55	593	yes
X1854_61	156	104	1.599	0.88	0.047	0.1033	0.0023	0.0618	0.0024	641.4	13	633.9	7	657	42.5	633.9	yes
X1854_63	53	58.4	0.922	0.718	0.042	0.0892	0.0023	0.0581	0.0027	548	12.5	552	7	533	49.5	552	yes
X1854_64	217.3	42.2	6.47	8.146	0.42	0.4116	0.0086	0.1441	0.0052	2246	24	2221	19.5	2274	31.5	2274	yes
X1854_65	252	76.9	3.4	0.498	0.027	0.06642	0.0015	0.0543	0.0022	409.7	9	414.5	4.55	394	45.5	414.5	yes
X1854_66	169.9	70.1	2.441	0.849	0.047	0.0964	0.0024	0.065	0.003	623	13	593	7	739	40	593	yes
X1854_67	133.6	39.5	3.407	0.757	0.042	0.0897	0.0021	0.062	0.0028	572	12	553.7	6	659	47	553.7	yes
X1854_68	60.9	33.2	1.885	0.85	0.049	0.1015	0.0027	0.0616	0.0027	625	13	623	8	666	48	623	yes
X1854_69	110.2	48.3	2.284	0.778	0.042	0.0953	0.0024	0.0588	0.0024	583	12	587	7	553	45	587	yes
X1854_70	100.4	13.72	7.14	0.686	0.039	0.0842	0.0021	0.0629	0.0029	528	11.5	521.2	6	577	55	521.2	yes
X1854_71	451	56	8.48	1.851	0.099	0.1769	0.004	0.07637	0.0028	1065.3	18	1050	11	1104	36	1050	yes
X1854_72	83.3	37.61	2.225	0.887	0.049	0.1045	0.0027	0.0608	0.0026	644	13.5	642	8	632	44.5	642	yes
X1854_74	125.4	47.4	2.625	0.708	0.042	0.0839	0.0027	0.0598	0.003	546	12.5	519	8	598	55	519	yes
X1854_75	362	52.1	6.74	0.3778	0.02	0.05101	0.0012	0.0532	0.0022	325.1	7.5	320.7	3.75	340	46	320.7	yes
X1854_76	13.41	2.995	4.51	7	0.4	0.3715	0.012	0.1358	0.0065	2105	26	2033	27	2171	41.5	2171	yes
X1854_77	11.66	7.34	1.598	0.784	0.065	0.0959	0.004	0.0616	0.005	592	18	592	12	570	85	592	yes
X1854_78	167.5	58.4	2.862	0.701	0.038	0.0853	0.0019	0.0591	0.0024	538	11.5	527.4	5.5	561	46	527.4	yes
X1854_79	89.9	30.2	2.939	0.796	0.045	0.0919	0.0022	0.0624	0.0027	593	13	566.8	6.5	680	46.5	566.8	yes
X1854_80	204.6	56.2	3.568	0.79	0.041	0.0949	0.0023	0.0591	0.0024	590.1	11.5	586	7	562	44	586	yes
X1854_81	8.26	2.03	4.15	2.53	0.19	0.2098	0.0077	0.0891	0.006	1274	26	1226	20.5	1390	65	1226	yes
X1854_82	79.1	38.3	2.025	1.039	0.059	0.1156	0.0028	0.0654	0.0029	722	14.5	705	8	762	48	705	yes
X1854_83	78.1	60.5	1.281	1.813	0.1	0.1763	0.0044	0.0747	0.0031	1050	17.5	1050	12	1053	41.5	1053	yes
X1854_84	86.9	52.3	1.603	0.963	0.053	0.1111	0.0026	0.0622	0.0026	688	13.5	679	7.5	688	45	679	yes
X1854_85	76	43.4	1.745	0.794	0.045	0.0965	0.0023	0.0593	0.0026	593	12.5	593.7	7	585	49	593.7	yes
X1854_86	288.7	115.4	2.484	0.2999	0.017	0.0398	0.00094	0.0538	0.0025	265.9	7	251.6	2.9	369	50	251.6	yes
X1854_87	99.5	30.06	3.239	7.319	0.37	0.3874	0.0085	0.1359	0.0049	2153	23.5	2110	20	2176	32.5	2176	yes
X1854_88	293	127.8	2.243	0.716	0.039	0.0851	0.0018	0.0614	0.0025	549	11.5	526.2	5.5	638	43.5	526.2	yes
X1854_89	38.3	19	1.882	0.982	0.066	0.1074	0.0032	0.0648	0.0038	693	16	657	9	750	60	657	yes
X1854_91	54.2	20.46	2.62	0.936	0.058	0.1014	0.0032	0.0661	0.0033	666	15.5	622	9.5	815	55	622	yes
X1854_92	149.8	78.5	1.839	0.666	0.037	0.0837	0.0021	0.0576	0.0025	517	11.5	517.8	6	508	45.5	517.8	yes
X1854_93	175.5	50.6	3.39	0.74	0.041	0.0898	0.0022	0.0595	0.0026	561	12	554.3	6.5	580	46.5	554.3	yes
X1854_94	210	51.2	3.957	2.005	0.11	0.1877	0.0043	0.0781	0.003	1119	18.5	1108	11.5	1146	38	1108	yes

