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Mesozoic tectonic history and geochronology of the Kular Dome, Russia and Bendeleben Mountains, Seward Peninsula, Alaska

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**MESOZOIC TECTONIC HISTORY AND GEOCHRONOLOGY OF
THE KULAR DOME, RUSSIA AND BENDELEBEN MOUNTAINS,
SEWARD PENINSULA, ALASKA**

Daniel B. Harris

Dissertation submitted to the
Eberly College of Arts and Sciences
at West Virginia University
in partial fulfillment of the requirements
for the degree of

Doctor of Philosophy
in
Geology

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pluton; Arctic tectonics

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ABSTRACT

Mesozoic Tectonic History and Geochronology of the Kular Dome, Russia and Bendeleben Mountains, Seward Peninsula, Alaska

Daniel B. Harris

The tectonic history responsible for formation of the major basins of the Arctic and movement of landmasses surrounding these basins remains unclear despite multidisciplinary efforts. Most studies focus on one of four potential movement pathways of the Arctic Alaska-Chukotka microplate during the Mesozoic and the relationship between this movement and formation of the Amerasian Basin. Due to difficulty in access and harsh climate of the Arctic Ocean, most geological studies focus on landmasses surrounding the Amerasian Basin. For this reason, we have conducted research in the Kular Dome of northern Russia and the Bendeleben Mountain Range of the Seward Peninsula, Alaska in an attempt to better constrain timing of emplacement of plutons in these areas and their associated tectonic conditions. For both areas, U-Pb zircon crystallization geochronology was performed on several samples collected from plutons responsible for gneiss dome formation during the Mesozoic. Dating of these plutons in tandem with field observation and thin section analysis of deformation suggests an extensional emplacement setting for both areas during the Middle to Late Cretaceous.

In the Kular Dome, intrusion of the Kular pluton occurred from approximately 111-103 Ma along with extensional development of the nearby Yana fault, which was previously interpreted as a regional suture between deposits of the Kolyma-Omolon superterrane and passive-margin sequences of the Verkhoyansk Fold-Thrust Belt. Evidence for extensional emplacement of the Kular pluton includes top-down shear around mantled porphyroblasts plunging along gentle foliation away from the pluton and abundant low-offset normal faults in the area. The Kular Dome also falls into a north-south oriented belt of Late Cretaceous plutons interpreted to have been emplaced under regional extensional conditions based on geochemical discrimination diagrams.

Detrital zircon geochronology was also performed on seven samples collected from Triassic sandstones and Jurassic greywackes near the Kular Dome and compared to results from previously studied surrounding regions in Russia and the Arctic Alaska-Chukotka

microplate in order to better define the relationship between the Arctic Alaska-Chukotka microplate and northern Russia during the Mesozoic. Results suggest that though the Chukotkan portion of the Arctic Alaska-Chukotka microplate was separated from the Kular Dome area during the Triassic, by the Tithonian it shared similar source regions for detrital zircon populations. Based on detrital zircon data from Chukotka, the Kular Dome, and the In'yali Debin area, a new tectonic model for the formation of the Amerasian Basin and structures within is proposed. In this new model, Chukotka separated from and moved independently of the North Slope of Alaska during the Late Triassic-Early Jurassic, experiencing strike-slip emplacement along the northern coast of paleo-Russia and closed the South Anyui Ocean via transpression to form the South Anyui suture.

Geochronologic and geochemical results from the Bendeleben and Windy Creek plutons of the southeastern Seward Peninsula were also studied to better describe Arctic tectonic conditions during the Late Mesozoic. In this area, six samples were collected from the multiple lithologies seen within the Bendeleben and Windy Creek plutons and were also dated by zircon U-Pb geochronology and analyzed for their major and trace element geochemistry. Results suggest that the Bendeleben and Windy Creek plutons were emplaced during multiple extensionally driven pulses of magmatism above a southward-retreating, northward-subducting slab causing extension in the overlying crust from about 104 Ma to 83 Ma. The magma chamber at depth was experiencing continuous replenishment and liquid segregation causing stratification of the Bendeleben pluton. Magmas of the felsic cap, which now form the outer region of the Bendeleben pluton, were emplaced first, followed by subsequent intrusion of younger, mafic magma from below. Evidence for north-south directed extension during emplacement of the Bendeleben pluton was in the form of consistent east-west dike orientation in the Seward Peninsula, top-down shear in mantled garnet porphyroblasts from country rock surrounding the Bendeleben pluton, gentle foliation dip away from the pluton and stretching lineations around the pluton. Discrimination diagrams based on Rb, Nb and Y concentrations from bulk rock samples supports a collisional or volcanic arc province and is consistent with emplacement in an extensional environment above a subducting plate.

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The completion of this document would not have been possible without the aid of several close friends and colleagues. My advisor Jaime Toro has been an instructor, a mentor and a friend to me along this journey and has greatly encouraged me to be a better scientist, teacher and father. The field work and critical reviews necessary for this document were greatly aided by Jaime Toro, Elizabeth Miller of Stanford University, Andrei Prokoviev of the Russian Academy of Science, and Kalin McDannell who completed his master's degree at West Virginia University in Spring, 2011. These field excursions resulted not only in tremendous field experience and educational exercise, but also in adventure and appreciation of the great outdoors. We have all shared unforgettable experiences and for those memories I am forever grateful.

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Daniel Harris

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PREFACE

A complete Mesozoic reconstruction capable of describing the movement pathways and the timing of movement for landmasses surrounding the modern Arctic, as well as formation of the numerous basins within the Arctic itself, has long remained enigmatic (see review in Lawver and Scotese, 1990). Geologic studies pertaining to this history have been attempted via many approaches, such as seismic imaging, dredging, paleontologic, geochronologic, stratigraphic, etc., resulting in datasets as immense as they are diverse (e.g. Dove et al., 2010; Embry, 1990; Kuzmichev, 2009; Lebedeva-Ivanova et al., 2006; Miller et al., 2006). Most tectonic studies of the Arctic focus on the formation of the Amerasian Basin, which opened during the Mesozoic as a result of movement of the Arctic Alaska-Chukotka microplate (AAC) which includes the North Slope and Seward Peninsula of Alaska, and Chukotka, the New Siberian Islands, Wrangel Island and the East Siberian Shelf of Russia (Figure 1).

Several models exist for the specific movement of this microplate including strike slip motion of the AAC either away from an initial location along the Barents Shelf (Figure 1a) or the Canadian Arctic Islands (Figure 1b), the “double windshield-wiper model” (Figure 1c) and the “rotational model” (Figure 1d) which is generally regarded as the most capable of describing data collected in and around the Amerasian Basin.

Figure 1: Multiple highly schematic models describing the formation of the Amerasian Basin of the modern Arctic including: a) strike-slip along the Canadian Arctic Islands and the Siberian shelf, b) strike-slip along the Barents shelf (restored) and northern Alaska, c) the double windshield-wiper model and d) the rotational model. AMB is the Amerasian Basin, AAC is the Arctic Alaska-Chukotka microplate, CB is the Canada Basin, EB is the Eurasian Basin, SP is the Seward Peninsula, WI is Wrangel Island and NSI are the New Siberian Islands. Base bathymetry maps are from the International Bathymetric Chart of the Arctic Ocean initiative (Jakobsson et al., 2008). The star indicates the location of the Kular Dome and Lower Yana River area and the circle represents the Bendeleben Mountains location on each map.

The rotational model was first proposed by Carey (1955; 1958) based on a concept of oroclinal bending and was later modified for compatibility with plate tectonic theory by himself and many others over the following decades using a variety of rotational poles generally located near the MacKenzie Delta (e.g. Rickwood, 1970; TAILLEUR, 1969; Grantz et al., 1979; references in Lawver and Scotese, 1990 and Lawver et al., 2002). While this model is supported by several bodies of evidence including bathymetric data across the Canada Basin, facies trends across northern Alaska and the Canadian Arctic Islands, magnetic anomalies in the Canada Basin, and a variety of other studies summarized in Lawver et al. (2002), most data supports specific movement of northern Alaska away from the Canadian Arctic Islands with little data supporting a similar movement of Chukotka. Problems with various pathways for Chukotka in the rotational model include a substantial overlap with continental crust north of Greenland (modern coordinates) when restored to a pre-rift location (Rowley and Lottes, 1988) and inconsistencies in the detrital zircon record when comparing Chukotka and the New Siberian Islands to a pre-rift location near the Ural Mountains (Miller et al., 2010; Miller et al., 2008). This same detrital zircon record has been used as support for the strike-slip models (Figures 1a and 1b), though data are also compatible with the double windshield-wiper model (Figure 1c) (Miller et al., 2010).

The Chukotkan portion of the AAC is widely regarded to have formed a continuous landmass with the North Slope of Alaska during the Paleozoic based on a multitude of data summarized in Miller et al. (2006) though the coherency of this block during Mesozoic movement across the modern position of the Amerasian has been met with skepticism by some. The double windshield-wiper model describes an emplacement of the AAC involving the separate and independent movement of the Chukotkan and Alaskan portions

of the AAC which retained an initial connection until the Middle Mesozoic (Amato et al., 2009; Miller et al., 2010; Miller et al., 2006). This model provides a solution to the continental overlap problem, is compatible with magmatic and faunal data from Alaska and Siberia and is consistent with the detrital zircon record for samples collected in Wrangel Island, Chukotka and the Seward Peninsula (Amato et al., 2009; Miller et al., 2010), however problems still exist in terms of timing and style of emplacement for a more complex movement path utilizing several independent blocks. Data presented in this document will add to the collective study regarding formation of the Amerasian Basin and general Mesozoic Arctic tectonic history via three independent studies of the structural setting and geochronology of the Kular gneiss dome of northern Russia and the Bendeleben gneiss dome and mountain range of the Seward Peninsula, Alaska. Due to the preference for each chapter to be written as a stand-alone, immediately publishable document, a certain amount of redundancy within the introduction to each chapter and this preface should be expected.

The first two chapters outline data collected during the summer of 2008 in and around the Kular Dome of northern Russia, located at 70.0°N/134.3°E approximately 30 km west of the town of Ust' Kuyga and the Lower Yana River (Figure 1). Chapter I describes the specifics regarding emplacement of the Kular pluton where field evidence supports an extensional emplacement mechanism. This evidence was combined with granitic zircon U-Pb geochronology using data collected from the USGS/Stanford University operated Sensitive High Resolution Ion-Microprobe, Reverse Geometry (SHRIMP-RG) instrument to provide timing for emplacement as well as an extrapolated regional tectonic setting for the surrounding area. Results from this study combined with

those performed nearby suggest that northern Russia was experiencing a diffuse extensional event which may have initiated as early as 110 Ma and was likely an early indicator for the eventual opening of the Gakkel ridge to the north during the Eocene.

Chapter II describes the sedimentation history for sandstones and greywackes located along the Lower Yana River directly south of the town of Ust' Kuyga, Russia and approximately 30 km east of the Kular pluton. U-Pb ages were calculated for detrital zircons extracted from samples collected also in 2008 and dated via laser-ablation multicollector inductively coupled plasma mass spectroscopy (LA-MC-ICPMS) at the University of Arizona LaserChron Center. Probability density functions of ages found from samples along the Lower Yana River were compared to samples of similar depositional age from various locations of the Arctic compiled from published literature in order to estimate the Mesozoic location of these landmasses based on probable depositional sources. Comparison of these data has led to a new proposed tectonic history describing the landmasses of the modern Arctic that is outlined in greater detail at the end of Chapter II.

The third chapter describes data collected in 2009 from the Bendeleben Mountain range in southeastern Seward Peninsula, Alaska where the Bendeleben pluton is exposed in the center of high-grade gneisses and schists of the Kigluaik Metamorphic Complex. The Bendeleben pluton is a lithologically diverse intrusion with localized areas ranging from gabbro to biotite-rich alkali-feldspar granite. The Windy Creek pluton, located directly east of the Bendeleben pluton in the northern reaches of the Darby Mountains was also examined in order to provide a complete emplacement history for igneous intrusives in the area. Field mapping performed by myself, Jaime Toro and Kalin McDannell resulted in an

updated geologic map at a scale of 1:24000 (Plate 1) in addition to samples analyzed for structural setting, geochemistry and U-Pb geochronology. Geochemical samples included lithologies from each zone of the Bendeleben pluton, the Windy Creek pluton and each of the major metapelitic bodies surrounding each pluton. U-Pb zircon geochronology was performed on multiple samples collected from the Bendeleben and Windy Creek plutons, which were analyzed using the SHRIMP-RG. Results from our field area were compared to the Kigluaik pluton located approximately 90 km to the west and similar to the Bendeleben pluton in terms of lithology, emplacement mechanisms and emplacement timing.

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Chapter I

Magmatic evolution and U-Pb geochronology of the Kular Dome as evidence for Middle Cretaceous extension in northeastern Russia

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Abstract:

The regional Mesozoic tectonic setting for northern Russia is an important consideration when examining processes responsible for formation of the Amerasian Basin and Verkhoyansk Fold-Thrust Belt. The Kular Dome, located at 70.0°N/134.3°E lies just south of the Laptev Sea and approximately 30 km west of the Yana fault. This fault was previously interpreted as a thrust fault potentially related to suturing between the Kolyma-Omolon superterrane and passive margin sequences of the North Asian craton which were deformed into the Verkhoyansk Fold-Thrust Belt in the Late Jurassic. The Yana fault is, however, shown to be a local normal fault which formed under extensional deformation related to emplacement of the Kular pluton in the core of the Kular gneiss dome. Evidence collected from the Kular Dome in the form of top-down shear seen around mantled porphyroblasts along gently dipping S_2 foliation, stretched andalusite grains defining gentle plunge parallel to S_2 dip direction and small offset normal fault development suggests that the Kular pluton was emplaced under extensional conditions. Dating of the pluton via U-Pb zircon geochronology of five samples collected from the Kular Dome yielded an emplacement age between 111.3 ± 1.4 Ma and 103.2 ± 0.9 Ma likely synchronous with extensional deformation and development of the Yana fault. The Kular Dome is also part of a north-south trending belt of Cretaceous plutons displaying continental within-plate extensional geochemical signatures and shows a southward younging direction from the Laptev Sea in the north, along strike of the Eocene-aged Gakkel Ridge. Seismic modeling and geophysical profiling in the Laptev Sea indicates diffuse extension in this area as early as the Late Cretaceous, but was likely initiated earlier during emplacement of the north-south trending extensional plutonic belt.

Introduction:

A complete Mesozoic tectonic reconstruction for the Arctic capable of incorporating all of the diverse and extensive data collected from landmasses surrounding the Arctic basins remains elusive despite recent international efforts. In the Mesozoic, as the Amerasian Basin opened through a rifting process of uncertain geometry (see review in Lawver and Scotese, 1990), a series of terranes of both Arctic and Pacific affinities were accreted to North America and Russia (Amato et al., 2009; Layer et al., 2001). The first Mesozoic accretionary event on the Russian side occurred during the Late Jurassic when the Kolyma-Omolon superterrane collided with passive margin sequences deposited along the east coast of the North Asian craton, closing a basin initially formed during the Devonian (Khudoley and Prokopiev, 2007; Oxman, 2003; Parfenov, 1991). Following accretion of the Kolyma-Omolon superterrane, a subduction zone formed on the northern edge of the Asian continent as the Arctic Alaska-Chukotka microplate, which was likely originally a piece of North America (Amato et al., 2009; Amato et al., 2004; Embry, 1990; Grantz and May, 1983; Lawver et al., 2002; Miller et al., 2006), moved toward Russia from its initial location along the northern edge of the modern Canadian Arctic Islands coincident with opening of the Canada Basin in the Late Jurassic-Early Cretaceous (Lawver et al., 2002; Lawver and Scotese, 1990). The Arctic Alaska-Chukotka microplate includes the modern Seward Peninsula and North Slope of Alaska, and the Chukotka Peninsula, Wrangel Island, New Siberian Islands and large portions of the adjacent East Siberian continental shelf of Russia (Figure 1). Accretion of the Arctic Alaska-Chukotka microplate was finished by the Middle Cretaceous when a large continental margin volcanic arc, the Okhotsk-Chukotka Volcanic Belt, overlapped the suture.

Figure 1: Russia location map with magmatic provinces shown in black. Terrane locations from Parfenov et al. (2009). Approximate Laptev Sea grabens and Gakkel Ridge locations from Drachev et al. (1998). Plate boundaries and relative plate motions from Fujita et al. (2009). The black dot shows the NA-EU pole location from Fujita et al. (2009). Abbreviations are: BLI, Bolshoi Lyakhov Island; CCB, Chersky Collisional Belt; ID, In'Yali Debin; KD, Kular Dome; MB, Main Belt; MR, Moma rift; NB, Northern Belt; OM, Okhotsk Massif; SAS, South Anyui Suture; TB, Transverse Belt; VFB, Verkhoyansk Fold-Thrust Belt. Inset abbreviations are: BE, Bering plate; EU, Eurasian plate; NA, North American plate; OK, Okhotsk plate; PA, Pacific plate.

Shortly thereafter, a period of east-west extension in northeastern Russia and north-south extension in parts of Alaska, caused widespread granitic magmatism during the Middle to Late Cretaceous (Miller et al., 2002; Miller and Hudson, 1991; Miller et al., 2006). This Middle Cretaceous event is important because several models exist for the specific configuration and interaction between the local terranes and basins (Lawver and Scotese, 1990). Formation of the Amerasian Basin was followed by a shift in the locus of rifting to the north when the northern Mid-Atlantic spreading center propagated northward as the Gakkel Ridge of the Arctic in the Eocene to form the modern Eurasian Basin, the growth of which continues today (Figures 1 and 2). However, a long standing problem has been to understand how rifting was accommodated on land where the Arctic spreading center intersected the Siberian margin at the Laptev Sea (Figures 2, 3 and 4). Studies performed in northern and central Russia provide evidence of several episodes of both extensional and compressional deformation in line with the Gakkel Ridge and tracing eastward across central Russia in what is known as the Moma “rift” system (Figure 2) (Fujita et al., 1990), which has been tentatively dated as Neogene-Quaternary based on sediment infill, though the timing and specific nature of events responsible for formation remain controversial (Franke et al., 2000; Fujita et al., 2009; Paech et al., 1998). Studies of modern seismic activity in Russia suggest current poles of rotation for both the Eurasian plate and the North American plate directly south of the Laptev Sea near their shared plate boundary at a range of locations from 70°N, 126°E to 67°N, 132° E and potentially as far north as the Laptev Sea (Figure 1) (Franke et al., 2000; Fujita et al., 2009). A pole of rotation along or near this plate boundary would cause an expected change from extension in the Gakkel Ridge north of the pole to convergence along the Chersky Seismic Belt south of the pole, though modern focal mechanism studies indicate that the tectonic history for northern Russia may not have been so

Figure 2: Arctic polar view of the relationship between the Gakkel Ridge, Laptev Sea and Kular Dome. Approximate minimum reported ages in Ma are for young igneous intrusive belts in northern Russia. $^{40}\text{Ar}/^{39}\text{Ar}$ and K-Ar ages (shown in boxes) are from Layer et al. (2001) and Trunilina (1994) respectively. Gakkel Ridge spreading rates are from Jokat and Schmidt-Aursch (2007), DeMets et al. (1994), Laptev Basin data are from Drachev et al. (1998), bathymetry is from IBCAO (Jakobsson et al., 2008). Abbreviations are: AR, Alpha Ridge; CAI, Canadian Arctic Islands; CC, Chukchi Cap; LR, Lomonosov Ridge; MR, Mendeleev Ridge; SP, Seward Peninsula; WI, Wrangel Island.

Figure 3: Generalized geology bordering the Kular Dome field area. Modified from Urzov et al. (1994), and Konstantinovskiy (2007). See Figure 1 for location. The boxed area indicates the location of Figure 5.

Figure 4: Generalized tectonic and terrane map of the Kular Dome area. Modified from Urzov et al. (1994), Konstantinovskiy (2007) and Oxman (2003). See Figure 1 for location. The boxed area indicates the location of Figure 5.

simple, instead involving a wide intraplate region of diffuse deformation (Fujita et al., 2009). Since continental rifting can precede continental drift by long periods of geologic time, it has been suggested that Cretaceous aged extension in northern Russia and the Laptev Sea may represent early evidence of continental rifting associated with the eventual opening of the Eurasian Basin during the Eocene (Drachev et al., 1998). For this reason, we have targeted the Kular Dome, located approximately 100 km south of the Laptev Sea where the Kular granitic pluton was emplaced into Triassic-Jurassic sedimentary units along strike with the Gakkel Ridge (Figures 2, 3 and 5). A Cretaceous extensional event would also provide a convenient explanation for a previously dated north-south trending belt of Late Cretaceous plutonism in northern Russia (Figure 2). Extension at this time could also be tied to closure of the South Anyui suture (Figure 1) causing eastern escape of the Asian continent similar to more recent structures in northeastern Asia formed during collision with India or as a backarc effect from westward subduction beneath Okhotsk-Chukotka (Layer et al., 2001). Formation of the South Anyui suture and closure of the South Anyui Ocean must have initiated by the Tithonian (~150 Ma) because detrital zircons sourced from the Siberian craton are found in Late Jurassic Chukotkan stratigraphy (Miller et al., 2008) and must have ceased by 106 Ma according to earliest volcanic ages of the Okhotsk-Chukotka Volcanic Belt which forms a continuous belt from the Uda River in southern Russia near the border with China to the eastern Chukchi Peninsula (Akinin and Miller, 2011).

Figure 5: a) Field map and igneous geochronology sample locations for the Kular Dome. Geology and unit ages from Oleshko (1981) and this study. See Figure 3 for location. Unit abbreviations indicate age: Meta₁, Paleozoic metasediments; P, Paleozoic sediments; T_{2a}, Anisian; T_{2l}, Ladinian; T₃, Late Triassic; J_{2a}, Alenian; J_{3ox}, Oxfordian; J_{3km}, Kimmeridgian; J_{3t}, Tithonian; K_{gr}, Cretaceous granite. b) Cross section is drawn along profile X-X' seen in Figure 5a.

Field area:

Northeast Russia:

The overall structure of northern Russia is generally divided from west to east into the Siberian platform, the Verkhoyansk Fold-Thrust Belt, the Chersky Collisional Belt, the Kolyma-Omolon superterrane, the Okhotsk massif, and the Koryak and Kamchatka blocks, with the Arctic Alaska-Chukotka microplate situated along the northern coast (Parfenov et al., 2009) (Figure 1). Shelf sediments and turbidites currently seen in the Verkhoyansk Fold-Thrust Belt were initially accumulated in the immense Verkhoyansk passive margin along the entire eastern margin of the Siberian platform from the Late Paleozoic to the Late Jurassic. Though the passive margin of the Siberian platform and the platform itself show very different histories in terms of surface structures, they share a common basement, and the combined Verkhoyansk passive margin sequence and the Siberian platform together form the North Asian craton (Khudoley and Prokopiev, 2007). Rocks of the Verkhoyansk passive margin consist of Devonian-Carboniferous clastic sequences including rift-related gabbro and basalt with gypsum and anhydrite interbeds and Late Paleozoic-Early Mesozoic beds of deltaic mudstone, siltstone and sandstone (Khudoley and Prokopiev, 2007; Konstantinovskiy, 2007; Oleshko, 1981; Oxman, 2003; Parfenov, 1991). The Kolyma-Omolon superterrane collided with the Verkhoyansk passive margin in the Late Jurassic to form the Verkhoyansk Fold-Thrust Belt which now defines the outer (foreland) part of the Verkhoyansk-Kolyma orogen, while the Chersky Collisional Belt to the east represents the inner (hinterland) region (Khudoley and Prokopiev, 2007). East of the Verkhoyansk Fold-Thrust Belt are several accreted terranes which experienced variable amounts of shortening and oblique strike-slip motion in the Mesozoic that are summarized in Parfenov et al. (2009).

Kular Dome:

The Kular Dome is located at 70.0°N/134.3°E just west of the Yana River in northern Russia within the northern Kular-Nera slate belt which is also referred to as the Kular-Ayan-Yuryakh terrane (Konstantinovsky, 2007) (Figures 3, 4 and 5). The Kular-Nera belt extends for over 1500 km in length from northwest to southeast. It was likely formed as a deep-water trough infilled by Late Permian-Early Jurassic black shale and turbidite deep-water fan deposits from the nearby continental margin (Konstantinovsky, 2007; Oxman, 2003; Parfenov, 1991). Deformed Jurassic rocks from the South Polousnyi synclinorium are found east of the Kular-Nera belt and are thought to be truncated by the Yana fault which has been most commonly interpreted as a westward thrust (Khudoley and Prokopiev, 2007; Konstantinovsky, 2007; Oxman, 2003; Parfenov, 1991), though results from this study and detrital zircon dating suggest otherwise (Harris et al., 2011, Chapter II, this volume). Middle to Late Jurassic synorogenic deposits of the Polousnyi synclinorium have experienced several compressional deformation events forming multiple fold-thrust structures with northwestern vergence in the central and southern region and south-southeastern vergence in the north (Figures 4 and 5) (Oxman, 2003; Urzov et al., 1994). Deep-water trough sediments preserved at depth near the Chai-Yuryue-Charky-Indigirka suture, which separates the Kular-Nera belt from the Polousnyi synclinorium approximately 60 km south of the Kular Dome (Figure 4), record a change in coastal depositional directions from northeast-directed sedimentation from the craton in the Triassic to southwest-directed sedimentation from the newly formed eastern Chersky cordillera (Konstantinovsky, 2007). Further east, the Chersky Collisional Belt (Figure 1) consists of several fault bounded allochthonous terranes of Paleozoic age and strike-slip bounded shear zones of ophiolite along with Late Mesozoic synorogenic deposits (Oxman, 2003). Directly west

of the Kular-Nera belt is the Adycha El'gy zone of the western Verkhoyansk Fold-Thrust Belt, which is separated from the Kular-Nera by the Adycha-Taryn fault zone (Figure 4).

The Kular Dome can be described as a gneiss dome in that it represents an area with a plutonic core rimmed by contact metamorphosed metapelites (Yin, 2004). Southeast of the dome is a large fault that follows the Yana River (Figure 3) and is inferred to be either the northern trace of the Chai-Yuryue-Charky-Indigirka suture (Konstantinovskiy, 2007; Parfenov, 1991), or the Yana thrust or strike-slip fault, which runs approximately parallel to the dome axis through the field area (Khudoley and Prokopyev, 2007; Oxman, 2003). The fault separates Triassic sedimentary units to the northwest from tightly folded Jurassic sediments to the southeast and is more likely to be a normal fault than the northern trace of the Chai-Yuryue-Charky-Indigirka suture. It will be referred to as the Yana fault in this paper. Development of the dome may be linked to several models of either extensional or compressional origin, though data from this study supports an extensional setting for the area during the Late Cretaceous. Normal faulting near the dome suggests emplacement of the granitic core through detachment related mechanisms thought to be in effect from 106 to 95 Ma (see review in Layer et al., 2001; Yin, 2004). Extensional Cretaceous magmatism is potentially associated with formation of the Gakkel Ridge to the north based on alignment of multiple Middle Cretaceous intrusions in Russia with the Gakkel Ridge and grabens in the Laptev Sea, including the Ust' Yana Graben which extends into the continent north of the Kular Dome (Figures 3 and 4).

Within northern Russia, there were several stages of magmatic activity (Figure 1) that have been dated by zircon U-Pb and biotite, hornblende and white mica $^{40}\text{Ar}/^{39}\text{Ar}$ methods (Layer et al., 2001). Based on ages and trace element analyses, these magmatic events have been organized into four belts (Figure 1), which include 1) the Late Jurassic-Early Cretaceous Main

Belt, 2) the Early Cretaceous Northern Belt, 3) the Early Cretaceous Transverse Belts and 4) a series of Middle Cretaceous extensional belts (Figure 2). The Main Belt (160 Ma and 145-135 Ma) is located along the western and southern boundaries of the Kolyma-Omolon superterrane and formed as an evolving arc above a subduction zone followed by collision resulting in quartz dioritic, granodioritic and monzogranitic plutonism (Layer et al., 2001). The Northern Belt and Transverse Belts were both emplaced from 138 to 120 Ma. The Northern Belt (138-120 Ma) is located along the northern margin of the Kolyma-Omolon superterrane and formed as a consequence of subduction prior to closure of the South Anyui Ocean. Tonalite, granodiorite, granite and syenite are the most common lithologies of the Northern Belt (Layer et al., 2001). The Transverse Belts (138-120 Ma) are composed of multiple extensionally-emplaced felsic and mafic magmatic lithologies and include plutons and dikes that radiate outwards from the Northern and Main Belts west of the Kolyma-Omolon superterrane (Layer et al., 2001). The remaining younger intrusions (106-95 Ma) fall into a north-south oriented belt of plutons emplaced during regional east-west extension that stretch from Bol'shoi Lyakhov Island in the north to the southern Verkhoyansk Range (Layer et al., 2001). Plutons of this belt show within-plate extensional trace element signatures and show a general younging trend from north to south (Figure 2). The Kular pluton is part of this younger intrusive suite.

Lithology:

Mesozoic sedimentary units:

Triassic sandstones found northwest of the Yana fault have been dated both paleontologically (Oleshko, 1981) and more recently by detrital zircon U-Pb geochronology

(Harris et al., 2011, Chapter II, this volume). Ages of Triassic strata directly west of the fault range from Ladinian near the Yana River to Anisian towards the northwest in contact with metasediments bordering the Kular pluton. Triassic sandstones are quartz-rich with a $Q_t (=Q_m + Q_p)$ range of 35-40% (mostly monocrystalline), feldspars and plagioclase range of 20-25%, iron oxide content of 2-15%, and total lithic content up to 25% with subequal proportions of volcanics and sedimentary fragments. High volcanic content in Triassic sandstones is suggestive of a north Siberian source from Siberian Trap magmatic rocks to the northwest as this area represents the only nearby significant volcanic system during the Triassic. Total biotite and minor associated muscovite content can comprise up to 10% of samples but is generally much less common. These units are also commonly interlayered with thick red-colored mudstone beds which often show slump folds from fluid-supported soft-sediment deformation. Three units of Triassic strata (T_{2a} , T_{2l} and T_3) have been previously mapped in the study area with thicknesses from 1.5 to 2.5 km (Oleshko, 1981; Urzov et al., 1994). Though outcrop exposures of T_{2l} were abundant near the Yana River, T_{2a} exposures were rare, mostly buried beneath cover, and T_3 units were not seen during fieldwork for this study. S_0 bedding measurements showed average strike values of northeast-southwest (Figure 6d) and were gently folded about northeast trending axes.

East of the Yana fault, Jurassic lithic greywackes dated paleontologically (Oleshko, 1981; Urzov et al., 1994) and by U-Pb detrital zircon geochronology from samples collected along the Yana River (Harris et al., 2011, Chapter II, this volume) yielded ages ranging from Oxfordian to Tithonian. These Jurassic units are found mostly east of the Yana fault and are quartz-rich lithic greywackes with about 20-30% matrix, 5-10% lithic fragments, 20-30% monocrystalline quartz, 30-50% feldspars, and minor biotite, white mica and iron oxides. Jurassic sediments are much higher in matrix content than the Triassic units, though grains were similar in terms of

Figure 6: Equal-area plots of foliations and stretched andalusite porphyroblast lineations seen in units of the Kular Dome. Dashed lines indicate calculated mean foliations. Plots made using GEORient, ver. 9.4.5 (Holcombe, 2010).

composition. Four units of Jurassic strata have been previously mapped in the study area (Figure 5) with thicknesses ranging from 1.0 to 1.5 km (Oleshko, 1981). Slump-folded interbeds and silty conglomerate lenses up to one meter in thickness were also observed. While S_0 bedding measurements have been folded along east-west trending axes east of the Yana fault (Figure 6b), vertical or near-vertical S_1 cleavages striking at an average of 012° are seen commonly along the Yana fault, related to east-west compression during accretion of the Kolyma-Omolon superterrane (Figure 6a). Northwest of the Yana fault, in Triassic strata, S_1 cleavage shallows with increasing distance from the fault. Based on 300-point count thin section analysis of several samples and comparison to provenance diagrams modeled after Dickinson et al. (1983), it was determined that Triassic sandstones were likely derived from a magmatic arc and that Jurassic greywackes were likely derived from a continental source (Harris et al., 2011, Chapter II, this volume).

Kular pluton:

The Kular Dome contains multiple large igneous intrusions including one large northeast-southwest oriented igneous pluton exposed over approximately 250 km^2 (Figures 3 and 5). Several plutonic intrusions lie along this northeast-southwest trend indicating emplacement within the core of a large anticlinal or oblong domal structure as branches of a deeper magma chamber. This field relationship is confirmed by consistent bedding dip away from the pluton on the northwest and southeast sides (Figure 5). The areas between each lobe of the intrusion are composed of Late Permian-Early Triassic metapelites with strongly crenulated fabrics. Petrology of the pluton is coarse biotite granite composed of 40-50% quartz, 30-40% K-feldspar, 5-10% plagioclase and 10-15% biotite. Common accessory minerals include zircon, muscovite and

apatite. Crystal sizes in granite samples are typically very coarse with quartz and feldspar grains commonly larger than one centimeter in diameter. Syn-cooling deformation is evident in the form of undulose or patchy quartz extinction resulting from high-temperature grain boundary migration (Figure 7), sericite formation and myrmekite development. A weak foliation defined by aligned biotites and flattened quartz grains was noticed in one unoriented sample near the contact between the pluton and country rock but wasn't noticed elsewhere in thin section or outcrop.

Paleozoic metasediments:

Country rock found bordering the Kular pluton was composed of Early Triassic-Late Permian aged metapelites formed under moderate temperature, low-pressure conditions associated with intrusion as indicated by prevalence of andalusite poikiloblasts (Figure 8a). These metapelites show strain in the form of stretched andalusites at both micro- and macroscopic scale along with evidence of top-down shear along several grains as evidenced by fractures and grain mantling (Figure 9). Andalusites are abundant, contributing up to 10% of total rock volume in certain exposures. Between the lobes of the pluton, metapelites are commonly crenulated with lineations plunging away from the nearest pluton contact. In general, foliation strikes parallel to the nearest pluton margin (Figure 5).

Metapelites near the pluton are well foliated along S_2 , and are visible macroscopically and microscopically by alignment of opaques, elongated quartz crystals and biotites. S_2 foliations near the pluton are generally shallowly dipping and strike parallel to the pluton margin (Figure 6e). With increasing proximity to the pluton, replacement of andalusite by white mica increases, commonly resulting in pseudomorphs recording initial orientation of andalusites prior

Figure 7: Quartz grain boundary migration preserved in the biotite granite of the Kular pluton. Strongly lobate contacts are common in samples collected from the pluton with bulging recrystallization apparent in several thin section samples. Picture taken under cross-polarizing light.

Figure 8: a) Andalusite prevalence in metapelites found near the Kular Dome. b) Cross-polarized photomicrographs of samples collected from Paleozoic metasediments showing that muscovite replacement of andalusite grains increases with proximity to the pluton to c) total replacement of andalusite by coarse-grained muscovite at the contact.

Figure 9: Andalusite stretching deformation at a) macroscopic and b) microscopic scale. c,d) Top-down shear from mantled porphyroblasts in thin section cut along L_1 and oriented top-up and down-right in all photomicrographs. All photomicrographs were imaged under cross-polarized light.

to replacement (Figures 8b and 8c). White mica in all pseudomorphs is randomly orientated and either did not record the state of stress during replacement or indicates low regional stress conditions during retrograde placement.

Andalusites were very commonly stretched near the pluton, showing obvious pull-apart zones in thin section, hand sample, and field observations (Figure 9). Thinning of andalusite grains along the long axis was also commonly observed in the field in the form of consistently oriented lineations as a result of grain stretching (Figure 9a). Strain measurements in three dimensions were not collected resulting in difficulty of assessing total strain by the Fry method or axial ratio comparison, but in a two dimensional sense, assuming initially equal lengths of andalusite short axes a and b in cross section (or X/Z assuming no strain in the Y direction), strain was estimated at a ratio of 2.4 with approximately 60-85% elongation from analysis of thin section and several field photographs (Figure 9). Oriented thin sections commonly show top-down shear along foliations which regularly dip to the south; away from the pluton contact. Consistent top-down shear evidence was in the form of pressure shadows, bent andalusite grains and mica-filled fracture orientations in andalusite porphyroblasts (Figure 9).

Geochronology:

Sensitive High-Resolution Ion Microprobe - Reverse Geometry (SHRIMP-RG):

Zircons have proven useful for U-Pb geochronology due to their high mechanical and chemical resistance, high blocking temperature of around 800° C, generally high U concentration, low common Pb retention during crystallization and abundance in both sedimentary and felsic igneous rocks. Geochronologic study of zircons utilizes the decay

pathways of ^{238}U to ^{206}Pb , ^{235}U to ^{207}Pb and ^{232}Th to ^{208}Pb , although for age calculations, $^{238}\text{U}/^{206}\text{Pb}$ ratios are typically used for ages less than 1.4 Ga and $^{207}\text{Pb}/^{206}\text{Pb}$ ratios are used for ages greater than 1.4 Ga due to the relatively low abundance of ^{235}U (Gehrels and Pullen, 2010), though concordant ages can be calculated by comparison of the two ratios.

We dated five samples from the Kular pluton using zircon U-Pb geochronology (Figure 5a). All samples were collected as bagged grab samples in the field from in-place outcrop or rubble at topographic high points when outcrop was unavailable. Rocks were cleared of all weathering rind prior to collection. Zircons were later separated using standard crushing, gravimetric and magnetic separation procedures at West Virginia University. Material that sank in methylene iodide (MEI, $\rho=3.3 \text{ g/cm}^3$) was picked through under a petrographic microscope to select inclusion and fracture free zircons for analysis. Picked grains were mounted in rows within 25 mm diameter, 6 mm thick pucks at the USGS-Stanford University SHRIMP-RG lab. Pucks prepared at the lab were polished to expose the inner structure of the zircons and coated with a thin film ($\sim 10 \text{ nm}$) of gold in a Denton sputterer to minimize charge effects during analysis. Prior to analysis, all samples were imaged with cathodoluminescence (CL) using a JEOL JSM 5600 electron microscope and reflected light in order to observe internal grain structure and to aid in selection of targeted grains. At least five grains per sample were targeted and measured for their U-Th-Pb and REE concentrations using both cores and rims as determined by CL imaging (Appendix 1). Analytical spots approximately $30 \mu\text{m}$ in diameter were sputtered with a primary oxygen ion (O_2^+) beam to release secondary ions which were focused into a secondary beam then counted (Coath and Long, 1994). An electrostatic analyser was used in the double-focusing mass spectrometer to reduce momentum effects caused by the magnetic separation of ions. Since a Reverse Geometry Microprobe was used, the magnet

preceded the electrostatic analyser along the secondary beam path so that mass dispersion occurred early and only one mass was passed through the collector at any given time. This causes increased resolution for the SHRIMP-RG but sacrifices the multiple beam collection speed afforded by Forward Geometry analysis where the electrostatic analyser precedes the magnet. Reported results are from five averaged measurement cycles per grain which were then processed using Squid and Isoplot software (Ludwig, 2009). Error correction was performed by targeting standard R-33, which yields a SHRIMP age of 419.9 ± 1.5 Ma (Black et al., 2004), one time per four sample grain analyses. For complete SHRIMP-RG routine procedures, see Williams (1998).

Results:

Geochronology:

Of the five samples collected from Kular, only samples 08DH09, 08DH11 and 08JT29 yielded concordant ages using $^{207}\text{Pb}/^{206}\text{Pb}$ vs. $^{238}\text{U}/^{206}\text{Pb}$ ratios (Figure 10). The two remaining samples (08DH08 and 08DH13) yielded poorly concordant ages, and are instead reported as weighted mean ^{207}Pb -corrected $^{206}\text{Pb}/^{238}\text{U}$ ages, though both concordia ages and weighted mean ages were calculated for each sample (Figures 10 and 11). Analyses with high U concentration, internal discordance or high common ^{204}Pb were excluded from concordia and weighted mean age determination (Table 1). Concordia ages were calculated in Isoplot v.3.71 using 1σ input errors in percent and output error of 2σ or 95% confidence (Ludwig, 2009). Complete results from all geochronologic analyses are listed in Appendix 2, concordia results are shown in Figure 10 and weighted mean age results are shown in Figure 11.

Figure 11: Weighted mean age diagrams for igneous zircons from Kular Dome calculated using Isoplot (Ludwig, 2009).

Sample locations shown in Figure 5. Vertical bars represent a calculated age range with error (2σ) for individually dated zircons.

Table 1: Results from SHRIMP-RG analysis of igneous zircons from Kular granite. In Isoplot v. 3.6 (Ludwig, 2009), only bold rows were used for concordia age analysis, all italicized rows (including bold) were used for weighted mean age calculations and gray rows were not used for analysis. Ages with lines through them have been rejected due to high U, high ^{204}Pb or discordance. Spot names ending with a “c” or “r” indicate targeting within the zircon core or rim respectively.

Spot name	% common ^{206}Pb	U (ppm)	Th (ppm)	$^{232}\text{Th}/^{238}\text{U}$	^{207}Pb corrected $^{206}\text{Pb}/^{238}\text{U}$	1σ error	^{207}Pb corrected $^{206}\text{Pb}/^{238}\text{U}$ age	1σ error	Total $^{238}\text{U}/^{206}\text{Pb}$	% error	Total $^{207}\text{Pb}/^{206}\text{Pb}$	% error	^{204}Pb corrected $^{207}\text{Pb}/^{206}\text{Pb}$	% error
08DH08-7c	7.21	209	158	0.78	.0131	.0002	84.1	1.3	70.66	1.2	.1049	7.0	.0436	39.4
08DH08-9r	15.05	533	135	0.26	.0156	.0001	100.1	0.9	54.30	0.8	.1675	1.6	.0204	76.3
08DH08-2r	7.05	1355	355	0.27	.0165	.0001	105.5	0.8	56.34	0.4	.1041	3.9	.0436	15.3
08DH08-1r	-0.10	649	187	0.30	.0170	.0001	108.8	0.7	58.79	0.6	.0474	2.3	.0446	3.7
08DH08-3r	0.15	1538	206	0.14	.0171	.0001	109.3	0.5	58.37	0.4	.0494	1.5	.0469	2.4
08DH08-4r	-0.12	1757	232	0.14	.0174	.0001	111.4	0.4	57.44	0.4	.0473	1.9	.0473	1.9
08DH08-11c	9.30	839	152	0.19	.0179	.0004	114.2	2.8	50.76	0.6	.1222	14.0	.0432	79.0
08DH08-10c	21.40	196	194	1.03	.0191	.0003	121.8	1.9	41.21	1.1	.2186	2.8	.0529	44.3
08DH08-6c	0.36	376	30	0.08	.0201	.0002	128.3	1.0	49.56	0.8	.0515	2.8	.0493	4.0
08DH08-12c	2.91	290	373	1.33	.0251	.0002	159.5	1.4	38.75	0.8	.0725	2.8	.0477	12.2
08DH08-5c	0.51	122	66	0.56	.0426	.0005	269.1	2.8	23.34	1.0	.0557	3.1	.0506	6.2
08DH08-c	12.53	270	70	0.27	.1481	.0009	890.1	5.1	5.91	0.5	.1728	0.6	.1644	1.1
08DH09-9c	0.32	473	462	1.01	.0162	.0001	103.5	0.8	61.59	0.8	.0506	2.7	.0496	3.0
08DH09-2c	0.15	158	87	0.57	.0166	.0002	106.0	1.5	60.23	1.3	.0493	4.9	.0405	12.6
08DH09-12c	0.47	187	113	0.62	.0167	.0002	106.7	1.4	59.66	1.3	.0519	4.5	.0444	11.9
08DH09-7c	1.24	306	153	0.52	.0167	.0002	107.0	1.0	59.03	1.0	.0580	3.3	.0460	10.9
08DH09-4c	0.26	278	95	0.35	.0169	.0002	108.0	1.2	59.05	1.1	.0503	3.8	.0473	5.2
08DH09-5c	-0.01	270	193	0.74	.0171	.0002	109.1	1.1	58.57	1.0	.0481	3.7	.0436	6.6
08DH09-1c	0.48	1307	810	0.64	.0171	.0001	109.1	0.5	58.28	0.5	.0520	1.7	.0484	3.1
08DH09-6c	-0.27	144	82	0.58	.0171	.0002	109.5	1.5	58.54	1.4	.0461	5.2	.0377	12.9
08DH09-8c	1.12	1085	126	0.12	.0217	.0001	138.3	0.7	45.60	0.4	.0578	3.9	.0516	5.2
08DH09-11c	0.49	328	100	0.31	.0240	.0002	153.2	1.2	41.38	0.8	.0530	2.6	.0520	2.9
08DH09-10c	1.96	502	208	0.43	.0556	.0003	348.9	1.8	17.63	0.5	.0692	1.3	.0542	4.5
08DH11-3r	0.10	840	206	0.25	.0160	.0001	102.6	0.6	62.25	0.6	.0488	2.1	.0462	3.4
08DH11-1c	0.14	273	184	0.70	.0162	.0002	103.5	1.1	61.69	1.1	.0492	3.8	.0472	4.8
08DH11-2c	0.01	291	78	0.28	.0163	.0002	104.0	1.0	61.46	1.0	.0482	3.6	.0482	3.6
08DH11-7c	0.14	135	102	0.78	.0163	.0003	104.3	1.7	61.25	1.6	.0492	5.7	.0492	5.7
08DH11-4c	0.00	478	438	0.95	.0167	.0001	106.9	0.8	59.78	0.8	.0481	2.7	.0461	3.6
08DH11-8r	0.13	272	121	0.46	.0170	.0002	108.5	1.2	58.82	1.1	.0492	3.9	.0492	3.9
08DH11-6c	0.12	770	107	0.14	.0173	.0001	110.5	0.7	57.78	0.7	.0492	2.7	.0492	2.7
08DH11-5r	1.09	118	85	0.74	.3072	.0027	1726.8	13.1	3.22	0.8	.1152	0.9	.1152	0.9
08DH13-1c	6.53	253	108	0.44	.0160	.0002	102.4	1.2	58.38	1.0	.0999	4.5	.0290	48.1
08DH13-3c	0.06	254	170	0.69	.0172	.0002	110.0	1.1	58.07	1.0	.0487	3.6	.0463	5.2
08DH13-5r	3.72	738	383	0.54	.0173	.0001	110.5	0.7	55.68	0.6	.0778	1.6	.0446	10.4
08DH13-4r	0.61	279	117	0.43	.0174	.0002	111.3	1.0	57.08	0.9	.0531	3.2	.0478	6.2
08DH13-2r	1.19	1355	234	0.18	.0175	.0001	112.0	0.5	56.40	0.4	.0577	1.9	.0469	5.0
08JT29-12r	-0.04	241	181	0.78	.0161	.0002	102.7	1.1	62.32	1.1	.0478	3.9	.0434	8.8
08JT29-8r	0.70	181	58	0.33	.0161	.0002	102.7	1.3	61.81	1.2	.0537	4.2	.0484	7.2
08JT29-6c	1.06	641	611	0.98	.0161	.0001	102.9	0.7	61.50	0.6	.0565	2.2	.0494	5.3
08JT29-5c	-0.40	246	128	0.54	.0163	.0002	104.2	1.1	61.60	1.0	.0449	3.8	.0403	8.9
08JT29-1r	0.68	205	128	0.64	.0164	.0002	104.8	1.2	60.60	1.1	.0535	3.8	.0535	3.8
08JT29-9c	0.03	199	119	0.62	.0164	.0002	104.9	1.3	60.94	1.2	.0483	4.4	.0483	4.4
08JT29-7c	0.09	336	48	0.15	.0166	.0002	105.9	1.0	60.32	0.9	.0488	3.4	.0488	3.4
08JT29-2r	0.16	678	64	0.10	.0169	.0001	107.9	0.7	59.14	0.6	.0494	2.2	.0478	2.8
08JT29-3c	0.06	1780	15	0.01	.0186	.0001	148.9	0.4	53.70	0.4	.0489	1.3	.0486	1.4
08JT29-13c	0.16	467	100	0.22	.0251	.0002	159.9	1.1	39.77	0.7	.0505	2.4	.0497	2.7
08JT29-10c	8.22	74	381	5.31	.0595	.0009	372.8	5.4	15.41	1.2	.1203	4.9	.0626	29.4
08JT29-4c	5.55	121	165	1.40	.1700	.0013	1012.3	7.2	5.55	0.7	.1194	1.1	.1095	2.0

Sample 08DH08:

This sample yielded a small separate of very fine zircons, generally 150 μm or less in length. In reflected light, zircons range from clear to honey colored and in CL show simple zoning and occasional xenocrystic cores with magmatic growth rims. Twelve grains were analyzed using four rims and eight cores. Results were highly discordant with no coherent age group showing most spot ages spanning 185 m.y. in the range of 84.1-269.1 Ma and one spot age of 890 Ma. Abnormally old ages are most likely the result of Pb inheritance causing lower $^{207}\text{Pb}/^{206}\text{Pb}$ and $^{238}\text{U}/^{206}\text{Pb}$ ratios which produce older calculated ages. Analyses do show abnormally high ^{206}Pb counts for grains with older ages (Appendix 2) and CL images show localized bright zones in these same zircons, suggestive of high U/Pb ratios (Appendix 1). A concordia age of 110.2 ± 1.4 Ma (MSWD 0.02) was calculated based only on U/Pb ratios from three grains shot within their rims. A weighted mean age of 109.7 ± 4.7 Ma (MSWD 54) was determined based on eight grain analyses using both cores and rims. Four grain analyses were left out due to high discordance from the mean and rejection by Isoplot weighted mean modeling.

Sample 08DH09:

A large separate of small honey colored zircons in long doubly-terminated prisms up to 300 μm in length and less than 100 μm in diameter was collected from this sample. Under CL, almost all zircons display simple zoning with little evidence of metamorphic or magmatic overgrowth. All grains analyzed were targeted within the core to obtain similar initial crystallization ages. Four grains were excluded from all age calculations due to high U or discordant flags leaving a total of seven available targets. A concordia age of 108.1 ± 0.6 Ma (MSWD 1.0) was calculated from six measurements excluding one spot for visual discordance.

A weighted mean age of 108.4 ± 1.1 Ma (MSWD 1.4) was calculated from all seven grains.

Sample 08DH11:

This sample yielded sub-equal amounts of fat, rounded, honey colored zircons (150 μ m in length and 100 μ m in diameter) and long, thin, clear zircons (up to 400 μ m in length and as thin as 25 μ m). The fat zircons were commonly fractured and were generally too high in U concentration to be targeted and were therefore excluded from age determination. The thin zircons mostly showed simple zoning patterns with no evidence of magmatic or metamorphic overgrowth. Within the thin zircon population, eight grains were targeted with four analyses excluded for final age determination due to high common Pb²⁰⁴ flags or discordance. Four grains were used for final age determinations using three core shots and one rim shot to calculate a concordia age of 103.3 ± 0.4 Ma (MSWD 0.9) and a weighted mean age of 103.2 ± 0.9 Ma (MSWD 0.6).

Sample 08DH13:

This sample also yielded two separate splits of zircons, the first being fat, rounded honey-colored zircons generally 150-200 μ m in length and the second set being clear, heavily fractured and thinner at around 200 μ m in length. Under CL, zircons from the first set were very dark, suggestive of high U content. Zircons from the second set were very bright under CL suggesting U concentrations too low for analysis. While neither population was optimal for U-Pb dating, the second set of fractured, low U concentration zircons had a few fine zircons with ordinary zoning patterns, no overgrowths and little fracturing which were used for analysis. Because of this small population of useful zircons, sputtering was only performed on five grains with four targets in the thin population of zircons and one from the squat, honey-colored zircons. The one

shot from the squat zircon was excluded from age determinations based on a high common Pb²⁰⁴ flag. The remaining four grains were shot using three rims and one core. Of these four shots, only two were used (one rim, one core) to produce a concordia age of 111.1 ± 4.2 Ma (MSWD 4.7) and a weighted mean age from all four shots of 111.3 ± 1.4 Ma (MSWD 1.3).

Sample 08JT29:

Our final sample yielded a small separate of fine doubly-terminated zircons typically 150-200 μm long and 50-100 μm in diameter ranging from clear to pale tan in color. Grains were generally squat and rounded with magmatic overgrowths around cores that sometimes contained multiple randomly oriented inclusions. Complex inclusion-containing zircons were avoided for analysis. Twelve grains were targeted with a mix of rim and core shots. Five grains were excluded from age determination due to high common Pb²⁰⁴ and high U flags. Of the remaining grains, four cores and three rims were used in analysis to give a concordia age of 104.5 ± 1.5 Ma (MSWD 1.5) and a weighted mean age of 103.8 ± 1.2 Ma (MSWD 1.4).

Mesozoic tectonic setting:

Late Jurassic-Early Cretaceous compression:

The Late Jurassic-Early Cretaceous is widely regarded as the time of collision between the Kolyma-Omolon superterrane and the Verkhoyansk passive margin along the east coast of the Siberian craton (Khudoley and Prokopiev, 2007; Parfenov, 1991). This collision caused widespread shortening within the basinal sedimentary deposits that previously formed as a consequence of Devonian rifting off the eastern margin of the Siberian craton. Compressional orogenesis in the area is thought to have ceased by 120 Ma based on overlapping sedimentary

and volcanic sequences and granitic intrusive suite relationships (Miller et al., 2002). In the Kular Dome area, this compressional event created vertical or near-vertical S_1 cleavages striking at an average of 032° that are inferred to have formed synchronously within large, open folds pervasive in Triassic sedimentary units. Axes for these open-folds strike parallel to S_1 cleavages west of the Yana fault and are in agreement with a west-northwest orientation of collision between the Kolyma-Omolon superterrane and the North Asian craton during the Late Jurassic. East of the Yana fault, tight folds in thinner Jurassic strata with axes striking at approximately 070° are seen. These folds and orientations of southward thrust sheets within the Jurassic units strike approximately 075° and are at odds with east-west collisional compression. Thrusts appear to be minor, typically dying out laterally over tens of kilometers and commonly show detachment along the base of J_{3ox} as indicated by repetition of exposed thrusts along the base of this unit (Figure 5). To the south, the Yana fault appears to either die out or bend to the east, following the Yana River. Thrust faults and fold axes in the neighboring Polousnyi Synclinorium range from east-west strikes in the north to an average strike of 035° about 150 km south-southeast of the study area (Figures 3 and 4).

The Chai-Yuryue-Charky-Indigirka suture (Figures 3 and 4) remains somewhat mysterious in that there is no clear agreement as to the specific nature or location of the fault in the north. The suture has been described as a thrust fault (Khudoley and Prokopiev, 2007; Oxman, 2003; Parfenov, 1991), a left-lateral strike-slip fault or a combination of the two (Konstantinovskiy, 2007), though a right-lateral strike-slip fault as an escape structure for the northern Kular region should not be discounted either. While some maps place the location of this fault or a regional unnamed thrust fault through the Kular Dome area, these interpretations are inconsistent with our observations at the Kular Dome. It is generally accepted that the Adycha-Taryn fault, located directly west of the Kular-Nera belt (Figures 3 and 4) represents the

eastern boundary of the Siberian craton and the location of the downgoing slab that resulted in suturing of incoming terrane material to the Verkhoyansk passive margin and is the boundary between the inner and outer Mesozoides (Parfenov, 1991). Comparison of detrital zircon populations collected along the Dyanishka River of the Verkhoyansk Fold-Thrust Belt, Lower Yana River and In'Yali Debin, however, supports a similar sedimentary source for these areas from the Triassic to the Jurassic and suggests a more eastern location for the limit of the Siberian craton during the Triassic and Jurassic (Harris et al., 2011, Chapter II, this volume). We suggest that the Yana normal fault, which parallels the Yana River in the Kular Dome area, is unrelated to the Adycha-Taryn fault to the west or to the Chai-Yuryue-Charky-Indigirka suture which either lies further east or is entirely absent in the north. Fault displacement is more likely to be normal than reverse in nature according to stratigraphic relationships across the fault assuming eastern dip and prevalent evidence of northwest-southeast directed extension in and around the Kular Dome.

Middle Cretaceous extension:

Compressional forces in the Kular Dome were the result of collision between the Kolyma-Omolon superterrane and the Siberian craton from roughly 150-135 Ma as determined by dating of faulted and folded granitic intrusions of the Main Belt (Layer et al., 2001; Oxman, 2003; Parfenov, 1991). However, evidence of extensional forces dominates the Paleozoic metasediments and Triassic units directly bordering and in close proximity to the pluton. The near-vertical S_1 foliations seen in Triassic sediments away from the pluton to the southeast near the Yana normal fault are gradually overprinted by a shallowly southeast dipping S_2 foliation to the northwest (Figure 6e). Top to the southeast shear and stretching of andalusite grains from macroscopic and microscopic analysis of oriented thin sections of country rock southeast of the

dome (Figure 9) as well as normal fault prevalence near the pluton are strong evidence supporting an extensional environment during emplacement of the Kular pluton. Outcrop-scale normal faults were also abundant along the Yana River, though commonly showing offset of 10 m or less. Grain-tail complexes seen in oriented thin sections around andalusite poikiloblasts show consistent top-down shear in foliations that dip gently away from the pluton. Lineations defined by stretched andalusite grains are commonly several centimeters in length and consistently display gentle southeast plunge away from the pluton (Figure 6f). Alignment of these lineations along shallow dip of S_2 foliations suggests synchronous development during emplacement of the Kular granite. Both $^{207}\text{Pb}/^{206}\text{Pb}$ vs. $^{238}\text{U}/^{206}\text{Pb}$ concordia and ^{207}Pb -corrected $^{206}\text{Pb}/^{238}\text{U}$ mean ages obtained from granitic zircons suggest a crystallization age for the Kular pluton between 111.3 ± 1.4 Ma and 103.2 ± 0.9 Ma limiting timing of extension to the Middle Cretaceous. These ages match previous results by Layer et al. (2001) who reported a $^{40}\text{Ar}/^{39}\text{Ar}$ biotite age of 103 Ma for the Kular granite. Geochemical data also from Layer et al. (2001) indicate the likelihood of magma generation and emplacement within an extensional environment through plots of Rb, Nb and Y concentrations using discrimination diagrams modeled after Pearce et al. (1984).

Discussion:

The Yana fault:

Though generally interpreted as a regional suture, the Yana fault is more likely to be a normal fault based on multiple observations including stratigraphic relationships across the Yana fault in the Kular Dome area, prevalence of smaller scale normal faults near the Yana fault and evidence of extensional emplacement of the Kular pluton. South of our field area, Triassic units

seen only west of the Yana fault near the Kular Dome, outcrop in the cores of anticlines east of the mapped location of the fault (Figure 3) providing strong evidence that the Yana fault is not a suture between two areas with differing sedimentation histories and sources. To the north, the Yana fault is buried beneath Cenozoic cover and deposits of the Ust' Yana Basin. If, however, the Yana fault initially formed as a reverse fault under collisional forces as is commonly mapped, later reversal of dip-slip motion to form a normal fault during emplacement of the Kular pluton would be necessary to explain current stratigraphic relations across the fault (Figure 5). This conclusion is based on the likelihood of an initially westward thrusting direction in accordance with other large-scale regional faults associated with development of the Verkhoyansk Fold-Thrust Belt. The Yana fault also may represent a right-lateral strike-slip zone with minor dip-slip movement, similar to faults seen in the nearby Adycha El'gy zone and fold-thrust belt, or perhaps as a facilitator to the escape of the Kular-Nera block to the north under east-west compression related to orogenesis in the Late Jurassic. Strike-slip faults seen in the Adycha El'gy zone trend northeast and show right-lateral displacement, also matching the general orientation of strike-slip faults in the Verkhoyansk zone to the west (Parfenov, 1991). Regardless, the Yana fault must have some amount of dip-slip displacement due to the lack of unit alignment on opposite sides of the fault upon restoration by pure strike-slip motion. While development of a normal fault is a convenient answer to some of the inherent problems with the mapping of this structure, all interpretations except that of synchronous fault and dome development either fail to explain the presence of Triassic strata in the cores of some Jurassic folds across the fault in the south or are unnecessarily complicated. It is most likely that the Kular Dome represents an area which has experienced diffuse extension that has been accommodated by brittle deformation in the north and ductile deformation in the south synonymous with intrusion of the Kular granite. This provides a simple explanation for both the

stratigraphic changes across the Yana fault and for exhumation of the Kular pluton and associated metasediments.

Regional tectonics:

Pluton emplacement and extensional tectonics:

Deformation in the Kular Dome area provides insight into the kinematics and timing of an extensional tectonic event in northern Russia during the Middle Cretaceous from 110 Ma to 92 Ma which may have persisted through the Eocene. Intrusion of the Kular pluton is inferred to have occurred between 111.3 ± 1.4 Ma and 103.2 ± 0.9 Ma based on igneous zircon U-Pb geochronology, followed by mild fluid-assisted high-temperature deformation and rapid exhumation as suggested by grain-boundary migration preserved in quartz grains (Figure 7) (Trouw et al., 2010). Exhumation history is further constrained by an $^{40}\text{Ar}/^{39}\text{Ar}$ age of 102.9 ± 0.5 Ma for muscovites and biotites collected from aplites, granites and monzonites within the Kular Range (Layer et al., 2001), suggesting cooling through 300-400°C soon after crystallization.

Fabrics in surrounding metasediments display strong evidence supporting emplacement of the Kular pluton within an extensional tectonic regime as described earlier. Timing of pluton intrusion is synchronous with that of a north-south oriented belt of relatively young intrusions in contrast to igneous rocks of the Main, Northern, and Transverse belts in the area. A study by Layer et al. (2001) groups these belts in terms of age and chemistry into four groups labeled “subduction belts” (aged approximately 160-113 Ma), “collisional belts” (aged 143-138 Ma), “old extensional belts” (aged 120-138 Ma) and “young extensional belts” (aged 92-107 Ma). The Kular granite falls into the “young extensional belt” category which is oriented

approximately north-south, showing an apparent southward younging direction from Bol'shoi Lyakhov in the north, to the southern Verkhoyansk Range (Figure 2). A potential compressional mechanism for emplacement involves the potential for plutonic development via decompression melting beneath an asymmetric pop-up structure which then experienced overthickening and extension associated with gravity spreading in the highlands following compressional release. This interpretation does not explain the extension-related chemical data from Layer et al. (2001) collected for the “young extensional belt” group, which includes the Kular pluton, nor does it explain the structural features seen in the Kular Dome area and is therefore deemed unlikely. Emplacement mechanisms may also be similar to the nearby Transverse Belt which is proposed to have been emplaced through pressure drops associated with fracture propagation under extensional conditions (Parfenov, 1991).

The tectonic evolution of the modern Arctic during the Middle Cretaceous was dominated by the opening of the Amerasian and Canada Basins, most likely related to counterclockwise rotation of the Arctic Alaska-Chukotka microplate from its original position along the Canadian Arctic Islands, and western subduction of the Pacific plate beneath the Eurasian plate at the eastern edge of Russia causing trench retreat and slab-rollback (Layer et al., 2001) [see Harris et al., 2011, Chapter II, this volume for detailed discussion of the tectonic history]. The Alpha and Mendeleev Ridges and the Chukchi Cap (Figure 2) all display extensional structures and upon closing the Eurasian Basin (pre-Eocene) would have been located more proximal to the Barents Shelf in the Middle Cretaceous. Assuming trench rollback of the Pacific plate during northwestern subduction along the eastern shelf of Paleo-Russia, synchronous right-lateral motion associated with the opening of the Canada Basin and emplacement of the Chukotka portion of the Arctic Alaska-Chukotka microplate, east-west extension in the Laptev Sea area and continental northern Russia is likely (Figure 12). The orientation of this extensional trend

matches well with graben timing and orientation in the Laptev Sea including the Ust' Yana Graben which extends into the continent north of the Kular Dome (Figures 3 and 4) (Drachev et al., 1998), young extensional belt orientation and structures of the Moma Rift system (Figure 2) which formed in the Early Cenozoic. For this paper, we refer to the "Moma Rift" as the sequence of half-grabens starting at the Laptev Sea and reaching southeast into central Siberia. Extensional features and restored poles of rotation for the Eurasian and North American plates during the Late Cretaceous-Early Cenozoic suggest extensional deformation reaching from the Gakkel Ridge to a point just south of the Laptev Sea where the poles of rotation for both the North American and Eurasian plates are found (Figure 1) (Franke et al., 2000; Fujita et al., 2009). While some have argued for the ongoing extensional deformation in the Moma Rift region, current seismic data and attenuation, and focal mechanism results support modern transpressional or compressional deformation reactivating initially extensional features (Cook et al., 1986; Franke et al., 2000; Fujita et al., 1990). Based on restorations of North Atlantic magnetic anomalies, Gaina et al. (2002) have demonstrated the potential for diffuse extension across the Laptev Sea and northern Russia from 79 Ma to 68.7 Ma (Figure 12), though it is possible that extension resulting from competing tectonic forces caused extensional forces as early as 100 Ma which is in agreement with a southward younging trend of plutons from northern Russia (Figure 1) (Layer et al., 2001). Though constraints on compressional deformation which resulted in formation of the Verkhoyansk Fold-Thrust Belt are limited to Late Jurassic-Middle Cretaceous time, opening of the Canada Basin altered the tectonic stresses of the area by the Late Cretaceous. Diffuse extension in northern Russia, which resulted in emplacement of a suite of plutonic intrusives, may have been an indication of early rifting of the Gakkel Ridge system. While magnetic anomalies in the Eurasian Basin show that new oceanic

Figure 12: Late Cretaceous (79-68.7 Ma) plate vectors for the North American plate relative to the Eurasian plate (fixed) superimposed on modern bathymetry from IBCAO (Jakobsson et al., 2008). Plate vectors are from Gaina et al. (2002), holding the Eurasian plate stationary. The dashed black line represents the approximate boundary of the Arctic Alaska-Chukotka microplate (AAC) and the dashed white line represents approximate plate boundaries between the Eurasian (A), North American (B) and Okhotsk (C) plates. Abbreviations are: UG, Uyandina Graben; UL, Ust' Lena Rift; UY, Ust' Yana Graben. Laptev Sea graben locations are from Drachev et al. (1998).

crust was forming along the Gakkel Ridge in the Eocene, there is no direct evidence of when continental rifting initiated since there are no wells in the Laptev Sea. However, Drachev et al. (1998) interpreted the lowest reflective bed within the Ust' Lena Rift of the Laptev Graben system (Figure 12) as Late Cretaceous-Paleogene in age and the base of the Ust' Yana Graben (Figure 12) as the Late Paleocene, suggestive of Late Cretaceous rifting as a precursor to opening of the Gakkel Ridge.