Appendix B: Point Count Data

Thin Section Point Count

	Qt	F	L	Qm	Qp	Fp	Fo	Lm	Ls	Lv
3578-1										
Points	339	41	10	324	15	31	10	3	0	7
$(Qt+F+L)/400$	.8475	.1025	.025							
Percent	84.75	10.25	2.5							

3578-2										
Points	352	42	6	336	16	40	2	2	0	4
(Qt+F+L)/400	.88	.105	.015							
Percent	88.00	10.5	1.5							
966-1										
Points	292	94	19	285	7	89	5	2	1	16
(Qt+F+L)/400	.655	.235	.0475							
Percent	65.5	29.76	4.75							
966-2										
Points	362	34	4	337	25	34	0	0	1	3
(Qt+F+L)/400	.905	.085	.01							
Percent	90.5	8.5	1.0							
966-3										
Points	379	19	2	367	12	14	5	2	0	0
(Qt+F+L)/400	.9475	.0475	.005							
Percent	94.75	4.75	.5							
966-4										
Points	364	30	6							
(Qt+F+L)/400	.91	.075	.015	340	24	28	2	2	0	4
Percent	91.0	7.5	1.5							
788										
Points	335	23	6	331	4	15	8	4	0	2
(Qt+F+L)/400	.8375	.0575	.015							
Percent	83.75	5.75	1.5							
15656										
Points	366	31	3	365	1	25	6	0	0	3
(Qt+F+L)/400	.915	.0775	.0075							
Percent	91.5	7.75	.75							
2012-1										
Points	380	12	8	364	16	12	0	4	4	0
(Qt+F+L)/400	.95	.03	.02							
Percent	95.0	3.0	2.0							
2012-2										
Points	374	26	0	353	21	24	2	0	0	0

(Qt+F+L)/400	.935	.065	0							
Percent	93.5	6.5	0							
12542										
Points	208	188	3	205	3	89	99	3	0	0
(Qt+F+L)/400	.52	.471	.008							
Percent	52.0	47.1	.8							

Qt= Quartz, F= Feldspar, L=Lithics, Qm=Quartz monocrystalline, Qp=Quartz polycrystalline, Fp=Plagioclase Feldspar, Fo/m=Orthoclase Feldspar, Lm=Metamorphic Lithics, Lv=Volcanic Lithics, Ls=Sedimentary lithics.

Appendix C: Thin Section Descriptions

Thin Sections: South Florida

The table of thin section data from southern Florida is displayed in Table 4. Sample descriptions are provided below. Coarse- grained samples were point counted and described using the Folk (1980) classification scheme (Figure 50). Several samples from South Florida were too fine-grained to point-count.

ODP

Although no zircons were obtained from the clastic interval of the ODP wells, two thin-sections were made. No thin-sections were made for the basement section due to the small sample size, and to increase the chances of getting a usable number of zircons for dating.

Sample 1 was collected from ODP Site 0537 from Core 13R, section 1, and interval 95-110 (Figure 51). It is interpreted as arkosic sandstone conglomerate with calcite cement. The sandstone consists primarily of quartz and volcanic fragments (perthite) with calcite cement. Quartz grains are large (up to 1 mm), and well rounded. Inclusions of zircon or tourmaline are present in several quartz grains. Calcite cements are sparry with a second phase of blocky calcite cement.

Sample 2 was collected from ODP site 77 hole 0538A, 034R, 01W, interval 54.57-57 (Figure 51). It is interpreted as diabase from Deep Sea Drilling report volume 77. It consists of fine-grained diabase with plagioclase, biotite, green clays, and opaque minerals. Quartz veins are common, and occur at three different angles. En echelon fractures may be present. Ribbons of quartz are interpreted as interstitial quartz, which formed during mild degrees of mylonitization (Deep Sea Drilling report, volume 77).