While the timing of specific events that have caused both compressional and extensional structures in the Moma Rift region are poorly constrained, the orientation of the overall rift system is in-line with a regional extensional event for northern Russia (Fujita et al., 1990; Paech et al., 1998), which we propose to have been initiated as early as the Middle to Late Cretaceous. Modeling of continental deformation along the northern Moma Rift indicates the potential for rifting near the Laptev Sea as early as 79 Ma (Gaina et al., 2002), so it seems reasonable that continental stretching may have been initiated prior to eventual graben formation to the southeast. The nearby Uyandina Graben (Figure 12) shows abundant extensional deformational features and no compressional features in the Upper Oligocene-Pleistocene clay, silt, conglomerate and lignite sediments (Paech et al., 1998), suggesting that while extension may have been initiated as early as the Middle Cretaceous, it may have resulted in minor deformation when spread across the continent until the Middle Paleogene when extension finally resulted in brittle deformation such as the Gakkel Ridge of the Eurasian Basin and graben development in the Moma Rift region.

Conclusions:

Field data presented in this study supports an extensional setting for the Kular Dome area and northern Russia during the Cretaceous through presence of normal faults that cut Triassic sandstones and Jurassic greywackes, stretched andalusites in contact metamorphosed schists, and down-plunge shear of coarse grains observed in oriented thin section samples. The Kular Dome is a 111.3 ± 1.4 to 103.2 ± 0.9 Ma aged granite based on U-Pb dating of igneous zircon and is thought to have been emplaced during a major east-west extensional event responsible for intrusion of a young series of plutons and dikes with extensional geochemical signatures from 110 to 92 Ma showing apparent southward younging (Layer et al., 2001). Orientation of this extensional episode is in agreement with potential forcing by opening of the Amerasian Basin of the Arctic and rollback above a westward subducting Pacific plate beneath the Eurasian plate during the Middle Cretaceous. The extensional event that created the Kular Dome and facilitated emplacement of this young extensional belt of granites is in-line with the modern strike of the Gakkel Ridge suggesting that an early Russian extensional event could have been a precursor to its eventual opening during the Eocene. This conclusion is also supported by the presence of Late Cretaceous deposits at the base of the Ust' Lena Rift of the Laptev Sea and Late Paleocene deposits at the base of the Ust' Yana Graben (Drachev et al., 1998) which are located between and along strike with the Gakkel Ridge to the north and the Kular Dome to the south.

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Chapter II

Detrital zircon U-Pb geochronology of Mesozoic sandstones from the Lower Yana River, northern Russia

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Abstract:

The formation of the Amerasian Basin remains enigmatic in terms of both timing and method of formation. Most models attempt to describe the movement of the Arctic Alaska-Chukotka microplate, which includes the New Siberian Islands, Wrangel Island, Chukotka and the Siberian Shelf of Russia as well as the North Slope and Seward Peninsula of Alaska. Movement of this microplate across the location of the modern Amerasian Basin is generally invoked to describe formation of the basin itself. Detrital zircon geochronology has been shown to be an inexpensive yet powerful method by which the tectonic correlation and proximity between multiple terranes over geologic time can be approximated. Seven detrital zircon samples to be dated for their U-Pb depositional ages were collected from Triassic sandstones and Late Jurassic greywackes from the Lower Yana River area. Triassic samples had detrital zircon age populations from 224-337, 341-387, 413-568, 738-825 and 1759-2011 Ma and Jurassic samples had detrital zircon age populations from 147-210, 223-396, 1639-2183 and 2281-3116 Ma. Comparison of detrital zircon ages from the Lower Yana River area to those dated from Chukotka, the Verkhoyansk Fold-Thrust Belt and the In'Yali Debin terrane suggests that Chukotka was separated from the North Asian craton during the Triassic. Jurassic detrital zircon age populations suggest that the Anyui Ocean had closed by the Tithonian via transpressional collision with northern Siberia. Integration of this data with previous multidisciplinary geologic studies has led to a new tectonic model describing the motion of the Arctic Alaska-Chukotka microplate across the Arctic during the Mesozoic as two separate, independently moving pieces in the Jurassic. Extension between the Alaskan and Russian portions of the Arctic Alaska-Chukotka microplate involving counterclockwise rotation of both during opening of the Canada Basin led to the composite strike-slip and extensional structures of the Alpha and Mendeleev Ridges. Chukotka likely moved from an initial position along the Barents Shelf eastward via dextral strike-slip motion along the north coast of Russia during the Late Jurassic to close the Anyui Ocean.

Introduction:

The tectonic history responsible for formation of the major basins of the Arctic has long been a topic of debate despite an increasing body of research. These efforts typically focus on the Amerasian Basin and its internal Canada Basin (see review in Lawver and Scotese, 1990) since the Eurasian Basin, located more proximal to the Barents Shelf of Siberia, is younger and has a more easily interpreted tectonic history (Figure 1a). Most models regarding the formation of the Amerasian Basin are described by entrapment of oceanic crust or sea-floor spreading, though the latter is given more common consideration. Sea floor spreading models utilize multiple interpretations of the movement and function of prominent features in and around the Amerasian Basin including the Lomonosov Ridge, the Alpha and Mendeleev Ridges, the Chukchi Cap, the Northwind Ridge and the Arctic Alaska-Chukotka microplate (AAC) which is of particular interest to this paper (Figure 1a). The AAC includes the North Slope and Seward Peninsula of Alaska, as well as Chukotka, the New Siberian Islands, Wrangel Island and the East-Siberian Shelf of northeast Russia. Similarity of stratigraphic records, magnetic anomalies, basin correlations and seismic profiles comparing northern Alaska to the Canadian Arctic Islands all support an opening of the Canada Basin involving counterclockwise rotation of the Alaskan portion of the AAC away from an original position along the Canadian Arctic Islands with proposed rifting ages from the Early Jurassic to the Early Cretaceous (Embry, 1990; Embry and Dixon, 1994; Grantz and May, 1983; Lawver et al., 2002) (Figure 1b). While there is an abundance of support for the pre-Canada Basin location of northern Alaska adjacent to the Canadian Arctic

Islands, there is little evidence for the original location of Chukotka which is generally assumed to have been attached to the North Slope of Alaska and to have experienced a similar rotational movement. However, under current interpretations regarding the Mesozoic location of Arctic landmasses it is not possible to restore the AAC back to its pre-rift position if it is treated as a rigid, coherent block due to large overlap of pre-rift landmasses and significant space problems during continental drift. Using detrital zircon geochronologic data, Miller and others (2008; 2006) suggested that Chukotka may have been disconnected from the Alaskan portion of the AAC and instead located closer to the Taimyr region prior to formation of the Amerasian Basin. They favor a dextral strike-slip emplacement of Chukotka and Wrangel Island along northern Siberia involving as much as 100% continental extension of the East Siberian Shelf. This pre-rift location of Chukotka ties in with a solution commonly referred to as the “windshield wiper model,” which assumes that Chukotka experienced clockwise rotation away from the Barents Shelf to close the Anyui Ocean concurrently with counterclockwise rotation of the North Slope of Alaska away from the Canadian Arctic Islands. Placing Chukotka closer to the Taimyr Peninsula during the Triassic has particular merit as it alleviates the problem of overlap between the AAC and Greenland created by closing the Amerasian Basin using the rotational model. The Chukotka part of the AAC is assumed to have reached its final position during the Late Cretaceous along the northern Kolyma-Omolon superterrane which deformed passive margin sequences along the eastern edge of the North Asian craton to form the Verkhoyansk Fold-Thrust Belt in the Late Jurassic. The specific location of the suture between the Siberian platform and the Kolyma-Omolon superterrane has been difficult to define, though current interpretations suggest a location

along the Adycha-Taryn fault which borders the Kular-Nera belt along its western boundary, separating it from the Verkhoyansk Fold-Thrust Belt (Figure 2) (Khudoley and Prokopiev, 2007).

Because of access difficulties to the Arctic basins, most studies are limited to research of the landmasses surrounding the Amerasian Basin. More specifically, detrital zircon geochronology has been shown to be a powerful tool for determining sedimentary provenance and for tectonic reconstructions when source regions can be identified (Andersen, 2005; Carrapa, 2010). Studies of modern river systems have shown that along a river transect, inputs of zircon from downstream sources can overprint upstream sources despite higher erosive rates in the headwaters (Cawood et al., 2003). This has important implications for tectonic reconstructions since under this conclusion a sampled detrital zircon population is more likely to have been deposited close to its original source than to have traveled a long distance. Though headwater zircon preservation may diminish downstream compared to more proximal sources, these signatures are present nonetheless and require long-distance transport. Results from a study of detrital zircons from sedimentary rocks in the Verkhoyansk Range of Siberia require transport of zircons for thousands of kilometers as well as persistence of the river responsible for deposition for up to 200 m.y. (Prokopiev et al., 2008). A similar study of marine and fluvial sandstones collected in the Colorado Plateau of the United States Cordillera suggests transport of detrital zircons from source regions in eastern and central Laurentia at times as far away as the Appalachian orogen along a trans-continental river system with headwaters in the southern Appalachian Mountains (Dickinson and Gehrels, 2009). These studies are strong support that long-distance transport of detrital zircons is possible

Figure 2: Generalized tectonic and terrane map of the Kular area. Modified from Urzov et al. (1994), Konstantinovskiy (2007) and Oxman (2003). See Figure 1 for location. The central boxed area indicates the location of Figure 3.

under the right circumstances. With the advent of laser-ablation multicollector inductively coupled plasma mass spectroscopy (LA-MC-ICPMS) the cost of individual zircon grain dating has gone down along with the rise in accuracy, speed and ease of analysis. Recent efforts towards the production of a detrital zircon database of Mesozoic U-Pb ages for landmasses surrounding the Amerasian Basin have been instrumental in revealing its tectonic history (Miller et al., 2006).

The Kular Dome is located at approximately 70.0°N/134.3°E about 135 km south of the Laptev Sea and about 30 km west of the Lower Yana River and Ust' Kuyga, Siberia. In this area, the Kular granite intrudes Paleozoic metasediments and Mesozoic sandstones and greywackes of the Kular-Nera slate belt (Harris et al., 2011, Chapter I, this volume; Parfenov, 1991) (Figure 3). The region can be classified as a gneiss dome defined as an igneous intrusion surrounded by contact metamorphosed strata in a domal structure (Yin, 2004). The intrusion which forms the center of the Kular Dome is an Early Cretaceous (Albian, 111-103 Ma) biotite granite that outcrops in multiple exposures along a northeast-southwest trend (Harris et al., 2011, Chapter I, this volume). The unit surrounding the pluton is an andalusite-bearing metapelite which displays top-down shear away from the pluton involving gently plunging stretched andalusites and mantled porphyroblasts (Harris et al., 2011, Chapter I, this volume). The next units outward from the pluton are Triassic aged sandstones with shale interbeds that display open folds along axes paralleling the long direction of the Kular granite (Figures 2 and 3). This unit continues to be exposed to the southeast until it reaches the Yana fault, an eastward dipping normal fault which separates Triassic units to the west from Jurassic aged greywackes to the east. In the Kular area, the fault location is defined by the Lower

Figure 3: a) Kular field area and location of detrital zircon samples collected for U-Pb geochronology analysis in this study. Geology from Oleshko (1981) and this study. Unit abbreviations indicate age: Meta₁, Paleozoic metasediments; P, Paleozoic sediments; T_{2a}, Anisian; T_{2l}, Ladinian; T₃, Late Triassic; J_{2a}, Alenian; J_{3ox}, Oxfordian; J_{3km}, Kimmeridgian; J_{3t}, Tithonian; K_{gr}, Cretaceous granite. b) Cross section is drawn along profile X-X' seen in Figure 3a.

Yana River for some 30-40 km (Figures 2 and 3). The Jurassic sediments are tightly folded along axes striking approximately east-west and are cut by several southward vergent thrust faults with minor displacement.

The Lower Yana River area, describing the general area east of the Kular Dome surrounding the Yana fault and lower Yana River, has been selected for this study as it is located between the Verkhoyansk Fold-Thrust Belt and the AAC, two areas that are well studied and have abundant detrital zircon U-Pb data for the Mesozoic. A study by Miller et al. (2010) has already compared Triassic detrital zircon geochronologic results from several areas surrounding the Amerasian Basin. Our data will serve as a supplement to the ongoing formation of a comprehensive Triassic dataset currently in preparation, and will add insight from Jurassic samples to the Mesozoic tectonic evolution of the Arctic. For brevity, the Lower Yana River area will be referred to as the Kular area as it only includes data collected along the Yana River east of the Kular Dome.

Stratigraphy of the Kular area:

Geologic maps of northeastern Russia place the Kular Dome and Triassic sequences of the Kular area within the Kular-Nera slate belt, an approximately 900-1200 km long belt of Late Permian-Early Jurassic black shale turbidites which extend from the Laptev Sea in the northwest to the Sea of Okhotsk in the southeast (Konstantinovskiy, 2007; Oxman, 2003; Parfenov, 1991). These sequences are thought to have been deposited as continental basin fan deposits which formed after Middle to Late Paleozoic

rifting (Oxman, 2003; Parfenov, 1991). Unconformably above the black shales are Middle to Late Jurassic deposits of the eastern Kular area and In'Yali Debin terrane, which is located directly east of Kular-Nera belt in the south (Figure 1a), and the Polousnyi synclinorium which is directly east in the north (Figure 2). To the west, the Kular-Nera slate belt is separated from the Verkhoyansk Fold-Thrust Belt by the Adycha-Taryn fault zone (Figure 2).

In the Kular area, the relevant stratigraphy for this geochronologic study includes Triassic sandstone sequences of the Kular-Nera slate belt west of the Yana fault and tightly folded Jurassic greywackes within the Polousnyi Synclinorium east of the Yana fault (Figure 3). Russian geologic maps further separate these units by age as determined by paleontology (Oleshko, 1981; Urzov et al., 1994). These ages are supported by the detrital zircon data described later in this text and were therefore adopted in our updated maps for the area. Russian maps name the units based on their ages as T_{2a} (Anisian), T_{2l} (Ladinian), T_3 (Late Triassic), J_{3ox} (Oxfordian), J_{3km} (Kimmeridgian) and J_{3t} (Tithonian) (Oleshko, 1981). While ages of these units have been defined based on their fossil content, which are supported by detrital zircon data, all observed Triassic units were lithologically similar and all observed Jurassic units were also lithologically similar within the field area. Eight thin sections were prepared using three samples from T_{2l} and five from J_{3ox} , though several outcrops were studied in the field from all mappable units. Unfortunately, in-place sedimentary outcrop was difficult to find away from the Yana River, so most data collection and observation was along a transect of this river from Ust' Kuyga to the Kyuchus mining operation near the confluence with the Kyuchus tributary (Figure 3). Due to the similarities in lithology between all Triassic units and all Jurassic

units, for descriptive purposes, all mapped units will be referred to as either Jurassic greywackes or Triassic sandstones.

Triassic sandstones found west of the Yana fault show a general composition of 25% lithics with subequal proportions of volcanic and sedimentary fragments, 35-40% quartz, mostly monocrystalline with few polycrystalline grains, 20-25% feldspars and 2-15% opaque iron oxide material. High volcanic content in Triassic sandstones is indicative of a source area for sedimentation from the Siberian Traps to the northwest as this area represents the only significant nearby volcanic system during the Triassic. Total biotite with minor associated muscovite may locally comprise as much as 10% of sample volume, though is in general much less common. All grains are generally medium sized and angular with poorly defined grain boundaries. Laminated black shales and red colored mudstone interbeds, generally less than one millimeter thick, are also common and often show thin, soft-sediment, fluid-supported slump folds with wavelengths of one meter or less, rip-up clasts of partially lithified mud and burrows. Three Triassic units have been mapped in our field area previously based on their paleontological ages of T_{2a} , T_{21} and T_3 with thickness variations from 1.5 to 2.5 km (Oleshko, 1981; Urzov et al., 1994). These units generally dip gently to the southeast but are sometimes vertical (Figure 4a) and also commonly display near vertical to vertical pencil cleavage related to formation of the Verkhoyansk Fold-Thrust Belt during the Late Jurassic. A ternary plot of monocrystalline quartz, feldspar and total lithic content (QmFLt) based on multiple 300-point count analyses of thin sections of Triassic samples yields a magmatic arc as the most likely provenance according to diagrams developed by Dickinson et al. (1983) (Figure 5).

Figure 4: a) Vertical bedding in Triassic sandstones west of the Yana River. Two separate shear bands can be seen cutting the strata. View to the north. Cleavage at this location is 082/50 S. b) Flute casts commonly seen along the bottom bedding surface of Jurassic strata along the Yana River. Orientations of the casts suggest an approximate paleocurrent direction of 032° upon bed restoration.

Figure 5: Probability density plots and ternary provenance diagrams for Kular data. Ages listed for each sample are inferred to be the maximum possible depositional age for each unit and are based on overlap of at least three overlapping ages within error as calculated by AGEPIK (Gehrels and Pullen, 2010). Ternary plots are based on 300-point counts from thin section samples and plotted in fields defined by Dickinson et al. (1983). Abbreviations for the ternary diagrams are: Qm, monocrystalline quartz; F, Feldspars; L_t , total lithics. Provenance field abbreviations are: CB, continental block; MA, magmatic arc; RO, recycled orogen; m, mixed. Sample locations seen in Figure 3a.

Jurassic units east of the Yana fault are finer grained than Triassic units and have a high enough percent mud matrix to be classified as lithic greywackes. Clasts are angular and poorly sorted with grain sizes ranging from less than 30 μm to 0.5 mm. Samples are composed of 20-35% matrix, 5-10% lithic fragments with subequal proportions of volcanic grains and chert, 20-30% quartz, mostly monocrystalline, 30-35% feldspars, and minor amounts of white mica, biotite and opaque iron oxide. Bedding of Jurassic units was commonly massive with beds 5-6 m thick showing abundant laminated black shale and coal interbeds and occasional conglomerate lenses up to 2 m in diameter. Flat, rounded rip-up clasts similar to those found in Triassic units were also common along both the top and bottom of beds in Jurassic units. Reverse grading was visible in multiple locations along with prevalent slump-folding suggesting the likelihood of high-energy grain-flow deposition of turbidite sequences. Impressive flute casts several cm in thickness were also commonly visible on the underside of tilted layers suggestive of a paleocurrent direction of 032° upon restoration of bedding (Figure 4b). Four previously mapped units are adopted for this study based on previously published paleontological ages and detrital zircon ages from J_{3ox} , J_{3km} and J_{3t} occurring within our field area. These units are exposed as open folds striking approximately east-west within northward vergent imbricated thrust packages east of the Yana fault (Figure 3). Unit thicknesses range from 0.6 to 1.3 km (Oleshko, 1981). A QmFLt plot based on multiple 300-point count analyses of thin sections suggests that a continental source is most likely for Jurassic samples (Dickinson et al., 1983) (Figure 5).

Geochronology:

Geochronologic analysis of detrital zircons was performed on seven samples (two Triassic, five Jurassic) collected along the Yana River south of Ust' Kuyga (Figure 3) using LA-MC-ICPMS at the University of Arizona LaserChron Center. Samples were crushed and separated using standard gravimetric and magnetic separation techniques at West Virginia University. Following separation, grain mounts were created and polished at the LaserChron Center and were imaged using reflected light and cathodoluminescence (CL) (Appendix 3). No fewer than 100 grains per sample were randomly ablated using a 35 μm diameter laser. For every five sample grains ablated, one standard grain (also added to each mount) was targeted. For this study, standard R33 was used, which yields an ID-TIMS age of 419.3 ± 0.4 Ma (Black et al., 2004). Individual zircon grain ages were determined using $^{238}\text{U}/^{206}\text{Pb}$ ratios for grains younger than 1.4 Ga and $^{207}\text{Pb}/^{206}\text{Pb}$ ratios for grains older than 1.4 Ga due to higher precision within these respective ranges (Gehrels and Pullen, 2010). Analyses with greater than 30% discordance or greater than 5% reverse discordance between $^{238}\text{U}/^{206}\text{Pb}$ and $^{207}\text{Pb}/^{206}\text{Pb}$ ages were discarded. Of the grains ablated, 87% had a U/Th ratio less than 3 indicating a magmatic source (Hoskin and Black, 2000). All results are listed in Appendix 4. For more detailed information on the analytical process, see review of operating procedure in Gehrels and Pullen (2010) and Gehrels et al. (2006).

Results from geochronologic analysis of the Kular samples are listed in Appendix 4 and shown in probability density plots in Figure 5. Detrital zircon data from the Kular area are plotted in Figure 6 along with data compiled from previous studies in areas

Figure 6: Age ranges of detrital zircons collected from locations surrounding the Amerasian Basin. Vertical dark gray boxes show age ranges compiled from literature and calculated with AGEPIK (Gehrels and Pullen, 2010). Data are ordered west to east from left to right with Triassic data on the far left and Jurassic data on the far right (locations shown in Figure 1). Light gray lines within age ranges show peak ages within their respective populations. Wide light gray boxes, labeled on the right, show potential granitic sources for the detrital zircons displayed. Kular and In'Yali Debin (In'Y) data from this study, and all other data, are listed in Appendix 5 and were compiled from the following sources: **Triassic data:** Verkhoyansk (Verk) from Prokopiev et al. (2008), Chukotka (Chuk), Wrangel Island (Wran), Lisburne Peninsula (Lisb), Sadlerochit Mountains (Sad), Sverdrup Basin AE1 (AE1) and Sverdrup Basin AE2 (AE2) from Miller et al. (2006). **Jurassic data:** Verkhoyansk (Verk) from Prokopiev et al. (2008), Stolbovoi Island (Stol), Chukotka (Chuk) and South Anyui Zone (SAZ) from Miller et al. (2010). Magmatic source ages compiled from Miller et al. (2008), Miller et al. (2006), Scarrow et al. (2002), Prokopiev et al. (2008) and references listed in GSA data repository item 2008177.

surrounding the Amerasian Basin (Appendix 5). Statistically likely age peaks and ranges (those which display greater than three overlapping ages within error) for each sample were chosen using the Arizona LaserChron Center AGEPICK program. AGEPICK uses calculated weighted mean ages, MSWD and uncertainty of individual grain ages to objectively determine peak ages and age ranges for detrital zircon samples (Gehrels and Pullen, 2010). For Kular data analyses any age errors from the original analysis that had a 1σ less than 2% were adjusted up to 2% based on reproducibility of standards (McClelland, pers. comm., 2011). Provenance analyses were also performed using eight thin sections from the Kular area sedimentary units.

All samples were compared using Kolmogorov-Smirnov (K-S) tests using error from the calculated cumulative distribution function (Gehrels and Pullen, 2010; Press et al., 1992). Output values from K-S tests compare the difference between two distributions as a measure of the vertical separation of their cumulative probability plots. The output P-value from a K-S test is a measure of the probability that the measured difference between the two samples is the product of random sampling of the same parent population. P-values of zero imply that any similarity between the two samples is likely due to random chance. P-values near the maximum value of 1.0 suggest that there is low chance that the similarity is due to random chance alone and that the two populations are likely from the same “parent,” or in this case magmatic source. Because of the calculated P-value among Triassic samples of 1.000 (Tables 1a and 1b), these samples have been combined for subsequent analysis into one plot diagnostic of Triassic sandstones (Figure 6). For the Jurassic samples, 08DH02, 08DH03 and 08DH30a were determined to be similar and samples 08DH29a and 08DH32 were determined similar (Tables 1a and 1b).

Table 1: a) Kolmogorov-Smirnov (K-S) test results for all samples collected from the Kular area. b) K-S test results for all samples from the Kular area with ages younger than 229 Ma removed (age of the youngest Triassic zircon). Zircons younger than 229 Ma are not considered as they represent additions based on depositional age. See Figure 3 for sample locations.

a:		Tr		Jr					
Tr		08DH01a		08DH33	08DH02	08DH03	08DH29a	08DH30a	08DH32
		08DH01a	08DH33						
08DH01a	08DH33	1.000							
08DH02	08DH03	0.001	0.003						
08DH03	08DH29a	0.006	0.013	0.769					
08DH29a	08DH30a	0.000	0.000	0.002	0.000				
08DH30a	08DH32	0.026	0.017	0.983	0.898	0.013			
08DH32		0.000	0.000	0.008	0.027	0.403	0.024		

b:		Tr		Jr					
Tr		08DH01a		08DH33	08DH02	08DH03	08DH29a	08DH30a	08DH32
		08DH01a	08DH33						
08DH01a	08DH33	1.000							
08DH02	08DH03	0.006	0.003						
08DH03	08DH29a	0.106	0.074	0.936					
08DH29a	08DH30a	0.000	0.000	0.001	0.001				
08DH30a	08DH32	0.005	0.003	0.827	0.939	0.016			
08DH32		0.000	0.000	0.001	0.017	0.791	0.009		

The main statistical (P-value) difference between individual Jurassic samples seems to be the contribution of grains older than 1.0 Ga (Figure 5).

Combined datasets for Kular Triassic and Jurassic detrital zircon peak ages were compared to similar datasets for regions surrounding the Amerasian Basin that potentially shared source areas during their respective periods of deposition. Combined Triassic data show peak ages at 242, 301, 370, 501, 789 and 1851 Ma with age ranges of 224-337, 341-387, 413-568, 738-825 and 1759-2011 Ma. Combined Jurassic data show peak ages at 167, 203, 255, 269, 287, 321, 339, 1921, 2544 and 2739 Ma with age ranges of 147-210, 223-396, 1639-2183 and 2281-3116 Ma. Age windows common to both Triassic and Jurassic Kular samples occur in the ranges of 223-396 Ma and 1639-2183 Ma. Jurassic samples differ from Triassic samples in that they have young zircon ages at 147-210 Ma which are absent from Triassic samples due to depositional timing, but also display differences in older populations of zircons that can't be explained by timing of deposition alone (Figure 5). All Jurassic samples show a range of very old zircons of 2200-3100 Ma that is not evident in the Triassic samples. Jurassic samples are also missing a Late Proterozoic-Early Paleozoic (413-825 Ma) population of zircons that are abundant in the Triassic samples.

Discussion:

When possible, age ranges and peak ages using complete datasets from samples in the literature were calculated with AGEPICK and compiled into sets of representative age ranges for each location (Appendix 5, Figure 6). Most representative age ranges are

based on multiple samples, though some were based on a single sample. Detrital zircon populations were compiled from the literature from multiple sources surrounding the Amerasian Basin and are described in the following sections, though zircons collected near Pevek, Russia and along the Dyanishka River within the Verkhoyansk Fold-Thrust Belt are most relevant to this discussion.

Zircons from Chukotka Triassic 5.5 km thick sequences of distal turbidites near Pevek, Russia were dated in Miller et al. (2006) and were supplemented with Jurassic zircons from nearby massive, well-cemented arkosic sandstones collected north of Bilibino to Pevek (Miller et al., 2008). Pennsylvanian-Jurassic detrital zircon samples diagnostic of Siberian cratonic passive margin sequences collected from the central Verkhoyansk Fold-Thrust Belt are described in greater detail in Prokopyev et al. (2008) and Miller et al. (2006). Units of the Verkhoyansk Fold-Thrust Belt are well exposed along the Dyanishka River just east of the Vilyui graben. Triassic samples from this area were from the Tolbon and Khedalichen Formations which were previously dated as Anisian-Ladinian and Carnian-Norian based on faunal data (Gradstein et al., 2004).

Triassic detrital zircon data:

Results from the Kular area are in agreement with interpretations by Miller and others (2006, 2008) that detrital zircon data from Chukotka and western Alaska place these areas more proximal to the Taimyr Peninsula and the Verkhoyansk Fold-Thrust Belt than to the Canadian Arctic during the Early Mesozoic. This observation is based on abundance of detrital zircons in Chukotka likely sourced from Taimyr granitoids and higher similarity of detrital zircon populations between Chukotka and Russian areas than

between Chukotka and Laurentian areas (Figure 6). In Triassic samples, Chukotka and western Alaska display a different range of zircon ages than the Verkhoyansk Range while Triassic data from Kular shows similarities to both Chukotka and Verkhoyansk (Table 2). Specifically, both Kular and Chukotka Triassic samples have zircons in age ranges of 225-260 Ma and 730-850 Ma that are absent from Verkhoyansk Triassic samples (Figure 6). However, both Kular and the Verkhoyansk Range lack zircons in age ranges of 800-1000 Ma and 1000-1315 Ma that are present in Triassic Chukotka samples. The presence of Permo-Triassic zircons in Kular and Chukotka is significant since granitic rocks of this age are uncommon in Russia. Potential source areas for zircons of this age are the southern Taimyr Mountain range where doleritic sills aged 220-230 Ma and 250 Ma A-type granites are common (Walderhaug et al., 2005) and the widespread Siberian Traps south of Taimyr which contain mafic volcanics with mean ages of approximately 250 Ma (Dalrymple et al., 1995; Reichow et al., 2002; Renne and Basu, 1991). High volcanic fragment content seen in Kular area Triassic sandstone thin sections is further evidence of a Siberian Trap magmatic source for these samples. Zircons of these ages were likely carried eastward along a northerly river system which supplied clastic material to the northeastern part of the platform, the Kular area and to the Polousnyi synclinorium, but not to the more southern Verkhoyansk region which was fed mostly by the paleo-Lena River (Prokopyev et al., 2008). These ages are also absent from Sadlerochit Mountains and Sverdrup Basin data (Miller et al., 2006) despite other similarities to Triassic data from the AAC microplate. Another difference in Triassic detrital zircon data is the lack of 730-850 Ma zircons in the Verkhoyansk Range, but their presence in both Kular and Chukotka. In Miller et al. (2006), these zircons are suggested

Table 2: Presence or absence of dated zircons within specific age ranges from locations compared in this study for both Jurassic and Triassic datasets. Refer to Figure 1 for locations. See text and Figure 6 for literary references. SAZ refers to the South Anyui Zone.

TRIASSIC	225-260 Ma	730-850	850-1000 Ma	1000-1315 Ma
1: Verkhoyansk	No	No	No	No
2: Kular	Yes	Yes	No	No
6: Chukotka	Yes	Yes	Yes	Yes

JURASSIC	225-260 Ma	730-850	850-1000 Ma	1000-1315 Ma
1: Verkhoyansk	Yes	No	No	No
2: Kular	Yes	No	No	No
6: Chukotka	Yes	No	No	No
5: SAZ	Yes	No	No	No
4: Stolbovoi	Yes	No	No	No
3: In'Yali Debin	Yes	No	No	No

to have also been from the Taimyr region. Another potential source for zircons of this age is the Baikalia region (Transbaikalia and Prebaikalia) to the south which is known to have granitic intrusions ranging in age from 772-831 Ma, though the lack of zircons of this age in the Verkhoyansk Range suggests that the Taimyr region is a more likely source for Chukotka and Kular. Zircons in the range of 850-1000 Ma and 1000-1315 Ma are prevalent in Triassic Chukotka samples, but are conspicuously absent from both Kular and the Verkhoyansk Range. Interestingly, zircons of this age were also seen in Triassic samples from Wrangel Island, western Alaska (Lisburne Hills) and eastern Alaska (Sadlerochit Mountains and the Sverdrup Basin) (Figure 6). Though all three areas show zircons in the range of 800-1800 Ma, differences in younger populations of zircons (less than 400 Ma) suggest that Chukotka and western Alaska may have shared sedimentation sources that were different from those feeding eastern Alaska during the Triassic. The presence of zircons from 800-1800 Ma in Triassic samples from Chukotka, Wrangel Island and western Alaska suggests a connection to 900-1700 Ma igneous intrusions found in Baltica that is further supported by deposition in these areas across upper Paleozoic platformal sediments underlain by Neoproterozoic rocks of the Timanides also associated with Baltica (Bingen et al., 2008 and references within; Miller et al., 2010). Triassic samples from Kular, Chukotka and Verkhoyansk all contain zircons in the range of 1600-2100 Ma which match basement ages from the Siberian craton. Similarities between all three sites (Chukotka, Kular and Verkhoyansk) suggest that they shared some sedimentation sources during the Triassic, though Chukotka and to a lesser extent, the Kular region, seem to have been fed by more varied sources as they contain zircons from age ranges not seen in the Verkhoyansk Range. These

interpretations, including the similarity of detrital zircon ages seen in Chukotka and igneous ages from the Taimyr Peninsula, put Chukotka closer to the Russian shoreline prior to development of the Amerasian Basin than to the Canadian Arctic as is suggested by the rotational model for development of the Canada Basin.

Jurassic detrital zircon data:

Deposition of the Kular Jurassic units must have occurred following initiation of collision between the incoming Kolyma-Omolon superterrane and the Siberian platform. A stratigraphic unconformity between Early and Late Jurassic units (Parfenov, 1991) likely represents this change in structural setting, which is supported by differences between Triassic and Late Jurassic Kular detrital data. A potential source for the 162 Ma peak seen in Jurassic samples is the Uyandina-Yasachnaya volcanic arc which developed in the Late Jurassic on the margin of the Kolyma-Omolon superterrane. The Kular area was situated closer to the colliding terrane than was the Dyanishka River (Verkhoyansk in Figure 1a), which remained more insulated from the effects of collision with the Kolyma-Omolon superterrane in the Jurassic. Because of this, Jurassic zircon signatures in the Kular region are potentially related to incoming arc signatures of the Kolyma-Omolon superterrane with zircons having likely been transported to the Lower Yana region as air fall deposits. Mixing in trench sediments at the front of the arc is unlikely because of a lack of stratigraphic evidence for mixing, consistency of zircon grain ages older than 229 Ma between Triassic and Jurassic strata and lack of volcanic material in Jurassic strata. A study of detrital zircons collected from the Eocene-aged Geste Formation of the Central Puna Plateau within the Andean orogenic belt has shown that air

fall zircons from distant eruptive centers may be found in ash-free strata (DeCelles et al., 2007) and provides a potential analogue for deposition of air fall zircons within ash and volcanic fragment-free strata deposited near the Uyandina-Yasachnaya volcanic arc ahead of the Kolyma-Omolon superterrane. Jurassic aged samples collected from Jurassic units in the In'Yali Debin Synclinorium located directly east of the central Kular-Nera slate belt (Figure 1a), show a nearly identical zircon age distribution to the Kular area samples despite being located some 650 km to the southeast (Figure 6), suggesting the likelihood of a similar arc source with transport of zircons as air fall material. Western zircon source areas for older detrital grains are compatible with the interpretation that the Kular-Nera belt was a series of eastward deposited continental-slope fans (Konstantinovskiy, 2007; Oxman, 2003), which likely also applies to deposition within the In'Yali Debin terrane. In'Yali Debin sediments are described as synorogenic and are inferred to have been deposited synchronously with collision of the Kolyma-Omolon superterrane from the east (Oxman, 2003), which could be a potential source for the Late Jurassic aged zircons found both in the In'Yali Debin and Kular as previously described. Differences in the detrital signal strength between the In'Yali Debin and Kular areas may be related to their large geographical separation. Both the In'Yali Debin terrane and Kular lack a 450-550 Ma range of zircons seen in the Verkhoyansk Range which is attributed to a source in the central Asian fold belt, supporting a disconnect between parts of the paleo-Lena River and the Kular Nera terrane caused by deformation associated with the impending Kolyma-Omolon superterrane collision.

Triassic to Jurassic transition:

The differences in Triassic and Jurassic Kular detrital signatures suggest a large disturbance in the sedimentation system for northern Russia between 167 Ma and 242 Ma. While Triassic and Jurassic detrital data are relatively consistent in the Dyanishka River area of the Verkhoyansk Range with the only major changes being the expected addition of younger signatures to the Jurassic samples and the loss of zircons older than 2300 Ma, the Kular and Chukotka Triassic detrital signatures are very different from their Jurassic counterparts despite close proximity of sample collection (Figure 6). A K-S test of only Kular ages older than 229 Ma (the age of the youngest Triassic zircon dated) from both Triassic and Jurassic samples supports two different populations based on calculated P-values (Table 1b). P-values from 0.713-0.939 were calculated between all pairs of Jurassic Kular samples and values of 1.000 were found between the two Triassic Kular samples while the highest P-value between any Triassic and Jurassic Kular sample pair was 0.026 (Table 1a). Upon removal of all zircons with ages less than 229 Ma (the Jurassic input pulse), the highest P-value when comparing Jurassic Kular samples to Triassic Kular samples was 0.106 and statistical similarities were only seen between Triassic Kular samples and one Jurassic Kular sample (08DH03) (Table 1b). If these units had received sediment from similar sources during both the Triassic and Jurassic, as in the continual transport of sediment along the paleo-Lena River in the Dyanishka area (Prokopiev et al., 2008), Triassic aged signatures from Jurassic Kular samples would be similar to those seen in the Triassic Kular samples. However, Triassic samples collected from the Kular area include a dominant 400-500 Ma signature and a smaller 730-850 signature that are completely absent from Jurassic samples collected from the same area

(Figure 5 and 6). These age ranges are most likely representative of source regions in the Central Asian foldbelt and Aldan Shield which were cut-off from deposition in the Kular area and In'Yali Debin (which also lacks Central Asian foldbelt and Aldan Shield zircon signatures in Jurassic samples) by the Late Jurassic (Figure 1a) due to compressional deformation to the west in the Verkhoyansk Fold-Thrust Belt, blocking eastward flow input from the paleo-Lena River.

Though Taimyr and Baltica zircon ages from 800-1800 Ma are common in Triassic Chukotka and western Alaska samples, suggesting close proximity between these areas in the Triassic, by the Jurassic none of the samples from similar geographic locations (South Anyui suture, Chukotka, Verkhoyansk, Kular, Stolbovoi Island, and In'Yali Debin) display zircons in this range. This suggests that by the Jurassic, these areas had likely become more closely linked geographically than they were in the Triassic and that they were also separated from the source of the 800-1800 Ma zircons by this time. Chukotka, Verkhoyansk and the Kular areas are, however, similar in terms of other age distributions and prominent peak ages in Triassic samples (Figure 6) indicating some similarity in sedimentation systems during the Triassic and further evidence that Chukotka was not separated from northern Russia during the Triassic as is suggested by the rotational model. Incorporating Jurassic detrital zircon data into emplacement models for Chukotka suggests that by the Tithonian, Chukotka was situated north of the Kular area, which is in agreement with Miller and others' (2008) conclusion that the South Anyui suture must have begun to form by the Tithonian, closing the Anyui Ocean. The youngest age in Kular Jurassic sediments is approximately 160 Ma and Kular Jurassic data matches Chukotka Jurassic data precluding separation of the two areas by an oceanic

basin by the Late Jurassic despite likely separation in the Triassic. Further evidence supporting closure of the South Anyui Ocean by the Tithonian is the presence of zircons with likely source areas from south of the South Anyui suture (1.7-2.1 Ga) found in Late Jurassic samples from Chukotka (Miller et al., 2008). Metamorphic mineral assemblages from ophiolitic complexes in the Chersky Range also indicate a possible collisional period between Chukotka and northern Russia as early as 170-174 Ma (Oxman, 2003; Parfenov, 1991).

Kular and Chukotka appear to have similar detrital zircon signatures in the Jurassic (Table 2) despite differences in the Triassic. Neither have zircons older than 2200 Ma in Triassic samples, then both have zircons ranging in age of 1600-2800 Ma with wide age ranges older than 2200 Ma and a matching age peak at 1920 Ma in Jurassic samples, matching Aldan Shield ages seen in Triassic Verkhoyansk data. This means that the change in sedimentation source that added older zircon populations by the Late Jurassic (possibly Aldan Shield or equivalent basement) affected both Kular and Chukotka suggesting connection to a sedimentation system that had previously only reached the Verkhoyansk area. The absence of this 2200-3000 Ma signature in the Verkhoyansk Jurassic samples suggests both a change in the paleo-Lena River deposition as this age range was present in Triassic samples and also that the paleo-Lena was not responsible for transport of Aldan Shield zircons to Chukotka and the Kular area. It could be that as collision with the Kolyma-Omolon superterrane began, it formed a northwest-southeast oriented watershed where sediments from the Aldan Shield could have travelled up the northeast edge of the continent, bypassing the paleo-Lena River. So in the Triassic, this extra sedimentation source was likely just moving eastward into the

basin and most sediments to Chukotka and Kular were coming through the Verkhoyansk area along the paleo-Lena River (Prokopiev et al., 2008). Following Jurassic accretion, this new pathway from the Aldan Shield could have bypassed the paleo-Lena River to the east and supplied an additional older population to both Chukotka and Kular, though both would still receive paleo-Lena sediments.

Tectonic implications of detrital zircon data:

Extensive work performed around the Canada Basin supports a Late Jurassic-Early Cretaceous opening for the basin which is at odds with detrital data presented here if the Alaskan and Chukotkan portions of the AAC are treated as a coherent block during opening of the Canada Basin. Resolutions to this problem involve either rifting of the AAC away from the Canadian Arctic Islands earlier, during the Middle to Late Jurassic as one coherent block similar to the rotational model (Figure 1b), or separation of the Alaskan and Chukotkan portions of the AAC which would allow Chukotka to be near the Kular area during opening of the Canada Basin. Due to the strong support for Late Jurassic-Early Cretaceous opening of the Canada Basin involving rifting of the North Slope of Alaska away from the Canadian Arctic Islands [evidence summarized in preface of this document, Lawver and Scotese (1990) and Lawver et al. (2002)] we feel that the tectonic movement pathway for Chukotka was independent of the Alaskan portion of the AAC in the Mesozoic.

Detrital zircon data from these areas also suggest that the eastern margin of the Siberian craton and the location of the downgoing slab that resulted in suturing of incoming terrane material to the Verkhoyansk passive margin would have been further

east of its presently interpreted location along the Adycha-Taryn fault west of the Kular-Nera belt. The similarities seen between the Kular and Verkhoyansk data suggest that they were sedimentologically linked during the Triassic and into the Jurassic and not separated by a regional suture. Other interpretations placing a large thrust fault (the Yana fault) as a suture of separate terranes just east of the Kular Dome are likely also in error since the chronologic relationship of units across the fault support normal offset and the detrital data from this study link the Verkhoyansk Range to the Jurassic strata east of the Yana fault. Field investigation further supports this conclusion since evidence of extensional deformation is abundant in the form of stretched andalusites, top-down shear away from the pluton (mostly seen in mantled porphyroblasts of oriented thin sections) and gently southeast dipping S_2 foliations south of the Kular pluton (Harris et al., 2011, Chapter I, this volume). Similar detrital zircon signatures between Triassic samples from the Kular area and the In'Yali Debin synclinorium (detrital zircon data from Triassic samples of the In'Yali Debin terrane excluded from this document at the request of Andrei Prokopiev) further dispute the existence of a large suture between the Kular-Nera slate belt and the eastern Polousnyi-Debin terrane.

New model for development of the Amerasian Basin:

Based on the available detrital zircon data for the Arctic an alternative model for the formation of the Amerasian Basin is proposed (Figure 7). It should be noted that the reconstruction presented here is based mostly on detrital zircon data presented in this paper and the detailed stratigraphic, paleontological, paleomagnetic and geophysical studies necessary for verification are beyond the scope of this paper.

a:

Triassic

b:

Late Jurassic

Caledonide orogen

Siberian Trap magmatism

passive margin sedimentation

Fold-thrust belts

Okhotsk-Chukotka Volcanic Belt
(Middle Albian to Early Campanian)

Northern Belt magmatism
(Early Cretaceous)

Main Belt magmatism
(Late Jurassic to Early Cretaceous)

Subduction zone*
Divergent boundary*
Transform boundary*
Normal fault*

*All plate boundaries and fault locations are dashed when approximated

Figure 7: Schematic Mesozoic to present plate reconstruction for the motion of various continental fragments of the Arctic, see text for discussion. Alaska terrane accretion history from Plakfer and Berg (1994), evolution of Alaska chapter 33, South Anyui Suture info from Sokolov et al. (2009), Russian terrane accretionary history from Parfenov et al. (2009) and bathymetric images and approximate locations of the Alpha Ridge and Mendeleev Ridge are from Jakobsson et al. (2008) and Dove et al. (2010).

Magmatic arc ages are from Akinin and Miller (2011) and Layer et al. (2001).

Abbreviations are: AA, Arctic Alaska; AR, Alpha Ridge; CC, Chukchi Cap; Ch, Chukotka; Kb, Koyukuk Basin; KO, Kolyma-Omolon superterrane; KOR, Koryak-Kamchatka tectonic collage; Ky, Koyukuk arc; LR, Lomonosov Ridge; MR, Mendeleev Ridge; Okh, Okhotsk terrane; PA, Penzhina-Anadyr tectonic collage; SAZ, South Anyui Suture zone; SP, Seward Peninsula; VFB, Verkhoyansk Fold-Thrust Belt; VK, Verkhoyansk tectonic collage; WCT, Wrangellia composite terrane; YCT, Yukon composite terrane.

In the Triassic (Figure 7a), the AAC formed a continuous landmass with the North Slope of Alaska situated against the Canadian Arctic Islands and Chukotka near Taimyr. During this time, the Kolyma-Omolon and Okhotsk terranes were still separated from the North Asian craton by ocean while a passive margin sequence developed along the eastern coast of paleo-Russia. In this model, the Siberian Shelf is noticeably less extensive in the Triassic as compared to modern conditions as it has yet to experience Jurassic and Cretaceous sedimentation and extension responsible for its eventual extent (Vinogradov et al., 2006). Pre-extended continental crust which will evolve into the Alpha and Mendeleev Ridges in the Late Jurassic was also situated within the AAC at this time. During the Early to Late Jurassic, Chukotka experienced dextral strike-slip motion across northern Russia, bringing Chukotka to a location more proximal to the Kular area and gradually closing the Anyui Ocean as a transpressional basin to form the South Anyui suture (Figure 7b). By the Late Jurassic, collision between the Kolyma-Omolon superterrane, Okhotsk terrane and the passive margin sequences of eastern Russia formed the Verkhoyansk Fold-Thrust Belt. The Canada Basin had also begun formation via rifting between the North Slope of Alaska and the Canadian Arctic Islands by this time. Extension between Chukotka and the North Slope of Alaska during rotation is invoked in this model to explain formation of the Alpha and Mendeleev ridges via rifting of continental crust with a component of strike-slip deformation. By the Late Cretaceous (Figure 7c), Chukotka had completely closed the Anyui Ocean via transpression to form the South Anyui suture zone. Final emplacement of Chukotka must have occurred by 106 Ma as earliest volcanic deposits of the Okhotsk-Chukotka Volcanic Belt of this age overlap the suture (Figure 7c) (Akinin and Miller, 2011).

Spreading in the Canada Basin also caused collision in Alaska which had recently formed by a complex series of accretion events. From the Eocene to present (Figure 7d), the Gakkel Ridge opened as the northern trace of the Mid-Atlantic Ridge, separating the Lomonosov Ridge from its initial location along the Barents Shelf. A right-lateral transform fault along the northern boundary of the Siberian Shelf is invoked to explain motion associated with opening of the Eurasian Basin, though the location of this fault near Alaska is uncertain. Evidence from the eastern Seward Peninsula as well as the Hope and Norton Basins are supportive of north-south directed, right-lateral deformation in the Cenozoic (Dumitru et al., 1995).

In the proposed model, the AAC is broken into two separate pieces, the northern Alaska and Seward Peninsula portion and the Chukotka portion, which move independently of each other. Previous work along the North Slope of Alaska and the Canadian Arctic Islands provides a compelling case for rotational opening of the Canada Basin during the Late Jurassic-Early Cretaceous about a pole south of the Mackenzie Delta that is supported in this reconstruction (Carey, 1955; Carey, 1958; Lawver et al., 2002; Lawver and Scotese, 1990). The suggestion that the Chukotka portion of the AAC may have moved independently of the northern Alaska portion is not new, though the model presented here is at odds with the previously suggested movement pathway of the “double windshield wiper” model in which Chukotka experienced clockwise rotation away from its original location along the Barents Shelf. Our reconstruction places Chukotka and the New Siberian Islands along the Lomonosov Ridge as it was restored along the Barents Shelf. We also have a sliver of continental crust between the North

Slope of Alaska and Chukotka in order to maintain detrital deposition pathways and basement consistency throughout the AAC.

The reconstruction proposed here is supported by the following observations:

- 1: The detrital data presented in this paper suggests that Chukotka was likely separated from the Siberian craton and Kular area during the Early Triassic, but by the Tithonian had become more closely linked with the Kular and Verkhoyansk areas.
- 2: Trap magmatism prevalent in the New Siberian Islands and Chukotka places these landmasses near the Siberian margin by approximately 250 Ma and supports close proximity between these locations (Kuzmichev and Pease, 2007).
- 3: Dextral north-south oriented strike-slip faults associated with Early Cretaceous northeast-directed collisional features present in the western Anjou Islands of the New Siberian Islands (Kos'ko and Korago, 2009; Kuzmichev, 2009) support eastern translation of Chukotka along the Siberian continent in the Neocomian. Further evidence of this translation includes dextral strike-slip deformation of collisional features in the South Anyui suture zone and clockwise rotation of both the Vurguveem ophiolitic subterrane and rocks of Lower Cretaceous age (Sokolov et al., 2009; Sokolov et al., 2002).
- 4: Extensive evidence summarized in Amato et al. (2009) and Miller et al. (2006) supports the pre-Amerasian Basin location of components of the AAC in the Early Triassic. This evidence includes Nd and magmatic similarities between components of the AAC, the Caledonides and Taimyr, consistent 0.95-1.2 Ga plutonism intruding basement rocks in Novaya Zemlya, Franz Joseph Land and Severnaya Zemlya (Lorenz et al., 2011), faunal data and detrital zircon

depositional data. Evidence supporting the initial connection between components of the AAC in the Paleozoic include a distinctive carbonate basement cover sequence, prevalent 1.1-2.0 Ga detrital zircons throughout the AAC related to a consistent basement sequence, faunal data and widespread coeval Late Proterozoic magmatism in parts of the AAC, Scotland, the Taimyrs and the Scandinavian Caledonides (Amato et al., 2009; Dumoulin et al., 2002; Miller et al., 2006).

5: Closure of the Anyui Ocean in the Late Jurassic as a transpressional basin is in agreement with studies by Sokolov and others (2009; 2002) in which evidence of dextral strike-slip deformation in the late stages of collision provides an explanation for the absence of a prominent mountain range along the South Anyui suture while providing a means for ophiolite obduction. Nearby collisional areas such as the Verkhoyansk Fold-Thrust Belt, Chersky Range and Brooks Range of Alaska were all formed by basin closure near Siberia in the Late Mesozoic and all resulted in extensive high-relief mountain ranges. No such mountains exist along the entirety of the South Anyui suture, and so the collisional style was likely of a different nature than the areas previously described. For the South Anyui suture, a hybrid strike-slip/collisional closure of the basin involving oblique subduction is proposed (Figures 7b and 7c).

6: Numerous seismic and piston coring studies conducted across the Alpha and Mendeleev Ridges have provided robust datasets useful for determining the composition and formational history for these areas (Forsyth et al., 1986; Grantz et al., 2001; Jackson et al., 1986; Jokat, 2003; Langinen et al., 2009; Lebedeva-

Ivanova et al., 2006) and their implications for the origin of the Alpha and Mendeleev Ridges are thoroughly reviewed in Dove et al. (2010). Geophysical, gravity, faunal and dredging datasets all support an overthickened oceanic crustal structure with formation as an oceanic plateau prior to the Cenozoic similar to the Manihiki or Ontong-Java plateaus (Dove et al., 2010; Forsyth et al., 1986; Jackson et al., 1986; Jokat, 2003). Alternative interpretations support formation of these ridges as rifted continental margins, citing crustal thicknesses abnormally high for oceanic crust, velocity structures suggestive of underplated continental crust and presence of continental material as evidenced by bottom sampling via piston coring and dredging (Lebedeva-Ivanova et al., 2006). Based on the available data, we feel as though compelling arguments are made for at least partial continental crust composition for the Alpha and Mendeleev Ridges and propose that these structures were continental in origin, though they now bear more resemblance to oceanic plateaus due to transtensional deformation and associated rift-related activity. Dove et al. (2010) provide evidence that the Alpha Ridge and Mendeleev Ridge were formed contiguously during the same tectonic event, which is in agreement with the tectonic model proposed here. The datasets described earlier also show evidence of extensional deformation in the form of grabens, half-grabens and normal faults as well as strike-slip faulting, also in agreement with our newly proposed model (Jackson et al., 1986, Dove et al., 2010).

Conclusions:

In recent years, detrital zircon studies focusing on Wrangel Island and the Chukotka Peninsula have suggested that the Chukotka part of the AAC may have been disconnected from the Alaskan portion and instead have been closer to Siberia during the Neocomian than previously considered. Detrital zircon geochronology performed in the Kular area of northern Russia provides an important sedimentological link between previous studies performed in the Verkhoyansk Fold-Thrust Belt, Chukotka, and In'Yali Debin regions. Comparison of these results with those collected from landmasses surrounding the modern Amerasian Basin provides support for the separation of the Chukotka part of the AAC from the Alaskan portion and involving dextral strike-slip movement of Chukotka along the northern Siberian Shelf during the Late Jurassic-Early Cretaceous. Detrital zircon data from these landmasses in tandem with a growing body of data from a variety of geological disciplines has led to a newly proposed tectonic model for formation of the Amerasian Basin. The model provided in this paper is a hybrid of the rotational model and the double-windshield-wiper model that incorporates the respective strengths of both while also addressing some of the problems encountered in each. While this model is highly schematic in nature and certainly involves problems of its own, it is another option to be considered for explanation of the tectonic history of the Amerasian Basin. Detrital zircon age peaks seen in Kular samples also match well with global records for prominent zircon age peaks, contributing to the global supercontinent cycle record of zircon preservation (Condie and Aster, 2009).

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Chapter III

Geochronology and emplacement mechanisms of the Bendeleben and Windy Creek plutons above an extending arc, Seward Peninsula, Alaska.

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Abstract:

The Bendeleben and Windy Creek plutons of the Bendeleben and northern Darby Mountains, respectively, were emplaced during a multiple-phase injection event lasting from 104 to 82 Ma in an extensional setting on the Seward Peninsula. This extensional episode is indicated by dike orientations, sheared mantles around garnet porphyroblasts, gentle foliation dip away from the plutons and consistent stretching lineations plunging away from the plutons, all documented in country rock surrounding both plutons. This interpretation is also in agreement with a proposed model for emplacement of the nearby Kigluaik pluton to the west along the Bendeleben normal fault involving north-south or north-northwest to south-southeast extension induced by slab-rollback above a southward retreating, northward subducting slab. Petrology of the Bendeleben pluton is diverse, showing multiple lithologies of differing ages. U-Pb zircon geochronology was performed on samples collected within the various lithologies of the Bendeleben and Windy Creek plutons. Within the central and eastern Bendeleben pluton, a central gabbro unit is the youngest at 82.8 ± 0.5 Ma and is bordered to the south by granodiorite with a minimum age of 86.1 ± 0.3 Ma as indicated by cross cutting relationships with a dated pegmatite dike. The outer rim of the Bendeleben pluton to the south is a 65 km², biotite-rich alkali-feldspar granite. In the western part of the field area, this unit has a crystallization age of 95.9 ± 1.0 Ma, but in the east it has an age of 84.6 ± 0.4 Ma. The core of the pluton to the north is composed of monzogranite that was dated at 82.9 ± 0.3 Ma. Previous mapping along the western limit of the Bendeleben pluton outside of our study area has yielded a U-Pb age of 104 ± 1.0 Ma. The Windy Creek pluton to the east is separated from the Bendeleben pluton by the Telephone Creek normal fault and is composed of homogenous alkali-feldspar granite dated at 96.3 ± 0.6 Ma. Metamorphic rocks of the Nome Group that border the Windy Creek pluton are low-grade schists and marble of the Nome Group. The higher grade metamorphic equivalent of the Nome Group, named the Kigluaik Metamorphic Complex, borders the Bendeleben pluton to the south and was contact metamorphosed during intrusion of the pluton. The 13 m.y. age range of intrusions in the Bendeleben pluton is suggestive of constant rejuvenation of a magma chamber at depth experiencing liquid segregation which was tapped repeatedly for magmatic pulses of the Bendeleben and Windy Creek plutons under extensional conditions. This is supported by Rb, Nb and Y discrimination diagrams suggestive of magma generation under a syn-collisional or volcanic arc setting above a subducting slab. Timing of intrusion seen in the Bendeleben pluton matches that of the episodic eruptive nature of the Okhotsk-Chukotka Volcanic Belt which lies along strike with the Bendeleben pluton across the Bering Strait and stretches across most of Russia. Temperature of crystallization was modeled by Ti concentration in zircon and the results indicated emplacement temperatures for the Bendeleben pluton between 796° C and 836° C. The Bendeleben pluton was later exhumed during a rapid uplift event along the Bendeleben normal fault thought to be active until 35 Ma with early uplift as early as 65 Ma based on apatite (U-Th)/He modelling.

Introduction:

The Seward Peninsula is located along the west coast of modern Alaska within the southern salient of the Arctic Alaska-Chukotka microplate, which is thought to have reached its current relative position in the Late Jurassic-Early Cretaceous (Figure 1). Following accretion of the Arctic Alaska-Chukotka microplate, a period of extension accompanied by wide-spread granitic magmatism affected the entire Bering Strait region (Miller et al., 2009) as well as a more localized north-south extensional episode in the Seward Peninsula responsible for the formation of several gneiss domes and dike swarms. This Mid-Cretaceous event is important because several models exist for the specific configuration and interaction between the local terranes and basins (Amato et al., 2009; Hannula et al., 1995; Lawver et al., 2002; Miller and Hudson, 1991; Nelson and Colpron, 2007; Patton and TAILLEUR, 1977). The overall lack of detachment faulting and other brittle deformation structures around gneiss domes found in the Bering Strait region has led to skepticism regarding extensional deformation in the late Mesozoic for the Seward Peninsula; though recent work has provided strong evidence supporting this event (Amato et al., 2003; Amato et al., 1994; Klemperer et al., 2002a; Miller et al., 2002; Miller and Hudson, 1991; Wolf et al., 2002). Models for the Cretaceous tectonic behavior in the Bering Sea region include the following:

- 1: East-west compressive stress caused by opening of the Mid-Atlantic Ridge that produced a large oroclinal bending event (Patton and TAILLEUR, 1977).

Figure 1: Generalized geologic map of the Seward Peninsula and Bering Strait region. Digital data from Klemperer et al. (2002a) and related geographic information system database with geology from Till and Dumoulin (1994), Till et al. (2010) and Beikman (1980).

- 2: Arc-continent collision resulting in high-pressure, low-temperature rocks overprinted by higher temperature assemblages as a result of crustal telescoping and subsequent thermal relaxation (Patrick and Lieberman, 1988).
- 3: North-south extensional models from thinning of the over-riding plate above a northward dipping subducting plate experiencing rollback and trench retreat (Amato and Miller, 1997).
- 4: Strike-slip models showing movement across potential conjugate shears east of the Seward Peninsula along the Kaltag fault and an unnamed fault separating the Seward terrane from the Yukon-Koyukuk basin (Amato et al., 2004).

The Bendeleben Mountains, located in southeastern Seward Peninsula, have been previously mapped as being cored by a large Cretaceous granitic pluton and so should prove valuable in deciphering the tectonic setting during the Cretaceous (Figure 1). Our data includes higher resolution mapping of the eastern Bendeleben Mountains (previously mapped by Moffit, 1913; Sainsbury, 1974; Till et al., 1986; and Till et al., 2010) as well as a geochronologic and geochemical study of the Bendeleben and Windy Creek plutons, which core the central and eastern Bendeleben Mountains, and the northern Darby Mountains. Results from this study provide evidence regarding the style and timing of Cretaceous tectonic events in the Seward Peninsula and involve a comparative study with the nearby Kigluaik gneiss dome (extensive results by J.M. Amato: Amato and Miller, 1997; Amato et al., 2002; Amato and Wright, 1997; Amato and Wright, 1998; Amato et al., 1994).

An additional aspect of this study involves the mechanics of pluton emplacement into the shallow crust, a topic which has become controversial in recent years due to an increasing body of research in opposition to the long-accepted process of diapiric emplacement via stoping (Glazner and Bartley, 2006). Field mapping of plutons and their surrounding structures worldwide has greatly enhanced our understanding of emplacement mechanisms, but the topic is still under active research as several mechanisms have been proposed, often involving thoroughly studied field analogues (Daly, 1903; Glazner and Bartley, 2006; Glazner et al., 2004; McNulty et al., 1996; Miller, 2008; Molyneux and Hutton, 2000; Paterson and Fowler, 1993; Paterson and Vernon, 1995; Titus et al., 2005; Yin, 2004). The Cretaceous tectonic history of the Bendeleben and Windy Creek plutons is potentially similar to emplacement in a fault termination extensional setting of the Johnson Granite and Silver Pass Porphyries in the Sierra Nevada batholith which were suggested to have intruded via a series of dikes along local weaknesses induced by faulting in an extensional system (Titus et al., 2005). Other possible mechanisms include a ballooning mechanism like that proposed for the Ardara pluton, Ireland (Molyneux and Hutton, 2000) or a multiple phase dike fed emplacement as proposed for the McDoyle pluton of the Sierra Nevada batholith (Mahan et al., 2003).

Field area:

The Bendeleben and Windy Creek plutons are located at approximately 65.3°N/163°W and 65.1°N/162.6°W respectively, in southeastern Seward Peninsula (Figure 2, Plate 1). Cretaceous plutons are pervasive in this area, extending roughly west

to east across the southern region of the Seward Peninsula before taking an abrupt ninety degree southward bend in the east at the transition from the Bendeleben Mountains to the Darby Mountains (Figure 1). The east-west oriented Bendeleben pluton crops out over approximately 140 km² within our field area in the eastern Bendeleben Mountains and the Windy Creek pluton crops out over approximately 25 km² in the north-south oriented Darby Mountains. The approximately 200 km² Darby pluton crops out along the eastern edge of the Darby Mountains to the southeast. The Bendeleben pluton is separated from the Windy Creek pluton by the northeast-southwest striking Telephone Creek fault (Figure 2). The east-west striking high angle Bendeleben normal fault, which defines the southern edge of the Bendeleben Mountains, separates the mountains from a sedimentary basin (McCarthy's Marsh) to the south. These plutons and others to the west are theorized to be a driving force for the development of multiple gneiss domes found throughout the Seward Peninsula (Amato et al., 2003).

Lithology of the Seward Peninsula is broadly grouped into two terranes based on stratigraphy and metamorphic history, although the boundary between these terranes is poorly defined. The central and eastern portions of the peninsula are dominated by the Seward terrane, while the slightly smaller York terrane underlies most of the western peninsula and Bering Strait region and is beyond the scope of this study (Figure 1). The most diagnostic characteristics of the Seward terrane are its low to high-grade metamorphic rocks and intrusive granitoid plutons. Of the metamorphic suites, the most pervasive is the Nome Group, which has traditionally included four distinct metamorphosed units of quartz-rich schist and graphitic or chloritic marble thought to have evolved from Ordovician parent rock based on radiolarian and conodont dating (Till

and Dumoulin, 1994). Recent detrital zircon geochronology suggests a more complicated mix of ages within each unit, however, and Cambrian to Silurian aged carbonate rocks exposed in thin fault slices have further complicated the sedimentological history (Amato et al., 2009). The Kigluaik Metamorphic Complex (as defined by Amato et al., 2009) is also found within the Seward terrane and is composed of granulite-facies gneiss and amphibolite-facies schist found adjacent to granitoid plutons of the Bendeleben and Darby Mountains. Within these ranges are high-grade amphibolite-, granulite- and greenschist-facies schists, metapelites and marbles. This unit was originally described as the Kigluaik Group by Moffit (1913) and subsequently in greater detail by Till and Dumoulin (1994), but has been redefined as the Kigluaik Metamorphic Complex by Amato et al. (2009) due to failure to meet “Group” classification standards of the International Commission on Stratigraphy.

Two deformation events proposed by Hannula et al. (1995) are each represented by their own foliation orientations and metamorphic assemblages within the Seward terrane. The first deformational event (D_1) is indicated by S_1 foliations subparallel to lithologic layering that postdate an early high-pressure/low-temperature event (M_1) which formed pumpellyite- to actinolite-facies in the upper section (York terrane) and blueschist-facies in the lower section (Nome Group) (Figure 1). S_1 foliations are thought to have formed during a subsequent greenschist-facies overprint (M_2) which occurred at the end of D_1 before 120 Ma. This first event was the consequence of arc-continent collision along the southern Seward Peninsula and is thought by some to represent the only regional Mesozoic deformation event for the Seward Peninsula, having been followed only by decompression overprinting and thermal relaxation from exhumation

(Patrick and Lieberman, 1988). A second deformational event (D_2) is however supported by multiple studies and is indicated by subhorizontal metamorphic S_2 foliations thought to have formed under regional extension with peak metamorphic conditions around 91 Ma (Amato et al., 1994) with continued metamorphism between 90 and 80 Ma (Amato et al., 2003; Miller and Bunker, 1976). A weak northwest-southeast lineation defined by grain stretching is prevalent in Seward terrane units and becomes more common to the south. D_2 structures formed as a consequence of a third high-temperature metamorphic event (M_3) responsible for an amphibolite- to granulite-facies overprint at depth as a consequence of plutonism in the core of the Kigluaik and Bendeleben gneiss domes with cooling and unroofing during or soon after D_2 (Hannula et al., 1995).

Because there is no sharp break between the Nome Group and Kigluaik Metamorphic Complex, they are both inferred to have experienced the same high-pressure, low-temperature metamorphic conditions presumably before 120 Ma (D_1 , M_1 - M_2) which were later overprinted by a thermal event between 110-91 Ma at depth (D_2) (Amato et al., 2003; Hannula et al., 1995) thought to have been caused by mafic magmatism (Amato et al., 1994). The Kigluaik Metamorphic Complex is therefore considered the metamorphically upgraded equivalent of Nome Group units.

Methods:

Field mapping:

Updated field maps compiled during and directly following field work performed in 2009 will be used towards the eventual compilation of a 1:24000 scale geologic map of

the entire Bendeleben Mountain Range. Recent geologic mapping expeditions in the western and central Bendeleben Mountains performed from 2006 to 2007 have already resulted in several independent geochemical and geochronologic publications in addition to updated geologic maps for these areas (Gottlieb and Amato, 2007; Gottlieb and Amato, 2008a; Gottlieb and Amato, 2008b). During field work, hand samples were collected from all mappable units for thin section analysis. Thin section analysis involved identification of sense-of-shear indicators from oriented samples, 100-point grain counts and general visual analysis of country rock and granitic samples to determine specific lithology, deformation history, kinematics of deformation, mineral assemblages and metamorphic grade.

Geochronology:

During field investigation, granitic samples were collected from the Bendeleben pluton (5 samples) and Windy Creek pluton (1 sample) to be analyzed via zircon U-Pb geochronology (Figure 2). Grab samples were collected either from in-place outcrop or from topographic high-points. Weathering rind was cleaned from all samples in the field prior to collection. Following return from the field, zircons were separated using standard crushing, magnetic and gravimetric procedures at West Virginia University. U-Pb geochronology was performed at the USGS Sensitive High Resolution Ion-Microprobe, Reverse Geometry (SHRIMP-RG) facility at Stanford University. At the lab, grain mounts were made by forming distinct rows of zircons for each sample on 25 mm diameter, 6 mm thick pucks. Pucks were then polished and coated with a thin film (~10 nm) of gold in a Denton sputterer to minimize charge effects during analysis.