778

Two samples were examined from 778. Sample 778-1 consists of cuttings, and was not point-counted (Figure 52). The sample came from the mixed shale/sandstone/dolomite/limestone section. It consists mainly of shale and calcite, as well as chambered fossils. Blocky calcite cements and quartz fragments are also common.

Sample 778-2 was point counted (Figure 52). It was collected from the lower clastic section of the Wood River. Sample 778-2 consists primarily of angular-subrounded quartz

fragments. Grain size is fairly unimodal at around .5mm. Minor twinned feldspar and orthoclase/microcline is also present. Lithic fragments are extremely uncommon, although some volcanic fragments may be present.

10566

Sample 10566 was pointed counted (Figure 52). It consists primarily of quartz and feldspar fragments. Quartz fragments are well rounded and fairly unimodal (.25 mm). Lithic fragments are rare, aside from some perthite.

1655

No zircons were obtained from sample 1655. Sample 1655 was not point- counted. The sample comes from the upper mixed limestone/shale mix of the Wood River/proximal clastics. Sample 1655 consists mostly of mixed shale with quartz and ooid fragments. Carbonate fragments consist of mud and ooids. The matrix is composed of blocky calcite cement.

966

No zircons were collected from 966 but four thin-sections were point counted (Figure 52). Sample 966 consists mainly of sub-rounded quartz fragments and twinned/untwinned feldspar. Metamorphic fragments are mainly quartzite. Volcanic fragments include perthite. Porosity is fairly low (less than 5%). Some porosity may be secondary from feldspar dissolution. Grain size is somewhat unimodal (.1-.5 mm). The sample is moderately sorted.

2012

Three thin-sections were point-counted for sample 2012. It consists mainly of quartz, with some feldspar fragments (Figure 52). Lithic fragments are rare. Sample 2012 ranges from

an arenite to arkose sandstone. Some lithic fragments are present. The sample is fairly porous (~8%), but becomes more compact towards the base of the section. Thin- sections collected at the base is composed of metamorphic quartzite.

12542

No zircons were obtained from sample 12542 (Figure 53). The sample consists of detrital quartz (40%) and feldspars and other volcanic fragments (~60%). Feldspars are very common. Perthites typically have stained plagioclase cored, with mixed plagioclase/orthoclase exteriors. For the purpose of this study, perthites were counted as igneous fragments. Feldspars appear to have dissolved, forming secondary porosity. The abundance of perthite indicates a igneous source with close proximity to a granitic source.

3578

Three thin-sections were collected from 3578, one of which was composed of shale and was not point-counted. The shale sample consists mainly of mud and fine detrital quartz and muscovite. Sandy intervals consisted mainly of feldspars and quartz. Feldspar is twinned and in some locations appears to have been partially dissolved. Detrital mica is also present. Lithics consist primarily of sandstone/shale fragments, and possibly metamorphic fragments as well. Grains are subrounded-subangular, and well sorted. Porosity is fairly low (less than 5%), and compacted quartz grains are common. Quartz cements are also present..

Thin Sections South Georgia Rift

Table of thin-sections from the South Georgia Rift is displayed in Table 2. All samples from the South Georgia Rift collected were too fine-grained for point counting, but observations were recorded on grain- size and composition.

Sample 442

Sample 442 includes 442-1 and 442-2, which are composed mainly of quartz but also abundant muscovite and feldspar. Sample 442-1 is composed primarily of, with alternating laminae of fine- to medium-grained, poorly sorted, subangular quartz, and fine-grained, dark mudstone. Quartz grains range from .05-.15 mm (Figure 54). The grain size of quartz increases from layer to layer and although the up direction is not known, the sequence likely represents a coarsening or fining upward sequence. Possible fossils include bivalves, and chambered gastropods.

Sample 108

Sample 108 is composed mainly of detrital quartz and micas (Figure 54). Quartz fragments are subangular, and less than 0.1 mm in diameter. The matrix is composed of mud-sized particles. Abundant unknown opaque grains are present. Small calcite veins are present.

Sample 619

Sample 619 is shale composed mainly of mud-sized particles (Figure 54). A thin layer of fine-grained quartz and mica is present, but not prevalent throughout the sample. Grains are poorly sorted, and separated by mud matrix. Veins of calcite are also present.

Sample 3137

Sample 3137 was described from two thin-sections. It is composed mainly of black shale that is composed of fine mud (Figure 54). Detrital composition consists predominantly of quartz (<.15mm), feldspar laths, and muscovite. Muscovite is the most abundant detrital mineral (~60%) Quartz fragments are poorly sorted and subangular. Micas are small, and fibrous. Calcite fragments are also present.