Grains with simple or no zoning patterns were chosen for analysis following imaging by cathodoluminescence (CL) using a JEOL JSM 5600 electron microscope and reflected light (Appendix 6). Analytical spots approximately 30 μm in diameter were sputtered using a Kratos Duoplasmatron sourced primary oxygen ion (O_2^+) beam (Coath and Long, 1994). Ions were separated by mass using a double-focusing mass spectrometer in a Reverse Geometry orientation where the magnet precedes an electrostatic analyser along the secondary beam path. Under this orientation, only one mass is passed through the collector at a time, causing increased resolution at the cost of slower analysis time. At least seven grains were targeted per sample and measured for their U-Th-Pb concentrations using a mix of cores and rims as determined by CL imaging to verify magmatic age. Reported analyses are the result of five averaged measurement cycles per targeted grain and processed using Squid and Isoplot software developed by Ludwig (2009) with complete results listed in Appendix 7. Standard R-33, which yields a combined SHRIMP age of 419.9 ± 1.5 Ma (Black et al., 2004), was targeted one time per four sample grains and used for error correction. In addition to U-Th-Pb ions measured during SHRIMP-RG analysis, all zircons were also measured for Ti concentrations to be used for temperature of crystallization calculation modeled after Watson et al. (2006) and for their Rare Earth Element (REE) As-Yb series concentrations (La, Ce, Pr, Nd, Sm, Eu, Gd, Dy, Y, Er and Yb). Specific routine procedures for analysis via SHRIMP-RG are outlined in Williams (1998).

Bulk geochemistry:

Eight samples were sent to the Washington State University (WSU) geoanalytical laboratory for major and trace element measurement via inductively coupled plasma-mass spectrometry (ICP-MS) using an Agilent model 4500. Powdered samples were fused under low-dilution with di-lithium tetraborate flux followed by open-vial mixed digestion using hydrofluoric acid to remove silica and most of the flux (more than 90%). Instrumental drift was corrected using Ru, In and Re as internal standards. For more information on WSU methodology for ICP-MS geoanalytical work, see their website at <<http://www.sees.wsu.edu/Geolab/note/icpms.html>>. Five Bendeleben pluton samples, one Windy Creek pluton sample, one biotite-garnet schist sample from the Kigluaik Metamorphic Complex and one sample from the muscovite schist unit of the Nome Group were analyzed to better describe each unit. The five igneous samples collected from the Bendeleben pluton included a gabbro, monzogranite, pegmatite and two alkali-feldspar granites. One alkali-feldspar granite sample was sent from the Windy Creek pluton. All geochemical results are listed in Table 1 and Appendix 8.

Results:

Field data to be used in the composition of a higher-resolution, updated geologic map of the Bendeleben Mountains were compiled upon return from the field at a scale of 1:24,000 (Figure 2, Plate 1). Two separate packages of lithologies, the Nome Group and the Kigluaik Metamorphic Complex, comprise the country rock surrounding the plutons and are described below.

Table 1: Geochemical results from samples collected in the Bendeleben and northern Darby ranges. Weight percentages were adjusted so that total percentage is 100%. Kigluaik M.C. is the Kigluaik Metamorphic Complex. Abbreviations are: tr, trace elements; m, major elements.

	Bendeleben pluton					Windy Creek pluton	Kigluaik M.C.	Nome Group
	09BEN20	09BEN26	09BEN29	09BEN61	09BEN63	09BEN73	09BEN13	09BEN76
	pegmatite	alkali- feldspar granite	monzogranite	gabbro	alkali- feldspar granite	alkali- feldspar granite	biotite- garnet schist	muscovite schist
Normalized Major Elements (Weight %)								
<i>SiO₂</i>	75.2	72.4	72.2	60.6	70.9	67.2	70.0	57.2
<i>TiO₂</i>	0.1	0.4	0.4	1.4	0.4	0.4	1.0	0.9
<i>Al₂O₃</i>	14.4	14.6	14.8	17.8	15.8	16.3	14.9	20.3
<i>FeO*</i>	0.5	1.8	2.0	5.5	2.5	2.7	7.2	8.9
<i>MnO</i>	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1
<i>MgO</i>	0.2	0.3	0.5	1.6	0.6	0.8	2.8	5.6
<i>CaO</i>	1.8	1.1	1.9	4.4	1.7	2.3	0.4	1.2
<i>Na₂O</i>	3.4	3.0	3.6	4.2	4.0	4.7	0.3	1.9
<i>K₂O</i>	4.1	6.3	4.5	3.9	3.8	5.4	3.2	3.8
<i>P₂O₅</i>	0.1	0.1	0.1	0.6	0.2	0.1	0.2	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unnormalized Trace Elements (ppm)								
<i>Ni</i>	5.5	4.8	3.9	7.3	3.0	7.7	57.1	103.9
<i>Cr</i>	27.3	17.7	17.6	12.8	12.3	18.2	115.9	144.4
<i>Sc</i>	2.4	2.1	4.3	6.6	4.6	2.8	17.5	23.9
<i>V</i>	3.5	9.4	17.5	50.6	22.3	35.6	145.2	143.6
<i>Ba</i>	230.5	1062.2	1033.8	3055.2	862.6	1237.1	501.7	595.4
<i>Rb</i>	184.7	296.2	195.6	105.7	260.4	253.7	167.2	145.5
<i>Sr</i>	109.1	275.3	428.4	1604.4	401.3	876.2	24.8	91.7
<i>Zr</i>	124.3	305.3	194.6	474.3	205.2	307.9	289.3	167.8
<i>Y</i>	6.3	9.2	18.3	18.6	27.2	22.5	42.6	29.8
<i>Nb</i>	7.6	13.2	12.9	24.7	21.5	30.0	16.7	13.1
<i>Ga</i>	20.2	22.0	19.8	23.1	30.0	20.8	19.6	24.7
<i>Cu</i>	11.2	3.9	1.6	5.7	0.7	2.9	18.4	76.8
<i>Zn</i>	20.2	56.6	45.6	122.9	91.1	47.3	122.7	125.3
<i>Pb</i>	30.8	49.6	38.4	25.4	28.0	28.6	6.4	12.0
<i>La</i>	8.3	108.9	53.1	134.2	80.3	94.3	44.9	33.1
<i>Ce</i>	7.9	200.6	96.1	270.7	149.2	168.0	92.0	69.7
<i>Th</i>	4.0	76.7	28.9	21.1	31.4	58.4	14.0	11.4
<i>Nd</i>	3.8	64.7	36.9	100.3	53.4	56.9	40.2	30.0
<i>U</i>	2.7	5.3	6.4	4.0	5.2	4.9	5.1	1.9
<i>Cs</i>	10.1	5.9	5.0	3.5	4.6	8.3	18.4	6.2
<i>Nb+Y</i>	13.9	22.4	31.2	43.3	48.7	52.5	59.3	42.9
sum tr. (ppm)	834.3	2612.0	2289.9	6114.4	2343.0	3334.6	1819.0	1893.1
tr. (weight %)	0.1	0.3	0.2	0.6	0.2	0.3	0.2	0.2
sum m.+tr. (weight %)	98.3	98.9	99.3	99.4	98.8	98.2	97.4	95.0

Nome Group:

The Nome Group was originally described by Moffit (1913) and more recently in greater detail by Till et al. (2010) as a package of blueschist- to greenschist-grade metamorphic sequences with Early-Middle Paleozoic and older protoliths, scattered carbonates, and small bodies of orthogneiss. Within the field area, we mapped three units of the Nome Group including: (1) a muscovite-rich, chlorite-bearing pelitic schist, (2) a crystalline, commonly foliated diopside-bearing marble unit and (3) a black graphitic quartzite which in places contains very high percentage of quartz veins. All Nome Group units seen within our field area were found east of the Telephone Creek fault that separates the Bendeleben pluton from the Windy Creek pluton.

The muscovite schist is most likely correlative with light-green to silver colored, mafic, feldspathic and calcareous schist units described by Till and Dumoulin (1994) and Till et al. (2010) as the Ordovician (based on relationship to surrounding units) Casadepega schist (Ocs). It has a tendency to outcrop in several-meter high tors (Figure 3a), contains common quartz veins up to 10 cm in thickness and is albite-bearing. Geochemical results further support the connection to mafic portions of the Casadepega schist unit due to higher normalized weight percentages of FeO (8.9%) and MgO (5.6%) and low SiO₂ (57.2%) (Table 1) relative to other country rock units in the area. The schist is well foliated with prevalent millimeter to centimeter thick polycrystalline quartz lenses, inclusion-rich albite grains and high epidote content and can be easily recognized by its greasy sheen and dull green color. Minor chlorite and biotite can also be found, though the vast majority of the rock is composed of well foliated muscovite layers with

Figure 3 a) Muscovite schist (Ocs) with gently south-dipping foliation as commonly exposed in several meter tall tors. b and c) Thin sections of biotite-garnet schist (PzPh) showing mantled garnet porphyroblasts with strain shadows. Both photomicrographs are oriented top-up with south towards the right.

quartz-rich lenses. Thin section results from oriented samples show strong evidence of shear in the form of strain shadows and stretched grains. This unit was only seen south of the Windy Creek pluton and was separated from the pluton by units of marble and graphitic quartzite.

The impure marble unit of the Nome Group was found in closer proximity to and often in contact with the Windy Creek pluton and is correlative with a previously mapped unit (DOx) to the southeast that is a mix of marble, graphitic metasilicious rock and schist (Till et al., 2010). Marble units are easily visible in aerial photography both south of the Windy Creek pluton and also further west near the Bendeleben pluton as light gray exposures. Marble outcrops were well exposed and often in-place, though generally appearing only in lower-relief areas due to relative ease of weathering. Within the Nome Group this marble unit is strong, has a sugary appearance and is composed of millimeter sized crystals. Minor amounts of diopside were found in hand samples, though rare. Coloration of this unit varies from layered gray with prominent darker bands to pure white.

The graphitic quartzite unit was only seen near the southern edge of the Windy Creek pluton (Figure 2) and likely belongs to a part of the DOx unit defined by Till et al. (2010) as “black metasilicious rock.” It is a very hard, black quartzite found in well-exposed in-place outcrop. At the contact with the Windy Creek pluton, this unit has a very high percentage of quartz-vein material, commonly up to 50% of the outcrop. Though generally exposed in sections less than one meter in thickness, this unit is common and mappable south of the Windy Creek pluton.

Kigluaik Metamorphic Complex:

Our mappable units within the Kigluaik Metamorphic Complex include a quartz-rich, garnet-bearing, pelitic biotite schist and a metamorphosed impure marble. These units are correlative with those described by Moffit (1913), Till and Dumoulin (1994) and Till et al. (2010) as the uppermost units of the Kigluaik “Group” and are thought to be the higher grade metamorphosed and structurally more deeply buried equivalents of Nome Group units.

The garnet-biotite schist is exposed directly south of, and in contact with, the Bendeleben pluton in either frost heaved boulder mounds or in-place outcrop (Figure 2). This unit was the most common metamorphic unit mapped in our field area and is correlative with parts of a Paleozoic-Proterozoic unit of high-grade metasedimentary and metaigneous rocks named by Till et al. (2010) as PzPh. Although PzPh, as defined by Till et al. (2010), describes a diverse package of metamorphic rocks, biotite-garnet schist was the only lithology from this unit observed in our field area. Diagnostic traits of the unit are high garnet and biotite content and well-foliated biotite layering, though samples from this unit also contain chlorite (likely retrograde), muscovite, apatite, K-feldspar, plagioclase, sillimanite and cordierite. Presence of garnet, sillimanite, cordierite and biotite within samples suggests stability at a temperature greater than 600° C at pressure less than 6 kbar according to the KFMASH ($\text{SiO}_2\text{-Al}_2\text{O}_3\text{-MgO-FeO-K}_2\text{O-H}_2\text{O}$) system (Spear, 1993), which is in agreement with contact metamorphism from the Bendeleben pluton.

Marble outcrops similar to those found in the Nome Group are seen further south of the Bendeleben pluton near the east-west striking Bendeleben normal fault. This

marble unit is correlative with the Paleozoic-Proterozoic(?) PzPm unit described by Till et al. (2010) and the PzpCm unit of Till et al. (1986) (the more recent nomenclature, PzPm, is used in this study). This unit is very similar to marbles found within the DOx unit of the Nome Group, but has greater diopside content and is weaker and crumbly, making up the low relief regions in the foothills of the Bendeleben Mountains.

Structural fabrics:

While the pelitic schist unit (Ocs) of the Nome Group exposed south of the Windy Creek pluton is well-foliated, the typical nature of the outcrops as shifted tors led to inconsistency between measurements of both foliation and lineation. Impure marble outcrops of the DOx unit were generally poorly exposed leading to a paucity of field measurements.

The biotite-garnet schist unit (PzPh) of the Kigluaik Metamorphic Complex is well foliated with strikes that average 085° and dips that average 30° , mostly to the south (Figure 4a). Lineations within the Kigluaik Metamorphic Complex are defined by stretched quartz grains with an average trend of 153° and gentle plunges between $10\text{--}20^{\circ}$ degrees (Figure 4c). Shear bands, mica fish and strain shadows around garnet porphyroblasts show top-down shear (Figures 3b and 3c) and presence of biotite- and white mica-bordered shear zones from exposures are all indicative of extensional deformation. The marble unit of the Kigluaik Metamorphic Complex (PzPm), is generally well-foliated with strikes at an average of 092° and dips at an average of 36° consistently to the south (Figure 4b).

Figure 4: Equal-area stereonet plots of foliations and lineations within units of the Kigluaik Metamorphic Complex. Fabric orientation in Nome Group units were inconsistent. Plots made using GEORient ver. 9.4.5 (Holcombe, 2010).

Bendeleben pluton:

Analysis of hand samples, thin sections and field observations indicates that the Bendeleben pluton is actually composed of several igneous lithologies rather than one homogenous intrusion as was originally mapped, though most are rich in biotite; a common feature for Cretaceous intrusives of the Seward Peninsula (Amato and Miller, 1997; Amato et al., 2003). Within the study area, five separate mappable units within the Bendeleben pluton, ranging in composition from mafic to felsic, were recognized (Figures 2 and 5). Geochemical results from all igneous samples are summarized in Table 1. The gabbroic portion was the smallest mappable unit covering only approximately 2 km² of the Bendeleben pluton exposure (Kb-ga, Figure 2). Normalized weight percents of major elements show relatively low SiO₂ content (59.8%), and relatively high FeO (5.5%), MgO (1.6%) and CaO (4.4%) as compared to other intrusive lithologies mapped (Table 1). Point counts from thin section slides show average quartz, K-feldspar and plagioclase (QAP) proportions from gabbro samples of 1% quartz, <1% K-feldspar and 99% plagioclase (Figure 5). Very high amounts of biotite (up to 30% of sample) were also seen, as well as minor amounts of sphene, epidote, hornblende and apatite. This unit is bordered to the west by a 9 km² granodiorite unit (Kb-gr, Figure 2). Prevalent near the southern boundary of the granodiorite were multiple aplite and pegmatite intrusions, which locally cut through both the granodiorite and the country rock directly to the south. Geochemical analysis was not performed on any granodiorite samples. Thin section point count analysis shows average QAP proportions of 42% quartz, 18% K-feldspar and 40% plagioclase from granodioritic samples. This unit is also very rich in biotite (approximately 10-20% of sample) and other minerals present

Figure 5: Ternary diagram of plutonic rocks from igneous samples of the Bendeleben and Windy Creek plutons. Classification of samples is based on modal content from point count analysis of thin sections. Field boundaries modified from Le Maitre et al. (2002). Q, A and P refer to quartz, alkali-feldspar and plagioclase content, respectively.

include hornblende, sphene, apatite and zircon as well as rare garnet, epidote and muscovite. Surrounding the gabbro and granodiorite and extending east-west across the entire field area is a large (approximately 65 km²) body of alkali-feldspar granite (Kb-af, Figure 2). This unit extends another 10 km to the west of our field area with more details provided by Gottlieb and Amato (2008a). Chemical results from two alkali-feldspar granite samples show intermediate average normalized weight percents of SiO₂ (71.2%), FeO (2.2%) and MgO (0.5%) and the highest average K₂O (5.8%) weight percentages seen in the Bendeleben pluton (Table 1). Thin section point counts indicate average QAP proportions of 36% quartz, 59% K-feldspar and 4% plagioclase (Figure 5). Alkali-feldspar granites also contain common zircon, apatite and biotite (5-10% of samples) and have trace amounts of sphene, amphibole, muscovite and chlorite. To the north, the interior of the Bendeleben pluton is composed entirely of monzogranite (Kb-mo) exposed over approximately 20 km² within the field area and extending northward beyond it (Figure 2). Chemical results from this unit also show intermediate normalized weight percents of SiO₂ (72.2%), FeO (2.0%) and MgO (0.5%) (Table 1). Thin section analysis shows average QAP proportions of 24% quartz, 46% K-feldspar and 31% plagioclase as well as minor amounts of biotite (5-15% of sample), zircon, sericite, sphene, epidote, hornblende and muscovite (Figure 5).

The alkali-feldspar granite shows occasional biotite-defined foliation in the eastern part of the field area northwest of the Telephone Creek fault and east of a minor branching normal fault that cuts the Bendeleben pluton (Figure 2). Since this was the only granitic outcrop in our field area that displayed foliation, it was likely formed from interaction with the minor branching normal fault. If this foliation instead formed as a

consequence of flow, then fault movement may have initiated before complete solidification of the Bendeleben pluton. Foliations here were at an average strike of 109° , approximately parallel to the fault, with an average dip of 29° to the south.

A wedge shaped, high-strain mylonitic zone was exposed as a large field of rubble found along the Telephone Creek fault on the eastern margin of the Bendeleben pluton. In place outcrop was rare causing difficulty in determining shear zone orientation and kinematics. The mylonite was dominated by a well-foliated quartz groundmass with larger quartz and K-feldspar porphyroclasts, sericitized muscovite, garnet and minor epidote.

Windy Creek pluton:

The Windy Creek pluton, located southeast of the Bendeleben pluton, is composed of homogenous alkali-feldspar granite (Figure 5). The one sample analyzed for geochemistry shows relatively low SiO_2 (67.2%) normalized weight percent content compared to similar units in the Bendeleben pluton and intermediate FeO (2.7%) and MgO (0.8%) content (Table 1). K_2O normalized weight percent (5.4%) was similar to values seen in the Bendeleben pluton. Point count analysis of thin sections gives average QAP proportions of 29% quartz, 70% K-feldspar and 1% plagioclase (Figure 5). Thin section analysis also revealed presence of minor biotite, sphene, hornblende, zircon and apatite. Some locations near the rim of the pluton show mild evidence of foliation, but measurements were inconsistent.

Dike swarms:

Within the Kigluaik Metamorphic Complex are several aplite dikes, aplite porphyry dikes, lamprophyres and pegmatites, which intrude biotite-garnet schist, marble and granodiorite exposures. Diabasic dike swarms prevalent in and around the Kigluaik gneiss dome to the west of the Bendeleben pluton and other dike swarms ranging in composition from diabasic to rhyolitic found in the Bendeleben, York and Darby Mountains are thought to have been emplaced during or directly following extensional deformation (D_2) from 90 to 80 Ma (Amato et al., 2003; Amato and Wright, 1997; Amato et al., 1994; Miller and Bunker, 1976). In the Kigluaik dike complex, weighted-mean $^{40}\text{Ar}/^{39}\text{Ar}$ ages of dikes dated from groundmass and biotite samples range from approximately 80 to 84 Ma, approximately synonymous with D_2 (Amato et al., 2003). Dike thicknesses in the Bendeleben Mountains range from as thin as a few centimeters to as thick as 50 m and were found intruding all types of lithologies mapped in the field area (Figure 6). Bearings of these dikes range from 075° to 120° , though almost all are between 075° and 095° and all have dips between 80° to the southeast and vertical. Aplites range from 0.5-1.0 m thick and are composed mostly of quartz and feldspar with minor garnet, chlorite and biotite, which define a weak foliation. Aplite porphyry dikes are composed of feldspar groundmass with subhedral quartz phenocrysts with trace amounts of muscovite and sphene and were heavily altered by fluid interaction to form common calcite. Normalized weight percents from a pegmatite unit bordering the granodiorite show the highest SiO_2 (75.2%) content within the Bendeleben pluton and the lowest FeO (0.5%) and MgO (0.2%) content (Table 1). The majority of the pegmatite is composed of quartz (36%) and K-feldspar (52%) crystals commonly greater than 1 mm

Figure 6: Pegmatite intrusion (Peg) through impure diopside-bearing marble unit (mb, PzPm) in the Bendeleben Mountains. See text and Figure 2 for location. Sample 09BEN20 was collected from pegmatite at this location for geochronology and geochemistry and gave a concordant U-Pb age of 86.1 ± 0.3 Ma. View looking northwest.

in diameter, though plagioclase (7%), muscovite and sphene were also observed in thin section (Figure 5). A similar pegmatite unit bordering the nearby Kigluaik pluton was suggested to have been derived entirely by partial melting of the country rock based on isotopic composition (Amato and Wright, 1997) and is a possible analogue to pegmatite dikes in the Bendeleben Mountains.

Geochronology:

Five samples from the Bendeleben pluton and one sample from the Windy Creek pluton were dated using U-Pb ratios measured from zircons at the Stanford University/USGS operated SHRIMP-RG instrument. Since the Bendeleben pluton is compositionally and texturally diverse, samples diagnostic of each sub-unit were dated (Figure 2). Discordant analyses, or those which yielded high ^{204}Pb or very high U concentrations were discounted from age calculations. Some spots used in weighted mean plots were removed from concordia calculations due to visual misfit. All results are listed in Table 2 and Appendix 7 and shown in Tera-Wasserberg concordia plots in Figure 7 and in ^{207}Pb -corrected $^{206}\text{Pb}/^{238}\text{U}$ weighted mean age plots in Figure 8. All analyzed grains range in size from 100 to 500 μm in length and are largely free of inclusions, fractures and metamorphic overgrowths. See Figure 2 for all sample locations and Appendix 6 for CL images of all grains selected for analysis.

09BEN20 – Pegmatite cutting the Bendeleben pluton:

Sample 09BEN20 was collected near the southern margin of the granodiorite unit, from a pegmatite dike that cuts through a marble outcrop (Figure 6). Though no sample

Table 2: U-Pb SHRIMP-RG dated geochronologic results for samples collected from the Bendeleben and Windy Creek plutons. In Isoplot v. 3.6 (Ludwig, 2009), bold rows were used for concordia age analysis, italicized rows were used for weighted average age calculations and gray rows were not used for analysis. Ages with lines through them have been rejected due to high uranium, high ^{204}Pb or discordance.

Spot name	% common ^{206}Pb	U (ppm)	Th (ppm)	$^{232}\text{Th}/^{238}\text{U}$	^{207}Pb corrected $^{206}\text{Pb}/^{238}\text{U}$	1 σ error	^{207}Pb corrected $^{206}\text{Pb}/^{238}\text{U}$ age	1 σ error	Total $^{238}\text{U}/^{206}\text{Pb}$	% error	Total $^{207}\text{Pb}/^{206}\text{Pb}$	% error	^{204}Pb corrected $^{207}\text{Pb}/^{206}\text{Pb}$	% error
09BEN20-9r	0.53	246	105	0.44	.0127	.0002	84.6	4.0	78.09	1.2	.0519	4.4	.0479	7.7
09BEN20-6r	0.87	252	120	0.49	.0127	.0002	84.6	4.0	77.77	1.2	.0546	4.3	.0439	15.6
09BEN20-12r	0.24	358	209	0.60	.0131	.0001	83.9	0.9	76.18	1.1	.0496	3.9	.0496	3.9
09BEN20-1r	0.77	699	325	0.48	.0133	.0001	85.0	0.6	74.79	0.7	.0538	2.4	.0470	6.1
09BEN20-4r	-0.18	286	196	0.71	.0133	.0001	85.1	0.9	75.41	1.1	.0463	4.2	.0417	7.2
09BEN20-10r	0.08	373	104	0.29	.0134	.0001	85.6	0.9	74.73	1.0	.0484	4.1	.0437	7.1
09BEN20-11r	0.10	368	221	0.62	.0134	.0001	85.7	0.9	74.66	1.0	.0486	3.9	.0486	3.9
09BEN20-8c	0.06	561	112	0.21	.0135	.0001	86.5	0.7	74.01	0.8	.0482	3.1	.0457	4.2
09BEN20-2r	0.62	268	183	0.71	.0135	.0002	86.6	1.0	73.48	1.1	.0527	5.3	.0392	15.0
09BEN20-5c	0.03	694	386	0.57	.0136	.0001	87.1	0.6	73.53	0.7	.0480	2.6	.0458	3.7
09BEN20-7c	0.07	775	450	0.60	.0139	.0001	88.8	0.7	72.01	0.7	.0483	2.7	.0502	3.2
09BEN26-1c	0.28	245	96	0.40	.0145	.0002	92.7	1.1	68.88	1.1	.0501	4.0	.0445	7.3
09BEN26-6r	-0.26	382	77	0.21	.0145	.0001	92.8	0.9	69.17	0.9	.0458	3.6	.0426	6.2
09BEN26-9r	0.03	291	52	0.19	.0146	.0002	93.3	4.0	68.55	1.1	.0481	4.1	.0550	8.8
09BEN26-3c	-0.06	416	183	0.46	.0148	.0001	94.5	0.8	67.78	0.9	.0474	3.2	.0447	4.7
09BEN26-4r	0.33	391	107	0.28	.0149	.0001	95.4	0.9	66.87	0.9	.0506	3.3	.0491	3.9
09BEN26-8r	0.04	238	51	0.22	.0150	.0002	95.7	1.2	66.81	1.2	.0482	4.4	.0447	6.2
09BEN26-10c	-0.26	278	145	0.54	.0152	.0002	97.0	1.1	66.14	1.1	.0459	4.2	.0410	7.6
09BEN26-2r	0.05	731	345	0.49	.0152	.0001	97.3	0.7	65.74	0.7	.0484	3.0	.0484	3.0
09BEN26-5c	-0.28	117	34	0.30	.0152	.0003	97.5	1.7	65.81	1.7	.0458	6.9	.0654	15.4
09BEN26-7r	0.01	124	57	0.48	.2594	.0021	4486.9	40.9	3.85	0.7	.0930	1.1	.0930	1.1

Spot name	% common ²⁰⁶ Pb	U (ppm)	Th (ppm)	²³² Th/ ²³⁸ U	²⁰⁷ Pb		²⁰⁷ Pb		Total ²³⁸ U/ ²⁰⁶ Pb	% error	Total ²⁰⁷ Pb/ ²⁰⁶ Pb	% error	²⁰⁴ Pb	
					corrected ²⁰⁶ Pb/ ²³⁸ U	1σ error	corrected ²⁰⁶ Pb/ ²³⁸ U	1σ error					corrected ²⁰⁷ Pb/ ²⁰⁶ Pb	% error
09BEN29-1c	0.24	739	409	0.57	.0125	.0001	80.0	0.6	79.90	0.7	.0495	2.7	.0444	5.5
09BEN29-3r	0.08	845	147	0.18	.0126	.0001	80.9	0.6	79.15	0.7	.0483	2.7	.0446	4.7
09BEN29-2r	0.98	849	195	0.24	.0127	.0001	81.6	0.6	77.72	0.7	.0554	2.5	.0470	6.6
09BEN29-6r	0.04	670	309	0.48	.0128	.0001	81.8	0.6	78.24	0.8	.0480	2.9	.0497	3.5
09BEN29-9c	0.03	557	286	0.53	.0129	.0001	82.7	0.7	77.39	0.9	.0479	3.3	.0451	4.7
09BEN29-10r	0.24	373	132	0.36	.0130	.0001	83.0	0.9	77.00	1.0	.0495	3.7	.0468	4.9
09BEN29-4r	0.57	335	83	0.26	.0130	.0001	83.2	0.9	76.58	1.1	.0522	3.9	.0610	7.9
09BEN29-8r	-0.06	526	378	0.74	.0131	.0001	83.9	0.7	76.39	0.9	.0472	3.3	.0449	4.4
09BEN29-5c	-0.14	784	277	0.37	.0134	.0001	86.4	0.6	74.50	0.7	.0466	2.7	.0457	3.0
09BEN29-7r	-0.04	1140	98	0.09	.0135	.0001	86.3	0.5	74.20	0.6	.0475	2.3	.0448	3.8
09BEN61-4r	0.49	274	157	0.59	.0124	.0001	79.7	0.9	80.00	1.2	.0515	4.2	.0515	4.2
09BEN61-5r	0.07	240	169	0.73	.0127	.0002	81.7	1.0	78.39	1.2	.0482	4.4	.0439	8.1
09BEN61-1r	0.46	250	121	0.50	.0128	.0002	82.1	1.0	77.63	1.2	.0513	4.3	.0513	4.3
09BEN61-7r	0.14	181	115	0.65	.0129	.0002	82.4	1.2	77.59	1.5	.0488	5.6	.0431	11.6
09BEN61-8r	-0.02	277	127	0.47	.0130	.0002	83.5	1.0	76.72	1.2	.0475	4.5	.0380	12.6
09BEN61-2r	-0.04	133	73	0.57	.0132	.0002	84.7	1.4	75.62	1.7	.0474	6.3	.0293	27.8
09BEN61-6c	-0.19	308	175	0.59	.0134	.0002	85.8	4.0	74.82	1.1	.0462	4.3	.0376	12.7
09BEN61-3r	0.24	407	318	0.81	.0134	.0001	85.8	0.9	74.48	1.0	.0496	3.9	.0496	3.9
09BEN63-6c	0.14	334	62	0.19	.0129	.0001	82.9	0.9	77.18	1.1	.0488	4.1	.0483	4.2
09BEN63-1r	0.07	293	43	0.15	.0129	.0001	82.9	0.9	77.17	1.1	.0482	4.1	.0450	5.7
09BEN63-7r	0.32	291	128	0.45	.0130	.0002	83.5	1.0	76.47	1.2	.0503	4.4	.0438	9.0
09BEN63-8r	0.45	173	50	0.30	.0131	.0002	83.6	1.4	76.25	1.6	.0513	6.1	.0424	12.9
09BEN63-5r	0.07	384	144	0.39	.0133	.0001	85.1	0.9	75.24	1.0	.0483	3.8	.0437	8.2
09BEN63-2c	0.15	174	94	0.56	.0133	.0002	85.3	1.3	74.97	1.5	.0489	6.0	.0325	27.3
09BEN63-3c	0.12	389	189	0.50	.0135	.0001	86.6	0.9	73.86	1.0	.0487	3.7	.0455	5.1
09BEN63-4r	0.50	541	90	0.17	.0135	.0001	86.6	0.7	73.54	0.8	.0517	2.9	.0469	5.7
09BEN73-5r	0.06	625	421	0.70	.0146	.0001	93.1	0.7	68.69	0.7	.0483	2.7	.0454	4.4
09BEN73-1r	0.33	322	212	0.68	.0147	.0002	94.1	1.0	67.75	1.0	.0505	3.7	.0521	4.1
09BEN73-8r	0.57	572	419	0.76	.0148	.0001	94.6	0.7	67.24	0.8	.0524	2.7	.0441	7.5
09BEN73-4r	-0.15	435	445	1.06	.0151	.0001	96.3	0.9	66.54	0.9	.0467	3.4	.0452	4.1
09BEN73-2r	-0.11	370	211	0.59	.0151	.0002	96.6	1.0	66.34	1.0	.0471	3.7	.0471	3.7
09BEN73-7r	0.14	1018	1105	1.12	.0151	.0001	96.7	0.6	66.08	0.6	.0490	2.1	.0495	2.3
09BEN73-6r	0.11	885	657	0.77	.0152	.0001	97.3	0.6	65.69	0.6	.0488	2.3	.0460	3.4
09BEN73-3c	0.06	854	725	0.88	.0154	.0001	98.5	0.6	64.93	0.6	.0484	2.4	.0491	2.4

Figure 7: Concordia plots for U-Pb zircon ages from samples collected from a pegmatite dike (a) and the Bendeleben (b-e) and Windy Creek (f) plutons. Plotted using Isoplot v. 3.6 (Ludwig, 2009). Dotted ellipses represent spot analyses removed for discordance, regular ellipses represent spots used for age determination and bold ellipses represent calculated concordia ages with error.

Figure 8: Weighted mean ^{207}Pb -corrected $^{206}\text{Pb}/^{238}\text{U}$ ages for zircons from samples collected within a pegmatite dike (a) and the Bendeleben (b-e) and Windy Creek (f) plutons. Plotted using Isoplot v. 3.6 (Ludwig, 2009).

was dated from the granodiorite, the southern region of this unit is dominated by pegmatitic dikes which intrude both the marble unit to the south and the granodiorite. Due to cross-cutting relationships of pegmatites intruding the granodiorite, the age of the pegmatite gives a minimum age for the granodiorite unit. Zircon grains ranged from stubby and equant to long and skinny and ranged in color from honey to clear. CL imaging revealed simple zoning patterns and a general lack of metamorphic overgrowth, inclusions or fractures. Eight grains were used for the final age determination using two core analyses and six rim analyses to calculate a concordia age of 86.1 ± 0.3 Ma (MSWD 1.0), excluding one spot for discordance, and a weighted mean age of 85.7 ± 0.9 Ma.

09BEN26 – Bendeleben pluton, alkali-feldspar granite:

Sample 09BEN26 was collected from the biotite-rich alkali-feldspar granite unit near the western boundary of our field area and represents the westernmost sample collected. Zircons were almost entirely honey colored and subhedral. Separation yielded small amounts of zircon, mostly large in size around 300 μm long. Grains that were dark under CL, indicative of high uranium concentrations, were avoided for analysis, as were grains with complex zoning or metamorphic rims. Seven grains were used for final age determination using four core analyses and three rim analyses to calculate a concordia age of 95.9 ± 1.0 Ma (MSWD 0.3) and a weighted mean age of 95.7 ± 1.6 Ma. Alkali-feldspar granite of this age is likely truncated by the younger mafic intrusives to the east, so this age is inferred to be accurate for all alkali-feldspar granites west of the granodiorite within our field area (Figure 2).

09BEN29 – Bendeleben pluton, monzogranite:

Sample 09BEN29 was collected from the northern monzogranite unit. Zircons were mostly elongated, euhedral and clear and were rarely longer than 200 μm in length. Most grains showed simple zoning patterns under CL, though a few showed metamorphic recrystallization. Six grains were used for final age determination using one core analysis and five rim analyses to calculate a concordia age of 82.9 ± 0.3 Ma (MSWD 1.5), excluding one spot for discordance, and a weighted mean age of 82.5 ± 0.9 Ma.

09BEN61 – Bendeleben pluton, gabbro:

Sample 09BEN61 was collected from the central gabbro unit and was the youngest sample dated by zircon geochronology in our field area. All zircons were elongated, euhedral and clear. Grains were generally bright under CL imaging and showed simple zoning patterns. Five grains were used for final age determination using only rim analyses to calculate a concordia age of 82.8 ± 0.5 Ma (MSWD 1.0) and a weighted mean age of 82.7 ± 1.4 Ma.

09BEN63 – Bendeleben pluton, alkali-feldspar granite:

Sample 09BEN63 was collected from the alkali-feldspar granite unit in the northeastern region of the field area. Zircons were stubby and generally equant with either rounded or euhedral shapes and displayed a consistent honey-blonde color. Rounded grains had abundant zones of internal recrystallization and convolute zoning under CL (Corfu et al., 2003) and were avoided for analysis. Euhedral grains showed simple magmatic growth zoning and were used exclusively for analysis. Seven grains

were used for final age determination using three core analyses and four rim analyses to calculate a concordia age of 84.6 ± 0.4 Ma (MSWD 2.4) and a weighted mean age of 84.3 ± 1.4 Ma.

09BEN73 – Windy Creek pluton, alkali-feldspar granite:

Sample 09BEN73 was collected from the topographically highest point within the Windy Creek pluton and was the only sample dated from this unit. Zircons were bimodal in size with large (~ 200 μm long), cloudy, honey-colored grains and small (~ 100 μm long), clear grains. All zircons were dark under CL, but displayed simple zoning with no evidence for metamorphic overgrowth. Seven grains were used for final age determination using one core analysis and six rim analyses to calculate a concordia age of 96.3 ± 0.6 Ma (MSWD 0.8), excluding 2 spots for discordance, and a weighted mean age of 96.3 ± 1.7 Ma.

Trace element and REE

Comparison of incompatible trace element concentrations of Rb to Nb+Y has been shown to be useful in making interpretations as to the tectonic setting for intrusion of large igneous bodies into the shallow crust (Pearce et al., 1984). Ratios of (Nb+Y) to Rb in ppm for all plutonic bulk rock samples except the gabbro in the Bendeleben pluton plot along the boundary between the syn-collisional and volcanic arc fields of a trace element discrimination diagram modeled after Pearce et al. (1984) (Figure 9). The syn-collisional field most accurately describes S-type granites formed under continent-continent or arc-continent collisional settings where Rb values are enriched due to

Figure 9: Trace element discrimination diagram modeled after Pearce et al. (1984) for intrusive samples collected from the Benideleben and Windy Creek plutons (open circles), Kigluaik pluton (diamonds) (Amato and Wright, 1997) and Okhotsk-Chukotka Volcanic Belt (crosses) (Akinin and Miller, 2011). K1 represents the mafic root, K2 represents the mixing zone and K3 represents the felsic cap all from the Kigluaik pluton (Amato and Wright, 1997).

volatile interaction with a subducting slab. The volcanic arc field describes granites intruded at active continental margins where subduction of oceanic crust is occurring. Samples from the Bendeleben pluton suggest that the magma generation which later fed multiple injection events from 104-82 Ma was likely initiated during the long-lived pre-Cretaceous subduction setting for the Seward Peninsula along with terrane accretion via multiple arc and continental collision events. This interpretation is in agreement with the suggestion that Cretaceous plutonism in the Seward Peninsula is the result of slab-rollback-induced extension above an actively subducting slab during the Cretaceous (Amato and Miller, 1997). In this case, rollback was caused as the northward subducting plate beneath Russia and the Seward Peninsula moved southward, causing extension in the overlying plate (Figure 10). The tendency of some samples to plot near the boundary between the volcanic arc and syn-collisional fields is suggestive of either generation in a Rb-poor crust or of partial mixing between mantle and crust-derived magmas (Pearce et al., 1984). Data from the Kigluaik pluton plot near the triple junction between collisional, within-plate and volcanic arc granites, though the “felsic cap” plots in the within-plate field (Figure 9). Trace elemental data for volcanic samples from the Okhotsk-Chukotka Volcanic Belt (OCVB) at ages similar to the Bendeleben and Windy Creek plutons were also plotted in discrimination diagrams modeled after Pearce et al. (1984) and all fell into the volcanic arc field (Figure 9) descriptive of formation along an active subduction front. Plots of ppm Y, Rb and Nb against weight percent SiO_2 for samples in the Bendeleben and Windy Creek plutons also plot in fields supporting a combined collisional and volcanic arc setting for magma generation based on Nb and Y concentrations (Pearce et al., 1984), and are more likely to have intruded continental crust

Figure 10: Schematic plate reconstruction for the motion and location of various continental fragments of the Arctic during the Late Jurassic (a) and Late Cretaceous (b) (Harris et al., 2011, chapter II, this volume). The heavy dashed line in Figure 10b shows the prior location of subduction during the Jurassic seen in Figure 10a. Alaska terrane accretion history from Plafker and Berg (1994), South Anyui Suture info from Sokolov et al. (2009), Russian terrane accretionary history from Parfenov et al. (2009) and bathymetric images and approximate locations of the Alpha Ridge and Mendeleev Ridge are from Jakobsson et al. (2008) and Dove et al. (2010). Magmatic arc ages are from Akinin and Miller (2011) and Layer et al. (2001). Abbreviations are: AA, Arctic Alaska; AR, Alpha Ridge; CC, Chukchi Cap; Ch, Chukotka; Kb, Koyukuk basin; KO, Kolyma-Omolon superterrane; KOR, Koryak-Kamchatka tectonic collage; Ky, Koyukuk arc; LR, Lomonosov Ridge; MR, Mendeleev Ridge; Okh, Okhotsk terrane; PA, Penzhina-Anadyr tectonic collage; SAZ, South Anyui Suture zone; SP, Seward Peninsula; VFB, Verkhoyansk Fold-Thrust Belt; VK, Verkhoyansk tectonic collage; WCT, Wrangellia composite terrane; YCT, Yukon composite terrane.

than to be rift-related based on Rb concentrations (Figure 11). Samples from the Bendeleben pluton show a decrease in Rb concentrations along with younging of crystallization while (Nb+Y) concentrations show increase with younging (Figure 12). This is tentatively interpreted as gradual enrichment of incompatible elements in the melt phase of a core magma chamber leading to higher eventual concentrations in progressively younger intrusives. The gradual decrease of Rb concentrations is most likely related to the tendency of Rb to be incorporated into older alkali-feldspar granites as compared to younger, mafic lithologies.

Chondrite-normalized REE patterns for zircons that were collected from intrusive samples of our field area display similar patterns with minor differences (Figure 13, Table 3). Despite differences in relative REE amounts, zircons from all samples showed depletion in LREE and enrichment in HREE likely caused by similarity of HREE ionic radii to that of Zr leading to ease of substitution (Hoskin and Ireland, 2000). Negative Eu anomalies and positive Ce anomalies were also seen in zircons from all samples, which is a typical feature for chondrite-normalized REE in zircons (Hoskin and Ireland, 2000). Studies of zircon REE patterns as a tool for provenance indication have suggested that despite a diverse array of magma crystallization conditions, REE patterns are generally similar and are not typically useful in terms of provenance indication (Hoskin and Ireland, 2000; Sawka, 1988) though can be useful as source rock lithology indicators when found in detrital samples (Belousova et al., 2002).

Zircons from the pegmatite unit show relative enrichment in La, Pr and Nd relative to other samples, but are similar in all other REE content. Zircons from all other intrusive samples from the Bendeleben pluton are similar in REE content despite

Figure 11: Trace element concentrations in ppm plotted against SiO_2 expressed as weight % in discrimination diagrams modeled after Pearce et al. (1984). Abbreviations are: ocean ridge granites (ORG), volcanic arc granites (VAG), within-plate granites (WPG) and collisional granites (COLG).

Figure 12: Trace element concentrations in ppm plotted against sample age. Note the difference in scale between (Nb+Y) and Rb concentrations. Solid lines show trends for all data and dashed lines show trends for the younger pulse of magmatism. Graphs do not incorporate any correction for variable lithology.

Figure 13: Chondrite-normalized REE concentrations of zircons from samples collected within a pegmatite dike (a) and the Bendeleben (b-e) and Windy Creek (f) plutons. Data in Table 3.

Table 3: Chondrite-normalized REE content of zircons collected from the Bendeleben and Windy Creek plutons. Plots in Figure 13.

	La	Ce	Pr	Nd	Sm	Eu	Gd	Dy	Ho	Er	Yb
Atomic #	57	58	59	60	62	63	64	66	67	68	70
09BEN20-1	1.0	13.0	4.6	9.7	46.1	10.3	143.9	239.7	270.5	401.1	539.5
09BEN20-2	4.0	15.5	8.6	12.5	45.3	22.7	145.6	196.9	214.9	267.2	314.5
09BEN20-3	42.2	26.8	16.4	10.2	30.6	16.5	93.7	162.0	186.5	268.2	348.6
09BEN20-4	0.8	12.9	4.5	11.2	44.1	26.7	145.0	201.6	211.4	272.9	320.3
09BEN20-5	0.8	15.0	5.4	13.9	54.6	12.4	170.1	273.7	331.7	482.0	651.2
09BEN20-6	1.1	13.3	3.5	6.1	23.8	12.4	80.2	131.7	159.8	218.5	297.9
09BEN20-7	0.6	16.6	3.9	10.1	49.9	10.8	189.1	302.7	393.3	550.3	750.8
09BEN20-8	0.1	3.8	0.6	1.6	16.1	3.2	93.0	199.6	254.9	361.0	478.1
09BEN20-9	0.1	8.5	1.1	3.2	16.9	3.3	61.9	112.1	120.1	178.2	233.9
09BEN20-10	0.1	6.9	0.5	1.4	9.4	2.2	41.8	88.2	104.8	158.6	238.7
09BEN20-11	0.2	12.2	2.0	6.7	42.5	10.5	156.5	214.3	224.2	283.0	311.0
09BEN20-12	0.1	20.1	0.8	2.0	14.5	12.0	89.1	324.9	533.6	1034.7	2187.7
09BEN26-1	0.1	5.6	0.5	1.4	15.0	3.4	96.0	230.8	275.4	374.9	460.6
09BEN26-2	0.1	17.2	1.2	4.7	32.6	7.6	168.2	429.6	674.8	1041.3	1737.9
09BEN26-3	0.0	12.6	0.4	1.2	9.1	2.9	55.0	191.7	306.4	546.5	1039.9
09BEN26-4	0.0	7.4	0.2	0.7	8.1	1.8	55.0	206.3	318.0	561.7	1069.2
09BEN26-5	0.1	6.1	0.4	0.9	7.2	8.8	43.6	138.1	220.8	376.5	717.3
09BEN26-6	0.1	3.4	0.4	1.0	12.9	2.1	97.9	289.6	348.0	462.4	542.8
09BEN26-7	11.1	30.8	3.4	1.9	6.8	2.5	45.3	184.4	306.9	582.8	1112.2
09BEN26-8	0.0	4.5	0.2	0.6	5.8	1.5	40.0	141.9	198.6	345.5	602.5
09BEN26-9	0.1	3.2	0.2	0.5	4.5	0.6	33.2	131.2	196.4	349.3	684.3
09BEN26-10	0.1	13.1	1.0	3.3	19.4	8.8	107.7	274.1	400.7	633.2	1023.1
09BEN29-1	1.6	23.2	4.8	8.2	49.5	9.1	233.4	587.5	755.8	1316.8	1918.9
09BEN29-2	3.3	24.0	3.0	2.8	11.7	4.6	74.8	253.6	411.9	695.3	1190.4
09BEN29-3	0.5	9.3	0.7	0.8	5.5	1.3	47.1	185.5	305.3	543.9	988.8
09BEN29-4	0.1	4.0	0.5	1.3	12.9	1.1	81.0	235.3	341.2	551.8	881.1
09BEN29-5	0.2	9.8	2.1	7.8	52.4	4.6	177.8	264.6	300.7	445.8	618.1
09BEN29-6	1.2	22.6	2.6	3.8	25.7	7.0	144.8	409.4	606.8	1013.5	1624.9
09BEN29-7	0.0	3.9	0.3	0.8	9.9	1.0	70.3	269.8	456.0	760.2	1465.9
09BEN29-8	0.1	19.4	1.2	3.7	22.5	12.8	111.9	304.0	437.9	741.0	1181.2
09BEN29-9	0.2	13.1	2.0	6.1	37.1	3.1	164.9	372.6	499.5	796.0	1211.9
09BEN29-10	0.1	10.0	0.7	1.9	13.8	2.0	63.3	140.5	174.5	275.4	419.7

	La	Ce	Pr	Nd	Sm	Eu	Gd	Dy	Ho	Er	Yb
Atomic #	57	58	59	60	62	63	64	66	67	68	70
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09BEN61-1	0.1	23.5	0.6	1.8	13.2	3.5	58.7	133.1	161.5	249.8	362.5
09BEN61-2	0.1	11.4	1.0	3.0	18.5	7.6	81.2	155.5	184.5	274.8	356.2
09BEN61-3	0.9	21.2	7.5	21.3	102.7	55.4	370.3	565.8	662.3	931.9	1157.1
09BEN61-4	1.0	13.1	4.5	9.7	45.8	27.8	173.0	291.0	377.5	539.3	717.2
09BEN61-5	0.2	23.3	2.1	7.4	45.7	11.4	188.0	328.2	366.8	545.4	678.3
09BEN61-6	0.8	13.9	3.8	8.2	42.5	25.0	174.5	305.6	405.1	594.8	812.6
09BEN61-7	0.1	19.2	1.1	3.5	23.0	6.0	103.5	200.6	244.6	357.4	474.9
09BEN61-8	0.0	26.8	0.4	1.5	10.1	2.8	51.4	118.7	153.0	231.7	334.2
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09BEN63-1	0.0	5.3	0.1	0.1	1.1	1.3	9.0	55.1	99.3	180.6	459.9
09BEN63-2	0.1	8.6	1.8	6.7	32.0	6.4	109.0	162.8	187.1	249.1	328.1
09BEN63-3	0.2	11.1	2.2	7.6	40.9	9.2	147.2	222.4	263.9	355.1	451.3
09BEN63-4	0.7	8.8	1.2	1.5	11.6	6.6	74.3	208.9	292.7	436.0	666.1
09BEN63-5	0.1	7.9	0.8	2.2	16.2	2.6	85.9	221.2	321.0	521.1	882.2
09BEN63-6	0.1	2.9	0.7	2.2	20.4	3.6	90.2	114.3	97.7	111.0	115.6
09BEN63-7	0.1	7.8	1.0	3.0	19.8	2.7	87.7	153.6	177.5	249.6	333.0
09BEN63-8	0.0	6.2	0.3	0.8	6.5	4.9	42.1	132.6	215.9	344.3	610.4
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09BEN73-1	0.1	52.9	0.3	0.6	3.2	5.1	17.5	64.3	127.8	229.3	624.9
09BEN73-2	0.0	54.6	0.2	0.4	2.8	3.6	17.1	60.6	134.3	228.7	638.0
09BEN73-3	0.6	117.9	1.9	3.5	15.1	15.7	74.7	209.9	413.7	685.1	1581.6
09BEN73-4	0.1	75.5	0.7	1.8	8.2	11.7	43.3	121.5	213.2	355.3	737.9
09BEN73-5	0.1	78.9	0.5	1.1	4.5	5.6	24.4	80.9	162.9	289.1	764.2
09BEN73-6	0.5	124.3	1.2	1.9	9.6	9.1	46.8	155.0	353.7	587.1	1510.9
09BEN73-7	0.2	166.5	1.3	2.9	12.3	12.4	54.7	149.5	294.3	490.2	1167.8
09BEN73-8	0.6	99.8	1.2	1.7	6.7	8.4	35.8	107.8	214.4	359.4	822.2

difference in petrography. Zircons from the one sample collected from the Windy Creek pluton, however, are enriched in Ce by an order of magnitude relative to all other samples. Similarly, both Ce/Ce* and Eu/Eu* ratios are several times higher for zircons from the Windy Creek pluton than any lithologic unit of the Bendeleben pluton (Table 4) where Ce* and Eu* are the expected concentrations by interpolating bordering elements based on atomic number (La and Pr for Ce*, Sm and Gd for Eu*). Ce/Ce* ratios for all samples are greater than 1, indicative of positive anomalies, and Eu/Eu* values for all samples are less than 1, indicative of negative anomalies (Figure 13, Table 4).

Zircon Ti concentration geothermometry

Titanium concentrations were measured for all samples collected from the Bendeleben and Windy Creek plutons and were used as indicators of approximate crystallization geothermometers based on modeling by Watson et al. (2006). By conducting a series of experiments in which synthetic zircons were crystallized and subsequently analyzed for their Ti concentrations under various temperatures, a general equation of:

$$\log(\text{Ti}_{\text{zircon}}) = (6.01 \pm 0.03) - \frac{5080 \pm 30}{T \text{ (K)}}$$

was formed describing the dependence of Ti concentration in zircon structure to crystallization temperature (Watson et al., 2006). Results from samples collected in the Bendeleben pluton were similar to those for the Windy Creek pluton with a consistent crystallization temperature for all samples between 796° and 836° C ($\pm \sim 15^\circ \text{ C}$) except

Table 4: Chondrite-normalized Ce and Eu ratios of zircons collected from the Bendeleben and Windy Creek plutons.

	Ce/Ce*	Eu/Eu*		Ce/Ce*	Eu/Eu*
09BEN20-1	6	0.13	09BEN61-1	99	0.13
09BEN20-2	3	0.28	09BEN61-2	36	0.20
09BEN20-3	1	0.31	09BEN61-3	8	0.28
09BEN20-4	7	0.33	09BEN61-4	6	0.31
09BEN20-5	7	0.13	09BEN61-5	40	0.12
09BEN20-6	7	0.28	09BEN61-6	8	0.29
09BEN20-7	11	0.11	09BEN61-7	56	0.12
09BEN20-8	20	0.08	09BEN61-8	292	0.12
09BEN20-9	22	0.10			
09BEN20-10	32	0.11			
09BEN20-11	20	0.13	09BEN63-1	115	0.42
09BEN20-12	68	0.33	09BEN63-2	17	0.11
			09BEN63-3	18	0.12
			09BEN63-4	10	0.23
09BEN26-1	32	0.09	09BEN63-5	31	0.07
09BEN26-2	56	0.10	09BEN63-6	15	0.08
09BEN26-3	90	0.13	09BEN63-7	25	0.06
09BEN26-4	133	0.09	09BEN63-8	81	0.30
09BEN26-5	40	0.50			
09BEN26-6	23	0.06			
09BEN26-7	5	0.14	09BEN73-1	372	0.68
09BEN26-8	68	0.10	09BEN73-2	568	0.52
09BEN26-9	31	0.05	09BEN73-3	113	0.47
09BEN26-10	46	0.19	09BEN73-4	284	0.62
			09BEN73-5	321	0.53
			09BEN73-6	150	0.43
09BEN29-1	8	0.08	09BEN73-7	307	0.48
09BEN29-2	8	0.16	09BEN73-8	118	0.54
09BEN29-3	16	0.08			
09BEN29-4	23	0.03			
09BEN29-5	17	0.05			
09BEN29-6	13	0.12			
09BEN29-7	35	0.04			
09BEN29-8	53	0.26			
09BEN29-9	20	0.04			
09BEN29-10	37	0.07			

for the pegmatite unit (sample 09BEN20) which yielded a crystallization temperature of 911° C (Table 5).

Discussion:

Relationship between the Bendeleben and Windy Creek plutons:

The Telephone Creek fault mapped between the Bendeleben and Windy Creek plutons is an eastward dipping normal fault that separates the Bendeleben pluton and high-grade metamorphic rocks of the Kigluaik Metamorphic Complex from the Windy Creek pluton and greenschist-grade rocks of the Nome Group. On a more regional scale, this fault also separates the east-west trending Bendeleben Mountains from the northern part of the north-south trending Darby Mountains. Immediately obvious in the field is the discrepancy between topography of the landscapes in these two mountain belts (Figure 14). The Bendeleben Mountains are composed of high relief, jagged ridges with little vegetation cover at the summits. The Darby Mountains, in the eastern part of our field area, were much different, composed of lower-relief, broad, rounded peaks with prevalent vegetation cover (Figure 14). This is simplistic evidence that the Darby Mountains may represent longer exposure at the surface than the Bendeleben Mountains. The delayed exposure of the Bendeleben Mountains is most likely a consequence of exhumation of the Bendeleben Mountains along the Bendeleben fault to the south than exhumation along the Telephone Creek fault. Apatite (U-Th)/He dating is in agreement with young exhumation of the Bendeleben Mountains as average apatite ages dated from the Bendeleben pluton are 38.7 ± 2.4 Ma suggesting passage of the Bendeleben pluton

Table 5: Crystallization temperatures for magmatic samples collected in the Bendeleben and Windy Creek plutons based on titanium concentrations (ppm) of zircons as measured via SHRIMP-RG. At the end of the sample names an R indicates a zircon rim analysis and a C indicates a zircon core analysis. Temperature modeling performed using equations defined by Watson et al. (2006).

	Sample	Calculated T (°C)	Ti (ppm)	max calculated T (°C)	min calculated T (°C)
Pegmatite	09BEN20-1R	916.2	54.7	931.7	900.9
	09BEN20-2R	987.8	95.7	1004.8	971.1
	09BEN20-3R	996.2	101.7	1013.4	979.3
	09BEN20-4C	939.9	66.3	955.9	924.2
	09BEN20-5C	958.1	76.5	974.4	942.0
	09BEN20-6R	912.2	52.9	927.6	897.0
	09BEN20-7C	967.2	82.0	983.8	950.9
	09BEN20-8C	845.6	29.4	859.7	831.7
	09BEN20-9C	893.8	45.3	908.8	878.9
	09BEN20-10R	832.6	26.0	846.4	819.0
	09BEN20-11R	930.4	61.5	946.2	914.9
	09BEN20-12R	762.2	12.7	774.8	749.9
	AVERAGE 09BEN20	911.9	58.7	927.3	896.7
Alkali-feldspar granite (Kb-af)	09BEN26-1C	815.5	22.0	829.0	802.1
	09BEN26-2R	791.4	17.3	804.5	778.5
	09BEN26-3C	801.0	19.1	814.3	787.9
	09BEN26-4R	736.3	9.5	748.4	724.4
	09BEN26-5C	833.9	26.3	847.7	820.2
	09BEN26-6R	808.8	20.6	822.2	795.6
	09BEN26-7C	840.6	28.1	854.6	826.8
	09BEN26-8R	779.4	15.2	792.3	766.8
	09BEN26-9R	764.1	12.9	776.6	751.7
	AVERAGE 09BEN26	796.8	19.0	809.9	783.8
Monzogranite (Kb-mo)	09BEN29-1C	774.6	14.5	787.3	762.0
	09BEN29-2R	801.9	19.2	815.1	788.8
	09BEN29-3R	699.7	6.1	711.1	688.4
	09BEN29-4R	866.2	35.5	880.7	851.9
	09BEN29-5C	913.1	53.3	928.5	897.9
	09BEN29-6R	766.2	13.2	778.8	753.8
	09BEN29-8R	818.0	22.6	831.5	804.6
	AVERAGE 09BEN29	805.7	23.5	819.0	792.5

	Sample	Calculated T (°C)	Ti (ppm)	max calculated T (°C)	min calculated T (°C)
Gabbro (Kb-ga)	09BEN61-1R	839.1	27.7	853.0	825.3
	09BEN61-2R	767.7	13.5	780.3	755.3
	09BEN61-3R	838.9	27.6	852.8	825.1
	09BEN61-4R	844.2	29.0	858.2	830.3
	09BEN61-5R	861.0	33.9	875.4	846.8
	09BEN61-6R	859.2	33.4	873.6	845.1
	09BEN61-7R	878.0	39.5	892.7	863.4
	09BEN61-8R	812.5	21.4	825.9	799.2
	AVERAGE 09BEN61	837.6	28.2	851.5	823.8
Alkali-feldspar granite (Kb-af)	09BEN63-1R	669.4	4.2	680.3	658.7
	09BEN63-2R	951.4	72.6	967.6	935.4
	09BEN63-3C	882.2	41.0	897.0	867.6
	09BEN63-4R	738.3	9.7	750.4	726.4
	09BEN63-5C	855.9	32.4	870.2	841.8
	09BEN63-6C	908.7	51.4	924.0	893.6
	09BEN63-8R	805.7	20.0	819.1	792.6
	AVERAGE 09BEN63	830.2	33.0	844.1	816.6
Alkali-feldspar granite (Kwc)	09BEN73-1R	792.1	17.4	805.2	779.2
	09BEN73-2R	809.3	20.7	822.7	796.1
	09BEN73--3R	792.4	17.4	805.4	779.4
	09BEN73-4R	846.2	29.6	860.3	832.3
	09BEN73-5R	786.8	16.5	799.8	774.0
	09BEN73-6R	775.4	14.6	788.2	762.8
	09BEN73-7R	826.0	24.4	839.7	812.4
	09BEN73-8R	780.0	15.3	792.9	767.3
	AVERAGE 09BEN73	801.0	19.5	814.3	787.9

Figure 14: Topographic differences between the Bendeleben Mountains and the less-rugged and relatively longer-exposed northern Darby Mountains.

through the 70° He closure isotherm in the Eocene (McDannell, 2011). A (U-Th)/He apatite age collected from the Windy Creek pluton was dated at 53 ± 15 Ma with error too great to be useful in terms of exhumation history relative to the Bendeleben pluton (McDannell, 2011). The higher metamorphic grade of country rock surrounding the Bendeleben pluton as compared with country rock surrounding the Windy Creek pluton suggests equilibration at a deeper, hotter level for the Bendeleben pluton than for the Windy Creek pluton assuming a simple regional isotherm structure. This observation is in agreement with the well-documented interpretation that the Kigluaik Metamorphic Complex represents a higher metamorphic grade equivalent of the stratigraphically higher Nome Group units. The presence of cordierite, garnet and biotite in the biotite-garnet schist unit of the Kigluaik Metamorphic Complex surrounding the Bendeleben pluton provides an important low pressure, high temperature constraint for metamorphic conditions for the country rock. U-Pb dating of metamorphic monazite from metapelites in the Kigluaik Metamorphic Complex suggests a minimum age for high-temperature metamorphism of 91 Ma, though heating could have been as early as 115 Ma (Amato et al., 2002; Amato and Wright, 1998; Amato, pers. comm., 2011).

Pluton emplacement:

Data from the Bendeleben and Windy Creek granitoid plutons suggest emplacement during a multiple-phase injection event lasting about 20 m.y. within an area experiencing north-south oriented extension during the Late Cretaceous. $^{207}\text{Pb}/^{206}\text{Pb}$ vs. $^{238}\text{U}/^{206}\text{Pb}$ concordia and ^{207}Pb -corrected $^{206}\text{Pb}/^{238}\text{U}$ mean SHRIMP-RG ages of zircons from the Bendeleben pluton range from 95.9 ± 1.0 Ma in the center of the pluton (our

western field area) to 84.6 ± 0.4 Ma at the eastern margin. Localized gabbro and granodiorite zones found intruding older, more felsic, rocks within the Bendeleben pluton are as young as 82.8 ± 0.5 Ma. An age of 104 ± 1 Ma dated by U-Pb zircon geochronology from outside of our field area at the western margin of the Bendeleben pluton (Gottlieb, 2008; Gottlieb and Amato, 2008b), implies a more complex history of magmatism than previously suggested. Orthogneisses and strained metasyenites bordering the Kigluaik pluton even further to the west have been dated by zircon U-Pb geochronology at 105-115 Ma and are interpreted to represent limited early magmatic activity for the area (Amato and Wright, 1998). Stepwise dissolution of zircons collected from granodiorite within the mafic root of the Kigluaik pluton yielded an average age of 91 Ma (Amato and Wright, 1998; Amato, pers. comm., 2011). Crystallization of this phase was described as the main stage of magmatism for the Kigluaik pluton (Amato and Wright, 1998) and predates mafic intrusives of the Bendeleben complex by 7 m. y. Combined zircon U-Pb geochronologic results from the Kigluaik and Bendeleben plutons show a general younging trend of magmatism from west to east across the southern Seward Peninsula during the Cretaceous. Zircon geochronology and variable petrology within the Bendeleben pluton itself also support progressively eastward emplacement through multiple injection events. The absence of xenoliths from most pluton exposures, the diversity in crystallization ages and the diversity of pluton lithologies precludes intrusion via stoping and cooling as one coherent diapiric body.

Just across the Bering Sea to the west of the Seward Peninsula is the eastern Chukotka zone of the Okhotsk-Chukotka Volcanic Belt (OCVB) of Russia which stretches approximately 3250 km from the Uda River in southern Russia to the eastern

Chukchi Peninsula of northeastern Russia. The OCVB was originally described as a Neocomian to Paleogene province of calc-alkaline volcanic deposits formed in a supra-subduction setting (Akinin and Miller, 2011). Recent work towards a more precise compilation of ages for Early Cretaceous felsic volcanism in the OCVB has shown that eruptions were of a discontinuous, pulsed nature (Akinin and Miller, 2011). New ages for volcanic activity in the OCVB have been measured at 105, 100, 96, 93-92, 87, 82 and 77 Ma where events at 87 and 82 were most voluminous (Akinin and Miller, 2011). Plateau basalts emplaced around 77 Ma marked a change in tectonic setting from a subduction zone to a transform margin for the OCVB. Ages of plutonic intrusions from the Bendeleben Mountains all match very well with young volcanic events in the OCVB across the Bering Sea which were also induced by melting above a northward subducting plate resulting mostly in felsic volcanism (Akinin and Miller, 2011). Based on ages and geographical extent, it seems as though the OCVB and the Seward Peninsula may have been affected by a similar tectonic history responsible for Late Cretaceous magmatic and volcanic pulses involving extension above a subducting plate experiencing slab rollback (Figure 10).

Petrographic analysis of 85 samples collected from the plutons and surrounding country rock supports an extensional setting of the Seward Peninsula during the Cretaceous through observation of sense of shear indicators and well preserved high temperature sheared microfabrics in the metasediments. All are supportive of north-south directed extensional deformation and in agreement with previous studies of nearby gneiss domes and dike complexes in the Seward Peninsula (Amato et al., 2002; Amato et al., 2004). The nearby Kigluaik gneiss dome has been shown to contain numerous indicators

of north-south oriented extension in Kigluaik Metamorphic Complex country rocks above the biotite-in isograd. These sense of shear indicators are very similar to those documented in the Bendeleben Mountains such as pressure shadow development around garnet porphyroblasts showing top-down shear, biotite and white mica decorated shear bands and north-south lineations formed via mineral stretching (Amato et al., 2002). Igneous rocks of the Bendeleben pluton are variable in composition showing an outer zone of alkali-feldspar granite with localized zones of granodiorite and gabbro and homogenous monzogranite toward the interior of the pluton. The gabbro and monzogranite units are suggestive of juvenile mafic magma injections into a magma chamber which had previously produced the older, more felsic rocks. Country rocks south of the Bendeleben pluton are southward-dipping well-foliated units of garnet and sillimanite-bearing schist and boudinaged marble with top-to-south sheared strain shadows. The Bendeleben pluton is separated to the southeast from the Windy Creek pluton by the Telephone Creek normal fault, and it is possible that the Windy Creek pluton represents a branch of the outer, alkali-feldspar granite margin of the Bendeleben pluton based on similarity of age and lithology. The crystallization age of 96.3 ± 0.6 Ma for the Windy Creek pluton matches well with the alkali-feldspar granite intrusion in the western Bendeleben pluton (95.9 ± 1.0 Ma) and could have been emplaced synchronously at distance. It is also possible that the Windy Creek pluton was a completely separate intrusion unrelated to the Bendeleben pluton, although lithologic and geochemical similarity and the close proximity between the two, especially when restoring the Telephone Creek fault, are strong evidence supporting a related emplacement history.

The Bendeleben pluton shows several distinctive similarities to the nearby Kigluaik pluton including: 1) abundance of pegmatite near the upper contact, 2) granodioritic pluton composition near the upper contact and 3) common aplitic dikes in country rock near the pluton (Amato and Miller, 1997). The Kigluaik pluton has an intrusive age of 91 Ma though some samples indicate limited magmatism as early as 110 Ma (Amato, pers. comm., 2011). The similarity in magma crystallization ages for the Kigluaik pluton and the Bendeleben pluton suggests emplacement of both bodies under similar tectonic conditions. The variable ages of petrologically different units seen in the Bendeleben Mountains also matches the episodic nature of emplacement proposed for the Kigluaik pluton where geochemical evidence is suggestive that a late-crystallizing mafic root and felsic cap were either comagmatic or derived from the same source prior to emplacement (Amato and Wright, 1997). For the Bendeleben pluton, and likely the Kigluaik pluton as well, modal composition becomes more mafic with younger crystallization. This pattern suggests influence from liquid density segregation processes like those proposed for the Mount Mazama magma chamber where rhyodacite eruption was followed by andesite and mafic crystal mush emplacement, though all originating from a single zoned magma chamber experiencing repeated recharge by a mafic parent magma (Druitt and Bacon, 1989). Multiple eastward progressing episodes of extension in the Kigluaik and Bendeleben Mountains likely led to initial crystallization of the "felsic cap" described by Amato and Miller (1997) which became the outer biotite-rich granite now found around the margins of both plutons. Continued periods of extension provided the subsequent pathways for intrusion of the lower, depleted mafic units into the younger "cap" providing the large time differentials documented in zircon crystallization

ages. Replenishment of the magma chamber at depth by continuing subduction is invoked to explain the long lifetime of the magma chamber. As this slab experienced southward rollback, inducing extension in the over-riding plate, it also removed the magmatic source at depth, halting replenishment and intrusion by about 83 Ma.

The Bendeleben normal fault located south of the Bendeleben Mountains separates this range from an extensive basin, McCarthy's Marsh, to the south. Scarps ranging from 4-7 m high are preserved along the southern flank of the Bendeleben Mountain Range, bearing approximately east-west. This fault lies directly along strike with a north dipping normal fault located north of the Kigluaik Mountains to the west, suggesting continuation of an extensional system responsible for exposing both the Kigluaik and Bendeleben plutons and associated gneiss domes in the footwalls of both faults. Surface modeling based on apatite (U-Th)/He dating performed along a north-south transect through the Bendeleben Mountains to the normal fault using Pecube (Braun, 2003) and HEFTY software (Ketcham, 2005) suggests development of this fault by the Late Eocene, although the entire block was likely experiencing episodic exhumation and extension since the Cretaceous with greatest amounts of exhumation from 65 to 55 Ma (McDannell, 2011). These results match well with thermochronologic results from Calvert et al. (1999) who used the $^{40}\text{Ar}/^{39}\text{Ar}$ method to determine that the region surrounding the Kigluaik gneiss dome experienced cooling of hornblende through the 535° C isotherm between 86 and 82 Ma, cooling through mica 300°- 400° C isotherm around 85-83 Ma and variable K-feldspar isotherm spectra (300°-150° C) cooling between 82 and 65 Ma consistent with initial rising of the Kigluaik gneiss dome and potentially the Bendeleben complex from mid-crustal levels between 110 and 82 Ma.

Dumitru et al. (1995) determined a final core cooling age around 30 Ma which matches an average cooling age modeled by McDannell (2011) through the $75^{\circ} \pm 5^{\circ} \text{C}$ ^4He apatite closure temperature (Reiners and Farley, 2001; Wolf et al., 1998; Wolf et al., 1996) of 38.7 ± 2.4 Ma. Modeling results by McDannell (2011) suggest an exhumation history for the Bendeleben pluton involving an initial unroofing and cooling period from 80-65 Ma, normal fault development and rapid exhumation from 65-55 Ma followed by slow uplift, unroofing and cooling until 30 Ma. Further topographic development occurred in the final 30 m.y. until the present, associated with a final 1 km of unroofing (McDannell, 2011).

Cretaceous tectonic setting of the Seward Peninsula:

Middle to Late Cretaceous extensional emplacement of Kigluaik and Bendeleben plutons in the Bering Strait region is well supported via the following evidence:

- 1: Crustal thickness of approximately 32 km beneath the Chukchi and inner Bering shelves matches closely with average global thickness values for extended continental crust (Klemperer et al., 2002b).
- 2: Velocity data and reflectivity are also in agreement with extensional fabrics formed in a previously overthickened (greater than 47 km thick) crust within the Seward Peninsula and Chukotka (Klemperer et al., 2002b; Wolf et al., 2002).
- 3: Average orientations of dike swarms abundant in the Seward Peninsula from the York, Bendeleben and Darby Mountains is also in support of north-northwest to south-southeast oriented Middle to Late Cretaceous extension. Average strike orientation of dikes are 040° from the York Mountains, $30\text{-}50^{\circ}$ from the Darby

- Mountains and 085° from the Bendeleben Mountains (Amato et al., 2003 and this study). Dikes in the Kigluaik Mountains have an emplacement age of 84 Ma.
- 4: Consistent north-northwest to south-southeast stretching mineral lineations are abundant in the Seward terrane (Amato et al., 2002; Amato et al., 2004; this study).
- 5: Consistent sense of shear indicators in the metasediments found south of the Bendeleben pluton in the form of shallow south dipping foliations, mantled porphyroblasts showing top-down shear sense and plunging away from the pluton, centimeter scale normal faults and stretched mineral lineations plunging away from the pluton. Similar sense of shear indicators are also documented in the nearby Kigluaik gneiss dome, also indicating north-south extensional deformation (Amato et al., 2003; Amato et al., 2004).
- 6: Rapid Late Cretaceous exhumation of the Kigluaik and Bendeleben Mountains as documented by apatite (U-Th)/He and $^{40}\text{Ar}/^{39}\text{Ar}$ thermochronology (Calvert et al., 1999; McDannell, 2011).

The 91 Ma Kigluaik pluton is a close match to the Bendeleben pluton in terms of composition, age, orientation and interpreted emplacement history, and is located along strike of the Bendeleben normal fault to the west. For these reasons, it is likely also analogous to the Bendeleben pluton in terms of emplacement history. Extensive work performed on the Kigluaik pluton has provided strong evidence supporting north-south or north-northwest to south-southeast extensionally-driven emplacement, suggesting a similar style of emplacement for the Bendeleben pluton. There is also strong evidence

suggesting that the Kigluaik pluton formed in a subduction-related setting based on isotopic and trace element data and comparisons to high-K mafic plutonic rocks generated in known subduction related settings in locations such as the Andes, Australia and Japan (Amato and Wright, 1997).

Conclusions:

This study supports the hypothesis that the southward retreat of a northward subducting slab beneath the Seward Peninsula caused Cretaceous extension in the over-riding plate. This event would cause north-south or north-northwest to south-southeast directed extension in the Seward Peninsula and would explain the average orientation of dike swarms and the general shape of several Cretaceous intrusions such as the Bendeleben pluton. U-Pb zircon geochronologic data suggest that this extensionally driven emplacement most likely happened in a series of eastward younging pulses controlled by fracture-assisted emplacement from a large chamber of magma at depth. The occasional tapping of this chamber and associated depletion likely led to the compositional differences in the Bendeleben pluton. A similar history has been proposed for the nearby Kigluaik pluton and is supported by extensive evidence summarized previously.

Intrusion of the small gabbro unit at 82 Ma through more felsic units which predate the gabbro by as much as 13 m.y. in our field area and 21 m.y. for the entire Bendeleben pluton represents the final stage of crystallization which affected the deepest portion of the magma chamber under continued extension. The Bendeleben pluton

therefore represents the gradual depletion of a large, continually replenished, liquid-segregated magma chamber through multiple events of eastward progressing extension. This volatile-rich melt likely grew in a deep magma chamber induced by volatile-driven melting above a subducting slab until subsequent extension provided a pathway for upward intrusion of the more felsic capping units. These units were subsequently intruded by the lower mafic “root” during isolated periods of extension that affected the Seward Peninsula from 104 Ma to about 80 Ma.

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Appendix 1: Cathodoluminescence photomicrographs of zircons separated from igneous samples collected from the Kular pluton. Circles indicate spot location for U-Pb SHRIMP-RG analysis.

08DH13-

08JT29-

R33-

Appendix 2: Complete data from SHRIMP-RG analysis of zircons separated from igneous samples collected from the Kular pluton.

Errors are 1 σ unless otherwise specified

08DH08

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
08DH8-7C	11 Sep, 2009 14:08	3.01	0	0.66	4.1E-3	23	.105	7.0	.296	3.5
08DH8-9c	12 Sep, 2009 04:55	17.79	0	3.93	9.7E-3	9	.168	1.6	.357	1.6
08DH8-2R	11 Sep, 2009 12:12	1.08	0	5.28	4.1E-3	8	.104	3.9	.185	4.6
08DH8-1R	11 Sep, 2009 11:55	0.80	0	0.12	1.9E-4	45	.047	2.3	.086	2.4
08DH8-3r	11 Sep, 2009 12:28	1.35	0	0.26	1.7E-4	33	.049	1.5	.049	2.3
08DH8-4R	11 Sep, 2009 12:46	1.64	0	0.00	---	0	.047	1.9	.043	2.0
08DH8-11c	12 Sep, 2009 05:45	18.63	0	3.79	5.3E-3	33	.122	14.0	.245	22.6
08DH8-10c	12 Sep, 2009 05:11	18.07	0	2.78	1.1E-2	11	.219	2.8	.532	1.8
08DH8-6C	11 Sep, 2009 13:51	2.73	0	0.06	1.4E-4	63	.051	2.8	.042	4.3
08DH8-12c	12 Sep, 2009 06:02	18.91	0	0.65	1.7E-3	21	.072	2.8	.552	1.4
08DH8-5C	11 Sep, 2009 13:34	2.44	0	0.11	3.5E-4	51	.056	3.1	.182	2.5
08DH8-8c	11 Sep, 2009 14:24	3.28	0	1.86	6.6E-4	16	.173	0.6	.131	1.3

Errors are 1 σ unless otherwise specified

08DH08

Spot Name	Ln UO/U	Ln Pb/U	Corr 206 /238	% err	ppm Rad 206Pb	Total 208Pb /232Th	% err	Age S-K comm Pb	C-Pb 206 /204	C-Pb 207 /206	C-Pb 208 /206	204corr 206Pb /238U	Age	1 σ err
08DH8-7C	1.498	-3.983	.014	1.2	2.5	.0054	4.0	84	18.58	0.841	2.071	83.7	83.7	1.9
08DH8-9c	1.448	-3.923	.018	0.8	8.4	.0252	1.8	101	18.55	0.842	2.072	96.7	96.7	1.9
08DH8-2R	1.532	-3.682	.018	0.4	20.7	.0121	4.8	106	18.54	0.842	2.073	104.9	104.9	0.8
08DH8-1R	1.638	-3.445	.017	0.6	9.5	.0049	2.5	109	18.54	0.843	2.073	108.4	108.4	0.7
08DH8-3r	1.595	-3.520	.017	0.4	22.6	.0060	2.4	109	18.54	0.843	2.073	109.2	109.2	0.5
08DH8-4R	1.661	-3.375	.017	0.4	26.3	.0055	2.0	111	18.53	0.843	2.073	111.3	111.3	0.4
08DH8-11c	1.581	-3.508	.020	0.6	14.2	.0258	24.5	114	18.53	0.843	2.073	113.4	113.4	4.0
08DH8-10c	1.540	-3.516	.024	1.1	4.1	.0126	2.2	123	18.52	0.844	2.074	122.5	122.5	3.6
08DH8-6C	1.565	-3.420	.020	0.8	6.5	.0101	4.4	128	18.51	0.844	2.074	128.4	128.4	1.0
08DH8-12c	1.538	-3.247	.026	0.8	6.4	.0107	1.6	160	18.46	0.846	2.077	159.2	159.2	1.7
08DH8-5C	1.597	-2.603	.043	1.0	4.5	.0140	2.9	269	18.29	0.853	2.085	268.8	268.8	2.9
08DH8-8c	1.652	-1.133	.169	0.5	39.3	.0826	3.0	885	17.27	0.899	2.141	997.4	997.4	5.0

Errors are 1 σ unless otherwise specified

08DH08

----- 204 corrected -----

Spot Name	8corr 206Pbr /238U	1 σ err	Total			238/ 206r			207r /206r			207r /235			206r /238			err corr		
			Total 238 /206	% err	Total 207 /206	% err	Total 238/ 206r	% err	Total 207r /206r	% err	Total 207r /206r	% err	Total 207r /235	% err	Total 206r /238	% err	Total 206r /238	% err	Total err corr	Total err corr
08DH8-7C	.0138	.0002	70.66	1.2	.1049	7.0	76.55	2.2	.0436	39.4	.0436	39.4	0.08	39.5	.0131	2.2	.0131	2.2	.057	.057
08DH8-9c	.0159	.0002	54.30	0.8	.1675	1.6	66.14	2.0	.0204	76.3	.0204	76.3	0.04	76.4	.0151	2.0	.0151	2.0	.026	.026
08DH8-2R	.0169	.0001	56.34	0.4	.1041	3.9	60.96	0.8	.0436	15.3	.0436	15.3	0.10	15.3	.0164	0.8	.0164	0.8	.049	.049
08DH8-1R	.0171	.0001	58.79	0.6	.0474	2.3	58.99	0.6	.0446	3.7	.0446	3.7	0.10	3.7	.0170	0.6	.0170	0.6	.171	.171
08DH8-3r	.0171	.0001	58.37	0.4	.0494	1.5	58.56	0.4	.0469	2.4	.0469	2.4	0.11	2.5	.0171	0.4	.0171	0.4	.173	.173
08DH8-4R	.0174	.0001	57.44	0.4	.0473	1.9	57.44	0.4	.0473	1.9	.0473	1.9	0.11	1.9	.0174	0.4	.0174	0.4	.193	.193
08DH8-11c	.0179	.0006	50.76	0.6	.1222	14.0	56.33	3.5	.0432	79.0	.0432	79.0	0.11	79.1	.0178	3.5	.0178	3.5	.045	.045
08DH8-10c	.0214	.0004	41.21	1.1	.2186	2.8	52.14	2.9	.0529	44.3	.0529	44.3	0.14	44.4	.0192	2.9	.0192	2.9	.066	.066
08DH8-6C	.0200	.0002	49.56	0.8	.0515	2.8	49.69	0.8	.0493	4.0	.0493	4.0	0.14	4.1	.0201	0.8	.0201	0.8	.197	.197
08DH8-12c	.0238	.0003	38.75	0.8	.0725	2.8	39.99	1.1	.0477	12.2	.0477	12.2	0.16	12.3	.0250	1.1	.0250	1.1	.087	.087
08DH8-5C	.0427	.0005	23.34	1.0	.0557	3.1	23.49	1.1	.0506	6.2	.0506	6.2	0.30	6.3	.0426	1.1	.0426	1.1	.172	.172
08DH8-8c	.1652	.0010	5.91	0.5	.1728	0.6	5.98	0.5	.1644	1.1	.1644	1.1	3.79	1.2	.1673	0.5	.1673	0.5	.451	.451

Errors are 1 σ unless otherwise specified

08DH09

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
08DH9-9c	12 Sep, 2009 07:23	20.26	0	0.03	6.8E-5	64	.051	2.7	.323	2.0
08DH9-2c	11 Sep, 2009 15:25	4.29	0	0.08	6.0E-4	50	.049	4.9	.185	3.7
08DH9-12c	12 Sep, 2009 07:57	20.83	0	0.08	5.0E-4	63	.052	4.5	.204	3.9
08DH9-7c	11 Sep, 2009 17:20	6.21	0	0.25	8.2E-4	38	.058	3.3	.202	11.5
08DH9-4c	11 Sep, 2009 15:59	4.86	0	0.04	2.0E-4	50	.050	3.8	.126	3.5
08DH9-5c	11 Sep, 2009 16:47	5.66	0	0.08	3.0E-4	50	.048	3.7	.232	3.4
08DH9-1c	11 Sep, 2009 15:08	4.02	0	0.28	2.5E-4	33	.052	1.7	.206	1.2
08DH9-6c	11 Sep, 2009 17:04	5.94	0	0.07	5.6E-4	50	.046	5.2	.197	3.6
08DH9-8c	11 Sep, 2009 18:10	7.05	0	0.68	4.2E-4	24	.058	3.9	.072	9.0
08DH9-11c	12 Sep, 2009 08:14	21.11	0	0.03	6.6E-5	64	.053	2.6	.191	2.0
08DH9-10c	12 Sep, 2009 07:41	20.55	0	1.51	1.0E-3	15	.069	1.3	.179	1.6

Errors are 1 σ unless otherwise specified

08DH09

Spot Name	Obs 206 /238	% err	248 /254	% err	254 /238	% err	238 /196	Pb/U: UO/U^2	% err	% comm 206	ppm U	ppm Th	232Th /238U
08DH9-9c	.031	0.7	.961	0.6	5.21	0.2	.609	.00115	0.8	0.32	473	462	1.01
08DH9-2c	.028	2.1	.541	0.4	4.86	0.9	.213	.00118	1.3	0.15	158	87	0.57
08DH9-12c	.029	1.2	.594	1.2	4.97	0.4	.248	.00119	1.3	0.47	187	113	0.62
08DH9-7c	.027	3.8	.493	16.2	4.74	2.3	.420	.00120	1.0	1.24	306	153	0.52
08DH9-4c	.024	3.5	.336	0.7	4.43	1.5	.398	.00120	1.1	0.26	278	95	0.35
08DH9-5c	.029	1.5	.702	1.6	4.91	0.4	.362	.00121	1.0	-0.01	270	193	0.74
08DH9-1c	.028	1.7	.610	0.2	4.82	0.7	1.773	.00122	0.5	0.48	1307	810	0.64
08DH9-6c	.028	1.8	.556	0.9	4.79	0.6	.196	.00121	1.4	-0.27	144	82	0.58
08DH9-8c	.043	2.5	.114	4.6	5.23	0.8	1.395	.00156	0.4	1.12	1085	126	0.12
08DH9-11c	.049	1.3	.299	0.3	5.35	0.4	.415	.00172	0.8	0.49	328	100	0.31
08DH9-10c	.095	0.7	.408	2.4	4.85	0.6	.677	.00403	0.5	1.96	502	208	0.43

Errors are 1 σ unless otherwise specified

08DH09

Spot Name	Ln UO/U	Ln Pb/U	Corr 206 /238	ppm Rad 206Pb	Total 208Pb /232Th	% err	Age S-K comm Pb	C-Pb 206 /204	C-Pb 207 /206	C-Pb 208 /206	204corr 206Pb /238U		1 σ err
											Age	Age	
08DH9-9c	1.651	-3.472	.016	6.6	.0052	0.8	104	18.55	0.842	2.073	103.7	103.7	0.8
08DH9-2c	1.582	-3.585	.017	2.3	.0054	1.3	106	18.54	0.842	2.073	105.0	105.0	1.5
08DH9-12c	1.604	-3.534	.017	2.7	.0055	1.3	107	18.54	0.843	2.073	106.2	106.2	1.5
08DH9-7c	1.557	-3.609	.017	4.5	.0066	1.0	107	18.54	0.843	2.073	106.7	106.7	1.2
08DH9-4c	1.489	-3.737	.017	4.0	.0060	1.1	108	18.54	0.843	2.073	107.9	107.9	1.1
08DH9-5c	1.591	-3.535	.017	4.0	.0054	1.0	109	18.54	0.843	2.073	108.5	108.5	1.1
08DH9-1c	1.572	-3.566	.017	19.3	.0055	0.5	109	18.54	0.843	2.073	109.2	109.2	0.5
08DH9-6c	1.567	-3.585	.017	2.1	.0058	1.4	109	18.54	0.843	2.073	108.1	108.1	1.6
08DH9-8c	1.654	-3.158	.022	20.5	.0131	0.4	138	18.49	0.845	2.075	138.8	138.8	0.6
08DH9-11c	1.678	-3.011	.024	6.8	.0147	0.8	153	18.47	0.846	2.076	153.7	153.7	1.2
08DH9-10c	1.580	-2.370	.057	24.5	.0237	0.5	349	18.16	0.859	2.091	349.2	349.2	2.0

Errors are 1 σ unless otherwise specified

08DH09

Spot Name	SqIdNum	SqIdRej	207corr		1s	err	SqIdEr	flags	208corr		1s	err	204corr		1s	err	204corr		1s	err
			206Pb	/238U	Age				206Pb	/238U	Age		207Pb	/206Pb	Age		208Pb	/232Th		
08DH9-9c	4	rej			403.5	0.8	1.6	Hi U			103.6	1.0	177		104	71			2	
08DH9-2c	2				106.0	1.5	2.9				105.9	1.6	-322		95	324			8	
08DH9-12c	3				106.7	1.4	2.8				106.8	1.6	-87		100	290			8	
08DH9-7c	4				107.0	1.0	2.1				106.2	2.6	-5		112	263			15	
08DH9-4c	5				108.0	1.2	2.3				107.5	1.2	62		114	123			6	
08DH9-5c	6				109.1	1.1	2.2				109.2	1.3	-133		103	163			5	
08DH9-1c	7				109.1	0.5	1.0				109.5	0.6	120		106	73			2	
08DH9-6c	8				109.5	1.5	3.1				108.5	1.7	-508		103	345			8	
08DH9-8c	9	rej			438.3	0.7	1.4	Hi U			137.6	0.8	270		205	119			23	
08DH9-11c	40	rej			453.2	4.2	2.4	discordant			146.9	1.3	287		290	67			7	
08DH9-10c	44	rej			348.9	4.8	3.6	Hi U			347.7	2.1	379		372	101			17	

Errors are 1 σ unless otherwise specified

08DH09

Spot Name	% Discordant	4corr		%	7corr		1s	err	8corr		1s	err
		208r	/232		206Pbr	/238U			206Pbr	/238U		
08DH9-9c	71	.0052		2.2	.0162		.0001	.0002	.0162		.0002	.0002
08DH9-2c	-407	.0047		8.1	.0166		.0002	.0003	.0166		.0003	.0003
08DH9-12c	-182	.0050		7.8	.0167		.0002	.0002	.0167		.0002	.0002
08DH9-7c	-104	.0056		13.5	.0167		.0002	.0004	.0166		.0004	.0004
08DH9-4c	-42	.0057		4.9	.0169		.0002	.0002	.0168		.0002	.0002
08DH9-5c	-223	.0051		4.4	.0171		.0002	.0002	.0171		.0002	.0002
08DH9-1c	10	.0053		2.1	.0171		.0001	.0001	.0171		.0001	.0001
08DH9-6c	-570	.0051		7.3	.0171		.0002	.0003	.0170		.0003	.0003
08DH9-8c	94	.0102		11.3	.0217		.0001	.0001	.0216		.0001	.0001
08DH9-11c	87	.0145		2.3	.0240		.0002	.0002	.0231		.0002	.0002
08DH9-10c	9	.0186		4.7	.0556		.0003	.0003	.0554		.0003	.0003

Errors are 1 σ unless otherwise specified

08DH09

----- 204 corrected -----

Spot Name	Total			238/206r			207r/206r			207r/235			206r/238			% err corr		
	238/206	% err	%	238/206r	% err	%	207r/206r	% err	%	207r/235	% err	%	206r/238	% err	%	% err	%	err corr
08DH9-9c	61.59	0.8	.0506	61.67	0.8	.0496	.0496	3.0		0.11	3.1	.0162			0.8	.241		
08DH9-2c	60.23	1.3	.0493	60.90	1.5	.0405	.0405	12.6		0.09	12.7	.0164			1.5	.114		
08DH9-12c	59.66	1.3	.0519	60.22	1.4	.0444	.0444	11.9		0.10	11.9	.0166			1.4	.116		
08DH9-7c	59.03	1.0	.0580	59.94	1.1	.0460	.0460	10.9		0.11	10.9	.0167			1.1	.101		
08DH9-4c	59.05	1.1	.0503	59.27	1.1	.0473	.0473	5.2		0.11	5.3	.0169			1.1	.202		
08DH9-5c	58.57	1.0	.0481	58.90	1.0	.0436	.0436	6.6		0.10	6.7	.0170			1.0	.157		
08DH9-1c	58.28	0.5	.0520	58.55	0.5	.0484	.0484	3.1		0.11	3.1	.0171			0.5	.158		
08DH9-6c	58.54	1.4	.0461	59.16	1.5	.0377	.0377	12.9		0.09	13.0	.0169			1.5	.113		
08DH9-8c	45.60	0.4	.0578	45.95	0.4	.0516	.0516	5.2		0.15	5.2	.0218			0.4	.086		
08DH9-11c	41.38	0.8	.0530	41.43	0.8	.0520	.0520	2.9		0.17	3.0	.0241			0.8	.260		
08DH9-10c	17.63	0.5	.0692	17.97	0.6	.0542	.0542	4.5		0.42	4.5	.0557			0.6	.127		

Errors are 1 σ unless otherwise specified

08DH11

Spot Name	Date/Time	Hours	Pb/U		204 cts /sec	204 /206	207 /206		208 /206	% err	
			const #rej								
08DH11-3r	11 Sep, 2009 19:13	8.10	0		0.14	1.8E-4	.049	2.1	.085	45	3.2
08DH11-1c	11 Sep, 2009 18:39	7.53	0		0.03	1.3E-4	.049	3.8	.225	68	6.5
08DH11-2c	11 Sep, 2009 18:56	7.81	0		0.00	---	.048	3.6	.098	0	4.5
08DH11-7c	11 Sep, 2009 20:46	9.64	0		0.00	---	.049	5.7	.257	0	3.7
08DH11-4c	11 Sep, 2009 19:30	8.38	0		0.06	1.3E-4	.048	2.7	.300	50	1.6
08DH11-8r	11 Sep, 2009 21:03	9.94	0		0.00	---	.049	3.9	.149	0	3.3
08DH11-6c	11 Sep, 2009 20:28	9.35	0		0.00	---	.049	2.7	.047	0	3.5
08DH11-5r	11 Sep, 2009 20:12	9.07	0		0.00	---	.115	0.9	.215	0	0.9

Errors are 1 σ unless otherwise specified

08DH11

Spot Name	Obs 206 /238	% err	248 /254	% err	254 /238	% err	238 /196	Pb/U: UO/U ²	% err	% comm 206	ppm U	ppm Th	232Th /238U
08DH11-3r	.029	0.8	.241	1.6	5.07	0.2	1.101	.00114	0.6	0.10	840	206	0.25
08DH11-1c	.031	1.7	.663	6.2	5.15	0.6	.355	.00115	1.1	0.14	273	184	0.70
08DH11-2c	.031	1.9	.265	2.5	5.13	0.8	.378	.00116	1.0	0.01	291	78	0.28
08DH11-7c	.027	4.6	.746	0.7	4.76	0.7	.184	.00116	1.6	0.14	135	102	0.78
08DH11-4c	.033	0.7	.902	1.3	5.25	0.5	.612	.00119	0.8	0.00	478	438	0.95
08DH11-8r	.028	1.9	.437	0.3	4.78	0.6	.371	.00121	1.1	0.13	272	121	0.46
08DH11-6c	.024	2.2	.137	1.3	4.45	0.9	1.100	.00123	0.7	0.12	770	107	0.14
08DH11-5r	.616	0.7	.708	0.4	5.28	0.5	.150	.02205	0.8	1.09	118	85	0.74

Errors are 1 σ unless otherwise specified

08DH11

Spot Name	Ln UO/U	Ln Pb/U	Corr 206 /238	% err	ppm Rad 206Pb	Total 208Pb /232Th	% err	Age S-K comm Pb	C-Pb 206 /204	C-Pb 207 /206	C-Pb 208 /206	204corr 206Pb /238U Age	1 σ err
08DH11-3r	1.622	-3.534	.016	0.6	11.6	.0054	3.6	103	18.55	0.842	2.073	102.4	0.6
08DH11-1c	1.638	-3.487	.016	1.1	3.8	.0052	9.1	104	18.55	0.842	2.073	103.4	1.1
08DH11-2c	1.635	-3.488	.016	1.0	4.1	.0057	5.3	104	18.54	0.842	2.073	104.0	1.0
08DH11-7c	1.560	-3.630	.016	1.6	1.9	.0053	4.1	104	18.54	0.842	2.073	104.4	1.6
08DH11-4c	1.658	-3.424	.017	0.8	6.9	.0053	2.2	107	18.54	0.843	2.073	106.7	0.8
08DH11-8r	1.564	-3.587	.017	1.1	4.0	.0055	3.5	109	18.54	0.843	2.073	108.7	1.2
08DH11-6c	1.493	-3.711	.017	0.7	11.4	.0057	3.8	111	18.53	0.843	2.073	110.6	0.7
08DH11-5r	1.664	-0.484	.311	0.8	31.4	.0897	1.3	1725	15.71	0.974	2.249	1743.6	11.7

Errors are 1 σ unless otherwise specified

08DH11

Spot Name	SqIdNum	SqIdRej	207corr		1 σ	err	SqIdEr	flags	208corr		1 σ	err	204corr		1 σ	err	204corr		1 σ	err
			206Pb	/238U	Age				206Pb	/238U			207Pb	/206Pb			208Pb	/232Th		
08DH11-3r	1				102.6	0.6	1.2		102.5		0.6	0.6	9		81	100			5	
08DH11-1c	2				103.5	1.1	2.3		103.4		1.7	1.7	62		115	103			7	
08DH11-2c	3				104.0	1.0	2.1		103.6		1.1	1.1	109		84	115			5	
08DH11-7c	4				104.3	1.7	3.3		103.9		1.9	1.9	158		133	108			4	
08DH11-4c	5	rej			406.9	0.8	1.6		106.9		1.0	1.0	5		86	105			2	
08DH11-8r	6	rej			408.5	4.2	2.4		108.5		1.3	1.3	157		92	111			4	
08DH11-6c	7	rej			440.5	0.7	1.5		110.5		0.7	0.7	156		62	114			4	
08DH11-5r	8	rej			4726.8	43.4	26.1	Hi 204	1744.2		13.0	13.0	1883		16	1737			21	

Errors are 1 σ unless otherwise specified

08DH11

Spot Name	% Discordant	4corr		7corr		8corr		1 σ	err
		208r	/232	206Pbr	/238U	206Pbr	/238U		
08DH11-3r	-91		.0050	5.1	.0160	.0001	.0160	.0001	.0001
08DH11-1c	-40		.0051	6.8	.0162	.0002	.0162	.0002	.0003
08DH11-2c	5		.0057	4.6	.0163	.0002	.0162	.0002	.0002
08DH11-7c	51		.0053	4.0	.0163	.0003	.0163	.0003	.0003
08DH11-4c	-95		.0052	2.0	.0167	.0001	.0167	.0001	.0002
08DH11-8r	44		.0055	3.5	.0170	.0002	.0170	.0002	.0002
08DH11-6c	41		.0057	3.5	.0173	.0001	.0173	.0001	.0001
08DH11-5r	8		.0897	1.2	.3072	.0027	.3107	.0026	.0026

Errors are 1 σ unless otherwise specified

08DH11

----- 204 corrected -----

Spot Name	Total			238/206r			207r/206r			207r/235			206r/238			err corr		
	238/206	% err	%	238/206r	% err	%	207r/206r	% err	%	207r/235	% err	%	206r/238	% err	%	err	%	err
08DH11-3r	62.25	0.6	.0488	62.46	0.6	.0462	.0462	3.4	0.10	0.10	3.4	.0160	0.6	.171				
08DH11-1c	61.69	1.1	.0492	61.84	1.1	.0472	.0472	4.8	0.11	0.11	4.9	.0162	1.1	.221				
08DH11-2c	61.46	1.0	.0482	61.46	1.0	.0482	.0482	3.6	0.11	0.11	3.7	.0163	1.0	.263				
08DH11-7c	61.25	1.6	.0492	61.25	1.6	.0492	.0492	5.7	0.11	0.11	5.9	.0163	1.6	.264				
08DH11-4c	59.78	0.8	.0481	59.93	0.8	.0461	.0461	3.6	0.11	0.11	3.7	.0167	0.8	.208				
08DH11-8r	58.82	1.1	.0492	58.82	1.1	.0492	.0492	3.9	0.12	0.12	4.1	.0170	1.1	.267				
08DH11-6c	57.78	0.7	.0492	57.78	0.7	.0492	.0492	2.7	0.12	0.12	2.7	.0173	0.7	.241				
08DH11-5r	3.22	0.8	.1152	3.22	0.8	.1152	.1152	0.9	4.93	4.93	1.2	.3106	0.8	.657				

Errors are 1 σ unless otherwise specified

08DH13

Spot Name	Date/Time	Hours	Pb/U		204 cts/sec	204		207	208	% err	% err	% err	% err
			const	#rej		204	/206						
08DH13-1c	11 Sep, 2009 22:42	11.58	0	0	1.27	4.7E-3	.100	.237	2.4				
08DH13-3c	11 Sep, 2009 23:18	12.17	0	0	0.04	1.6E-4	.049	.205	2.6				
08DH13-5r	12 Sep, 2009 00:08	13.01	0	0	1.82	2.2E-3	.078	.256	2.2				
08DH13-4r	11 Sep, 2009 23:34	12.45	0	0	0.11	3.6E-4	.053	.143	2.8				
08DH13-2r	11 Sep, 2009 23:00	11.88	0	0	1.16	7.3E-4	.058	.074	3.2				

Errors are 1σ unless otherwise specified

08DH13

Spot Name	SqIdNum	SqIdRej	207corr			flags	208corr			204corr			204corr			208Pb			1σ err
			206Pb	/238U	Age		206Pb	/238U	Age	207Pb	/206Pb	Age	206Pb	/232Th	Age	206Pb	/232Th	Age	
08DH13-1c	1	rej	102.4		102.4	Hi	104.0		104.0	2.4			104.0		44			44	25
08DH13-3c	2		110.0		110.0		110.9		110.9	2.2		15			100			100	4
08DH13-5r	3		110.5		110.5		109.6		109.6	1.3		-76			115			115	8
08DH13-4r	4		111.3		111.3		111.6		111.6	2.1		91			105			105	6
08DH13-2r	5		112.0		112.0		112.3		112.3	0.9		44			93			93	11

Errors are 1 σ unless otherwise specified

08DH13

Spot Name	% Discordant	4corr 208r /232	% err	7corr 206Pbr /238U	1 σ err	8corr 206Pbr /238U
08DH13-1c		.0022	56.3	.0160	.0002	.0163
08DH13-3c	-87	.0049	3.5	.0172	.0002	.0174
08DH13-5r	-169	.0057	7.3	.0173	.0001	.0171
08DH13-4r	-18	.0052	5.7	.0174	.0002	.0175
08DH13-2r	-60	.0046	12.1	.0175	.0001	.0176

Errors are 1 σ unless otherwise specified

08DH13

----- 204 corrected -----

Spot Name	1 σ err	Total 238 /206	% err	Total 207 /206	% err	238/ 206r	% err	207r /206r	% err	207r /235	% err	206r /238	% err	err corr
08DH13-1c	.0002	58.38	1.0	.0999	4.5	63.95	1.9	.0290	48.1	0.06	48.2	.0156	1.9	.039
08DH13-3c	.0002	58.07	1.0	.0487	3.6	58.24	1.0	.0463	5.2	0.11	5.3	.0172	1.0	.187
08DH13-5r	.0001	55.68	0.6	.0778	1.6	58.10	0.8	.0446	10.4	0.11	10.4	.0172	0.8	.075
08DH13-4r	.0002	57.08	0.9	.0531	3.2	57.46	1.0	.0478	6.2	0.11	6.2	.0174	1.0	.155
08DH13-2r	.0001	56.40	0.4	.0577	1.9	57.17	0.5	.0469	5.0	0.11	5.0	.0175	0.5	.095

Errors are 1σ unless otherwise specified

08JT29

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
08JT29-12r	12 Sep, 2009 04:22	17.24	0	0.07	3.0E-4	74	.048	3.9	.252	3.4
08JT29-8r	12 Sep, 2009 02:56	15.82	0	0.06	3.6E-4	50	.054	4.2	.120	4.4
08JT29-6c	12 Sep, 2009 02:05	14.97	0	0.29	4.9E-4	32	.057	2.2	.321	1.4
08JT29-5c	12 Sep, 2009 01:48	14.68	0	0.08	3.1E-4	68	.045	3.8	.174	2.8
08JT29-1r	12 Sep, 2009 00:25	13.29	0	0.00	---	0	.053	3.8	.210	2.8
08JT29-9c	12 Sep, 2009 03:13	16.10	0	0.00	---	0	.048	4.4	.220	3.5
08JT29-7c	12 Sep, 2009 02:22	15.24	0	0.00	---	0	.049	3.4	.053	4.5
08JT29-2r	12 Sep, 2009 00:42	13.57	0	0.08	1.1E-4	45	.049	2.2	.033	3.8
08JT29-3c	12 Sep, 2009 00:58	13.85	0	0.04	2.2E-5	64	.049	1.3	.004	6.6
08JT29-13c	12 Sep, 2009 04:38	17.51	0	0.03	5.5E-5	64	.051	2.4	.114	2.3
08JT29-10c	12 Sep, 2009 03:31	16.39	0	0.95	4.0E-3	28	.120	4.9	.339	2.6
08JT29-4c	12 Sep, 2009 01:32	14.41	0	0.96	7.2E-4	18	.119	1.1	.191	1.2

Errors are 1 σ unless otherwise specified

08JT29

Spot Name	Obs 206 /238	% err	248 /254	% err	254 /238	% err	238 /196	Pb/U: UO/U^2	% err	% comm 206	ppm U	ppm Th	232Th /238U
08JT29-12r	.034	1.1	.738	0.4	5.48	0.4	.300	.00114	1.1	-0.04	241	181	0.78
08JT29-8r	.033	1.3	.312	0.5	5.32	0.9	.230	.00115	1.2	0.70	181	58	0.33
08JT29-6c	.028	2.8	.938	0.2	4.90	0.7	.860	.00115	0.6	1.06	641	611	0.98
08JT29-5c	.031	1.1	.511	2.5	5.19	0.6	.318	.00115	1.0	-0.40	246	128	0.54
08JT29-1r	.032	1.4	.611	0.3	5.18	0.8	.265	.00117	1.1	0.68	205	128	0.64
08JT29-9c	.030	1.6	.587	0.6	5.03	0.4	.262	.00117	1.2	0.03	199	119	0.62
08JT29-7c	.028	1.9	.140	1.1	4.84	0.7	.454	.00118	0.9	0.09	336	48	0.15
08JT29-2r	.028	1.1	.093	0.7	4.85	0.3	.915	.00120	0.6	0.16	678	64	0.10
08JT29-3c	.033	1.3	.009	0.7	4.99	0.5	2.360	.00132	0.4	0.06	1780	15	0.01
08JT29-13c	.039	2.6	.212	1.2	4.68	1.3	.645	.00179	0.7	0.16	467	100	0.22
08JT29-10c	.090	3.1	5.060	0.4	4.40	0.6	.107	.00461	1.2	8.22	74	381	5.31
08JT29-4c	.277	1.7	1.334	0.5	4.65	0.5	.169	.01278	0.7	5.55	121	165	1.40

Errors are 1 σ unless otherwise specified

08JT29

Spot Name	Ln UO/U	Ln Pb/U	Corr 206 /238	% err	ppm Rad 206Pb	Total 208Pb /232Th	% err	Age S-K comm Pb	C-Pb 206 /204	C-Pb 207 /206	C-Pb 208 /206	204corr 206Pb /238U Age	1 σ err
08JT29-12r	1.702	-3.376	.016	1.1	3.3	.0052	3.6	103	18.55	0.842	2.073	102.1	1.2
08JT29-8r	1.671	-3.429	.016	1.2	2.5	.0059	4.5	103	18.55	0.842	2.073	102.8	1.3
08JT29-6c	1.589	-3.588	.016	0.6	9.0	.0053	1.5	103	18.55	0.842	2.073	103.0	0.7
08JT29-5c	1.646	-3.476	.016	1.0	3.4	.0053	3.9	104	18.54	0.842	2.073	103.2	1.1
08JT29-1r	1.646	-3.455	.017	1.1	2.9	.0054	3.0	105	18.54	0.842	2.073	105.5	1.1
08JT29-9c	1.616	-3.522	.016	1.2	2.8	.0059	3.7	105	18.54	0.842	2.073	104.9	1.2
08JT29-7c	1.577	-3.585	.017	0.9	4.8	.0060	4.8	106	18.54	0.842	2.073	106.0	1.0
08JT29-2r	1.579	-3.566	.017	0.6	9.8	.0056	3.9	108	18.54	0.843	2.073	107.9	0.7
08JT29-3c	1.606	-3.414	.019	0.4	28.5	.0087	6.6	119	18.52	0.843	2.074	118.9	0.4
08JT29-13c	1.544	-3.234	.025	0.7	10.1	.0129	2.7	160	18.46	0.846	2.077	159.9	1.1
08JT29-10c	1.482	-2.487	.065	1.2	4.1	.0041	2.9	373	18.12	0.861	2.093	376.7	9.1
08JT29-4c	1.537	-1.298	.180	0.7	18.8	.0246	1.5	1010	17.05	0.910	2.155	1055.0	7.3

Errors are 1 σ unless otherwise specified

08JT29

Spot Name	SqIdNum	SqIdRej	207corr			SqIdEr	flags	208corr			204corr			204corr			1 σ	err
			206Pb	/238U	Age			206Pb	/238U	Age	207Pb	/206Pb	Age	208Pb	/232Th	Age		
08JT29-12r	1				102.7	1.1				102.3	1.3	-147				100	5	
08JT29-8r	2				102.7	1.3				102.6	1.3	120				106	8	
08JT29-6c	3				102.9	0.7				103.5	0.8	166				101	3	
08JT29-5c	4				104.2	1.1				103.6	1.2	-329				99	6	
08JT29-1r	5				104.8	1.2				105.1	1.3	350				109	3	
08JT29-9c	6				104.9	1.3				103.6	1.4	115				118	4	
08JT29-7c	7				105.9	1.0				105.6	1.0	140				121	6	
08JT29-2r	8	rej			407.9	0.7				108.0	0.7	87				98	8	
08JT29-3c	9	rej			448.9	0.4				118.9	0.4	128				139	24	
08JT29-13c	40	rej			459.9	4.4				156.7	1.2	181				254	7	
08JT29-10c	44	rej			372.8	5.4				1291.7	135.9	695				46	11	
08JT29-4c	42	rej			4042.3	7.2				1194.8	11.2	1791				424	14	

Errors are 1σ unless otherwise specified

08JT29

Spot Name	% Discordant	4corr 208r /232	% err	7corr 206Pbr /238U	1 σ err	8corr 206Pbr /238U	1 σ err
08JT29-12r	-244	.0050	5.0	.0161	.0002	.0160	.0002
08JT29-8r	17	.0053	7.9	.0161	.0002	.0160	.0002
08JT29-6c	61	.0050	2.5	.0161	.0001	.0162	.0001
08JT29-5c	-419	.0049	5.8	.0163	.0002	.0162	.0002
08JT29-1r	232	.0054	3.0	.0164	.0002	.0164	.0002
08JT29-9c	10	.0059	3.7	.0164	.0002	.0162	.0002
08JT29-7c	32	.0060	4.6	.0166	.0002	.0165	.0002
08JT29-2r	-19	.0049	7.9	.0169	.0001	.0169	.0001
08JT29-3c	8	.0069	17.6	.0186	.0001	.0186	.0001
08JT29-13c	13	.0127	2.7	.0251	.0002	.0246	.0002
08JT29-10c	84	.0023	23.0	.0595	.0009	.2219	.0258
08JT29-4c	70	.0212	3.3	.1700	.0013	.2036	.0021

Errors are 1σ unless otherwise specified

R33

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
R33-1	11 Sep, 2009 11:07	0.00	0	0.04	9.6E-5	72	.056	2.6	.222	2.2
R33-10	12 Sep, 2009 01:15	14.13	0	0.03	8.3E-5	64	.055	2.8	.190	2.3
R33-12	12 Sep, 2009 04:05	16.96	0	0.08	3.4E-4	50	.056	3.5	.140	3.2
R33-13	12 Sep, 2009 05:28	18.34	0	0.08	2.2E-4	45	.058	2.9	.130	2.8
R33-14	12 Sep, 2009 06:36	19.48	0	0.04	4.9E-5	72	.056	1.9	.280	1.2
R33-15	12 Sep, 2009 08:31	21.39	0	0.08	1.5E-4	50	.057	2.3	.204	1.8
R33-2	11 Sep, 2009 11:38	0.51	0	0.06	4.9E-5	50	.054	1.5	.184	1.2
R33-3	11 Sep, 2009 13:03	1.92	0	0.15	2.0E-4	35	.056	2.0	.241	1.4
R33-4	11 Sep, 2009 14:41	3.56	0	0.12	1.5E-4	45	.057	1.8	.194	1.5
R33-5	11 Sep, 2009 16:16	5.14	0	0.00	---	0	.054	3.0	.174	2.4
R33-6	11 Sep, 2009 17:51	6.73	0	0.03	9.0E-5	64	.055	3.0	.210	2.2
R33-7	11 Sep, 2009 19:47	8.65	0	0.06	1.4E-4	45	.056	2.6	.231	1.9
R33-8	11 Sep, 2009 21:21	10.23	0	0.09	1.4E-4	41	.058	2.1	.218	1.6
R33-9	11 Sep, 2009 23:51	12.72	0	0.04	8.6E-5	64	.054	2.5	.146	2.1

Errors are 1σ unless otherwise specified

R33

Spot Name	Obs		% err	248 /254	% err	254 /238	% err	238 /196	SqidNum	SqidRej
	206 /238									
R33-1	.117		1.6	.676	0.4	4.94	0.5	.167	1	
R33-10	.116		1.8	.559	0.8	5.05	0.7	.133	45	rej
R33-12	.118		1.4	.433	0.6	4.92	0.9	.089	16	
R33-13	.118		1.2	.374	0.8	5.04	0.5	.127	47	rej
R33-14	.114		1.2	.865	0.3	4.94	0.3	.344	18	
R33-15	.112		2.0	.628	0.4	4.89	0.8	.213	49	rej
R33-2	.109		1.9	.604	1.0	4.86	0.6	.494	2	rej
R33-3	.114		1.4	.726	0.3	4.92	0.4	.278	3	
R33-4	.114		1.2	.601	0.3	4.86	1.0	.331	4	
R33-5	.115		2.0	.508	0.5	4.88	0.7	.134	5	
R33-6	.119		1.4	.646	0.5	5.08	0.6	.117	44	rej
R33-7	.116		2.1	.699	0.4	4.89	0.8	.154	12	
R33-8	.113		1.6	.662	0.3	4.84	0.6	.236	13	
R33-9	.115		1.0	.454	0.4	4.89	0.4	.162	14	

Errors are 1 σ unless otherwise specified

R33

Spot Name	207-corr Pb/U: UO/U^2	SqIdEr	% err	Age Ma	$\pm$		% comm 206	ppm U	ppm Th	232Th /238U
R33-1	.00478	.00009	0.9	420	4		7.7	125	86	0.71
R33-10	.00454	.00009	1.0	397	4		7.9	102	58	0.59
R33-12	.00483	.00013	1.3	425	5		10.7	66	29	0.45
R33-13	.00460	.00010	1.1	405	4		8.4	97	37	0.39
R33-14	.00468	.00014	1.5	411	6		12.0	258	227	0.91
R33-15	.00463	.00008	0.8	407	3		6.6	159	101	0.66
R33-2	.00460	.00005	0.5	404	2		4.3	366	225	0.63
R33-3	.00470	.00007	0.7	413	3		5.8	208	153	0.76
R33-4	.00478	.00007	0.7	420	3		5.5	245	150	0.63
R33-5	.00480	.00010	1.1	422	4		8.7	99	51	0.53
R33-6	.00462	.00010	1.1	406	4		8.6	89	59	0.68
R33-7	.00478	.00009	1.0	420	4		7.9	115	81	0.73
R33-8	.00477	.00007	0.8	419	3		6.3	175	118	0.69
R33-9	.00482	.00008	0.9	423	4		7.2	121	56	0.48

Errors are 1 σ unless otherwise specified

R33

Spot Name	Ln UO/U	Ln Pb/U	204 overcts /sec (fr. 207)	204 overcts /sec (fr. 208)	208Pb* /206Pb* (fr. 207)	204 /206 (fr. 207)	204 /206 (fr. 208)	7-corr Pb/U: UO/U^2 delta%	8-corr Pb/U: UO/U^2 delta%	Uncorr Pb/U: UO/U^2	4-corr 207 /206 age	$\pm$
R33-1	1.598	-2.144	+0.01	+0.04	0.221	7.6E-5	9.0E-6	+0.04%	+0.16%	.00479	407.1	72.5
R33-10	1.620	-2.157	+0.03	-0.04	0.183	-7.8E-6	1.8E-4	+0.16%	-0.18%	.00451	-	-
R33-12	1.594	-2.143	+0.07	+0.09	0.142	3.1E-5	-5.5E-5	+0.56%	+0.72%	.00484	-	-
R33-13	1.618	-2.143	+0.00	+0.01	0.122	2.1E-4	2.0E-4	+0.03%	+0.03%	.00462	-	-
R33-14	1.597	-2.169	+0.00	+0.12	0.283	4.8E-5	-8.7E-5	+0.00%	+0.25%	.00468	-	-
R33-15	1.587	-2.196	+0.01	+0.11	0.206	1.3E-4	-4.4E-5	+0.04%	+0.35%	.00464	-	-
R33-2	1.580	-2.221	+0.13	+0.58	0.198	-4.6E-5	-3.9E-4	+0.17%	+0.80%	.00459	364.5	73.2
R33-3	1.594	-2.173	+0.12	+0.08	0.238	3.8E-5	9.1E-5	+0.29%	+0.19%	.00470	223.2	146.5
R33-4	1.582	-2.176	+0.02	+0.20	0.197	1.3E-4	-9.0E-5	+0.04%	+0.43%	.00479	410.5	91.0
R33-5	1.585	-2.166	+0.04	-0.07	0.166	-1.0E-4	2.0E-4	+0.18%	-0.37%	.00479	417.9	47.3
R33-6	1.625	-2.127	+0.04	+0.04	0.212	-1.8E-5	-4.0E-5	+0.20%	+0.23%	.00462	353.7	78.1
R33-7	1.588	-2.160	+0.04	+0.03	0.229	5.2E-5	7.6E-5	+0.15%	+0.11%	.00478	368.4	72.3
R33-8	1.577	-2.187	-0.03	+0.06	0.217	1.8E-4	5.2E-5	-0.08%	+0.15%	.00478	444.7	58.7
R33-9	1.588	-2.161	+0.10	+0.08	0.149	-1.0E-4	-6.2E-5	+0.34%	+0.27%	.00481	305.2	67.2

Appendix 3: Cathodoluminescence photomicrographs of detrital zircons separated from Triassic sandstone and Jurassic greywacke samples collected from the Lower Yana River.

08DH01

08DH02

08DH03

08DH029a

08DH030a

08DH032

08DH033

Appendix 4: Complete data from LA-MC-ICPMS analysis of detrital zircons separated from Triassic sandstone and Jurassic greywacke samples from the Lower Yana River area near the Kular Dome, northern Russia. Crossed-out ages were excluded from further analysis due to greater than 30% discordance or greater than 5% reverse discordance between $^{238}\text{U}/^{206}\text{Pb}$ and $^{207}\text{Pb}/^{206}\text{Pb}$ ages.

08DH01

Isotope ratios

Analysis	U (ppm)	$^{206}\text{Pb}/^{204}\text{Pb}$	U/Th	$^{206}\text{Pb}^*/^{207}\text{Pb}^*$	$\pm$ (%)	$^{207}\text{Pb}^*/^{235}\text{U}^*$	$\pm$ (%)	$^{206}\text{Pb}^*/^{238}\text{U}$	$\pm$ (%)	error corr.
08DH01A-1	211	19461	2.5	17.5628	3.4	0.6435	3.9	0.0820	1.9	0.49
08DH01A-2	360	17391	1.8	19.8616	2.4	0.2856	3.1	0.0411	2.1	0.65
08DH01A-3	55	2031	1.1	19.7490	11.6	0.3133	12.1	0.0449	3.4	0.28
08DH01A-4	130	5010	1.3	18.8102	9.4	0.3749	9.5	0.0511	1.7	0.17
08DH01A-5	68	2394	1.5	19.6525	8.7	0.3371	9.0	0.0481	2.2	0.25
08DH01A-6	122	14502	1.7	15.3509	2.6	1.1751	3.1	0.1308	1.6	0.53
08DH01A-7	241	4989	0.6	19.7412	7.6	0.2634	7.8	0.0377	1.5	0.19
08DH01A-8	211	60108	1.9	7.9578	2.2	6.4981	2.2	0.3750	0.5	0.23
08DH01A-10	55	3135	2.3	21.1067	16.4	0.3131	16.4	0.0479	1.0	0.06
08DH01A-11	205	14448	4.3	17.8497	2.3	0.6082	2.4	0.0787	0.8	0.33
08DH01A-12	55	2160	0.9	22.8922	15.3	0.2217	15.4	0.0368	1.7	0.11
08DH01A-13	75	4350	1.9	19.9594	7.2	0.3890	7.3	0.0563	0.8	0.10
08DH01A-14	231	8205	1.1	19.9424	3.1	0.2560	3.4	0.0370	1.3	0.39
08DH01A-15	149	2382	0.9	18.0903	6.6	0.2829	7.0	0.0371	2.4	0.35
08DH01A-16	64	31032	1.9	7.6924	2.2	6.8633	2.4	0.3829	0.9	0.36
08DH01A-17	143	13155	1.9	17.5439	2.2	0.6338	2.9	0.0806	1.9	0.65
08DH01A-18	117	6390	1.6	19.9817	4.9	0.3396	5.1	0.0492	1.4	0.27
08DH01A-19	141	8235	1.5	19.4695	3.9	0.3689	4.2	0.0521	1.6	0.38
08DH01A-20	326	10470	1.9	19.7149	2.1	0.2881	2.2	0.0412	0.5	0.23
08DH01A-21	442	77655	6.7	8.8387	1.7	5.0666	1.9	0.3248	0.8	0.43
08DH01A-22	149	5133	0.9	20.3510	4.6	0.2570	5.0	0.0379	1.9	0.37
08DH01A-23	311	5694	1.5	18.4303	15.0	0.2959	15.1	0.0396	2.0	0.13
08DH01A-24	83	3531	1.2	20.6238	6.5	0.2756	6.5	0.0412	0.7	0.11
08DH01A-25	537	40284	5.1	17.9289	1.6	0.5696	1.8	0.0741	0.8	0.47
08DH01A-26	412	14859	1.6	18.9048	2.7	0.3707	3.7	0.0508	2.6	0.69
08DH01A-28	371	39585	7.9	5.5103	1.2	10.1425	2.5	0.4053	2.2	0.89
08DH01A-29	116	5157	2.4	17.2638	12.4	0.6213	12.5	0.0778	1.3	0.10
08DH01A-30	416	29775	1.4	17.3842	1.6	0.7006	1.9	0.0883	0.9	0.50
08DH01A-31	125	5175	0.8	20.4793	5.4	0.2717	5.9	0.0404	2.4	0.40
08DH01A-32	98	6828	3.2	18.0005	4.6	0.5091	5.4	0.0665	2.9	0.53
08DH01A-33	248	13593	3.5	18.7896	2.9	0.4532	3.1	0.0618	1.2	0.38
08DH01A-34	237	12633	1.2	17.5753	1.9	0.6364	1.9	0.0811	0.5	0.26
08DH01A-35	153	40836	1.8	8.5944	1.4	5.4674	1.5	0.3408	0.5	0.33
08DH01A-36	196	14544	1.8	18.0818	3.1	0.5485	3.3	0.0719	1.2	0.36
08DH01A-37	125	5124	1.6	16.7961	13.6	0.6415	13.7	0.0782	1.3	0.09
08DH01A-38	133	5931	1.5	19.3924	5.6	0.3446	6.1	0.0485	2.4	0.39
08DH01A-39	84	28221	1.6	8.6296	2.3	5.5121	2.5	0.3450	0.9	0.34
08DH01A-40	73	2610	1.0	20.0603	7.3	0.3104	7.3	0.0452	0.8	0.11
08DH01A-41	97	12312	2.1	15.1507	3.3	1.1519	3.4	0.1266	0.9	0.26
08DH01A-42	145	6921	1.7	19.6463	2.9	0.3257	3.0	0.0464	0.9	0.29
08DH01A-43	137	4761	1.0	20.4673	4.5	0.2548	4.6	0.0378	1.1	0.23
08DH01A-44	164	5967	1.1	20.3638	5.4	0.2546	5.5	0.0376	0.6	0.11
08DH01A-45	48	4293	1.5	18.0654	4.7	0.6201	4.9	0.0813	1.3	0.26
08DH01A-46	36	3897	1.2	18.0763	8.4	0.6052	8.5	0.0793	1.3	0.15
08DH01A-47	373	23595	6.6	18.4118	2.9	0.4372	3.5	0.0584	2.1	0.58

08DH01

Apparent Ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH01A-1	507.9	9.1	504.5	15.3	489.2	74.3	507.9	9.1	103.8
08DH01A-2	259.9	5.2	255.1	7.1	211.1	55.4	259.9	5.2	123.1
08DH01A-3	283.0	9.4	276.7	29.2	224.3	268.2	283.0	9.4	126.2
08DH01A-4	321.5	5.2	323.3	26.4	335.7	213.0	321.5	5.2	95.8
08DH01A-5	302.6	6.6	295.0	23.0	235.6	200.7	302.6	6.6	128.4
08DH01A-6	792.6	12.1	789.0	16.9	778.9	55.1	792.6	12.1	101.8
08DH01A-7	238.7	3.4	237.4	16.5	225.2	176.7	238.7	3.4	106.0
08DH01A-8	2053.1	8.8	2045.6	19.5	2038.1	38.2	2038.1	38.2	100.7
08DH01A-10	301.8	2.9	276.6	39.8	68.3	392.5	301.8	2.9	441.7
08DH01A-11	488.5	3.9	482.4	9.4	453.3	51.2	488.5	3.9	107.8
08DH01A-12	233.1	3.9	203.4	28.3	-128.5	379.1	233.1	3.9	-181.4
08DH01A-13	353.2	2.6	333.7	20.7	199.7	168.1	353.2	2.6	176.8
08DH01A-14	234.3	3.1	231.4	7.0	201.7	71.8	234.3	3.1	116.2
08DH01A-15	235.0	5.6	253.0	15.7	423.5	147.1	235.0	5.6	55.5
08DH01A-16	2089.9	15.2	2093.9	21.1	2097.9	39.0	2097.9	39.0	99.6
08DH01A-17	500.0	8.9	498.4	11.2	491.5	47.8	500.0	8.9	101.7
08DH01A-18	309.7	4.2	296.9	13.0	197.1	113.2	309.7	4.2	157.1
08DH01A-19	327.4	5.1	318.9	11.4	257.1	88.7	327.4	5.1	127.3
08DH01A-20	260.2	1.3	257.1	5.0	228.2	49.5	260.2	1.3	114.0
08DH01A-21	1813.1	12.5	1830.5	15.7	1850.4	30.4	1850.4	30.4	98.0
08DH01A-22	240.0	4.4	232.3	10.3	154.4	108.0	240.0	4.4	155.5
08DH01A-23	250.1	4.8	263.2	35.1	381.8	339.0	250.1	4.8	65.5
08DH01A-24	260.4	1.8	247.2	14.4	123.1	153.3	260.4	1.8	211.5
08DH01A-25	460.6	3.7	457.8	6.5	443.4	34.9	460.6	3.7	103.9
08DH01A-26	319.6	8.0	320.2	10.2	324.4	61.3	319.6	8.0	98.5
08DH01A-28	2193.6	41.6	2447.8	23.4	2666.4	19.4	2666.4	19.4	82.3
08DH01A-29	482.9	6.0	490.7	48.7	526.9	273.6	482.9	6.0	91.6
08DH01A-30	545.7	4.9	539.2	7.9	511.7	35.9	545.7	4.9	106.7
08DH01A-31	255.1	6.0	244.1	12.8	139.7	126.9	255.1	6.0	182.6
08DH01A-32	414.9	11.5	417.9	18.5	434.6	101.5	414.9	11.5	95.5
08DH01A-33	386.3	4.4	379.5	9.8	338.2	64.9	386.3	4.4	114.2
08DH01A-34	502.8	2.4	500.1	7.6	487.6	40.9	502.8	2.4	103.1
08DH01A-35	1890.5	8.2	1895.5	13.0	1900.9	25.7	1900.9	25.7	99.4
08DH01A-36	447.8	5.1	444.0	11.8	424.5	68.5	447.8	5.1	105.5
08DH01A-37	485.1	5.9	503.3	54.3	586.8	296.7	485.1	5.9	82.7
08DH01A-38	305.1	7.0	300.6	15.7	266.2	128.0	305.1	7.0	114.6
08DH01A-39	1910.6	14.1	1902.5	21.4	1893.6	42.1	1893.6	42.1	100.9
08DH01A-40	284.7	2.2	274.5	17.5	188.0	169.0	284.7	2.2	151.5
08DH01A-41	768.3	6.4	778.1	18.4	806.5	68.3	768.3	6.4	95.3
08DH01A-42	292.4	2.5	286.3	7.5	236.3	65.9	292.4	2.5	123.8
08DH01A-43	239.3	2.5	230.4	9.6	141.1	106.4	239.3	2.5	169.7
08DH01A-44	237.9	1.4	230.3	11.3	152.9	127.6	237.9	1.4	155.6
08DH01A-45	503.6	6.1	489.9	19.0	426.5	105.3	503.6	6.1	118.1
08DH01A-46	492.2	6.2	480.5	32.5	425.2	187.2	492.2	6.2	115.8
08DH01A-47	365.8	7.4	368.3	11.0	384.0	64.7	365.8	7.4	95.3

08DH01

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH01A-48	266	6294	1.8	19.2425	2.3	0.3517	2.5	0.0491	0.8	0.32
08DH01A-49	178	8031	2.3	19.5111	4.1	0.3534	4.3	0.0500	1.1	0.26
08DH01A-50	107	5823	1.1	19.7348	2.8	0.2774	3.2	0.0397	1.5	0.47
08DH01A-51	119	5130	1.5	20.9797	6.8	0.2388	7.5	0.0363	3.1	0.41
08DH01A-52	273	21810	3.8	17.8539	2.0	0.5854	2.2	0.0758	0.8	0.35
08DH01A-53	63	2124	0.4	20.1553	9.2	0.2773	9.5	0.0405	2.5	0.27
08DH01A-54	55	5259	2.5	17.1048	4.2	0.6447	4.2	0.0800	0.5	0.12
08DH01A-55	80	5871	1.8	17.4758	2.8	0.6353	3.2	0.0805	1.5	0.48
08DH01A-56	93	6975	1.4	17.8375	3.3	0.6180	3.8	0.0799	1.8	0.49
08DH01A-57	250	22938	1.6	17.3836	3.4	0.6648	3.5	0.0838	0.8	0.23
08DH01A-58	182	7170	1.1	20.3505	4.6	0.2642	4.7	0.0390	0.7	0.15
08DH01A-60	153	15432	1.9	17.5690	2.4	0.6434	2.4	0.0820	0.5	0.21
08DH01A-61	370	10509	0.7	19.7878	3.1	0.2777	3.1	0.0399	0.5	0.16
08DH01A-62	424	10866	1.9	18.6841	3.1	0.3625	3.3	0.0491	1.1	0.32
08DH01A-63	105	3117	0.9	20.5864	6.6	0.2465	6.7	0.0368	1.0	0.14
08DH01A-64	103	4329	1.3	18.3593	17.4	0.3819	17.4	0.0508	0.7	0.04
08DH01A-65	377	17115	1.1	19.0604	0.7	0.3556	1.1	0.0492	0.8	0.74
08DH01A-66	307	12048	1.5	19.2148	1.8	0.3445	2.1	0.0480	1.1	0.53
08DH01A-67	49	5538	1.0	15.4632	3.3	1.1569	3.4	0.1298	1.1	0.31
08DH01A-68	138	5244	1.7	20.1738	4.2	0.2794	4.4	0.0409	1.0	0.24
08DH01A-69	223	23694	5.0	17.8604	2.9	0.6092	3.5	0.0789	1.8	0.52
08DH01A-70	130	3570	0.8	19.0317	7.8	0.2728	7.9	0.0377	1.4	0.17
08DH01A-71	131	1251	1.7	20.0483	11.3	0.4521	11.3	0.0657	1.1	0.09
08DH01A-72	174	49899	1.3	8.9258	2.0	4.6776	2.1	0.3028	0.5	0.24
08DH01A-73	730	12927	2.6	19.3017	1.6	0.3470	1.7	0.0486	0.7	0.39
08DH01A-74	169	6759	1.2	18.9794	5.9	0.3425	6.1	0.0471	1.4	0.23
08DH01A-75	133	14364	4.3	17.5272	2.7	0.6658	2.8	0.0846	0.7	0.26
08DH01A-76	55	1938	1.7	21.3160	10.9	0.2741	10.9	0.0424	0.8	0.07
08DH01A-77	154	2490	1.4	16.6099	4.4	0.6927	4.5	0.0834	0.5	0.11
08DH01A-78	97	17280	2.9	10.2273	1.5	2.5494	1.9	0.1891	1.2	0.63
08DH01A-79	91	5640	1.8	17.7441	2.5	0.6070	2.9	0.0781	1.5	0.51
08DH01A-80	180	7632	2.5	19.2380	2.9	0.3496	3.2	0.0488	1.2	0.38
08DH01A-81	222	14634	1.9	17.7457	1.4	0.5785	1.5	0.0745	0.5	0.33
08DH01A-82	257	17511	1.8	17.8248	1.6	0.5887	1.8	0.0761	0.7	0.38
08DH01A-83	134	3885	1.6	19.6598	4.3	0.3278	4.3	0.0467	0.6	0.15
08DH01A-84	193	56268	1.8	7.9326	3.2	6.2631	3.8	0.3603	2.0	0.53
08DH01A-86	165	5751	0.7	20.0389	3.7	0.2860	3.8	0.0416	0.7	0.18
08DH01A-87	710	168600	37.5	6.4452	1.5	8.4541	2.1	0.3952	1.5	0.71
08DH01A-88	82	7212	1.2	18.6374	7.9	0.5931	8.0	0.0802	1.2	0.15
08DH01A-89	261	6489	0.6	19.6737	2.2	0.2707	2.3	0.0386	0.7	0.29
08DH01A-90	223	21318	2.0	13.8887	2.7	1.5815	2.8	0.1593	0.5	0.18
08DH01A-91	134	5160	2.4	20.2371	5.5	0.2701	5.6	0.0396	0.9	0.17
08DH01A-92	229	6204	1.0	19.9749	2.8	0.2591	2.8	0.0375	0.7	0.23
08DH01A-93	434	18894	2.3	18.7992	2.0	0.4255	3.7	0.0580	3.2	0.85
08DH01A-94	106	10479	3.0	17.5957	3.3	0.6593	3.7	0.0841	1.8	0.48

08DH01

Apparent Ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH01A-48	308.9	2.4	306.0	6.5	284.0	53.3	308.9	2.4	108.7
08DH01A-49	314.6	3.5	307.3	11.4	252.2	95.4	314.6	3.5	124.7
08DH01A-50	251.0	3.7	248.6	7.1	225.9	65.8	251.0	3.7	111.1
08DH01A-51	230.1	6.9	217.4	14.7	82.7	162.4	230.1	6.9	278.4
08DH01A-52	471.0	3.5	467.9	8.2	452.7	45.4	471.0	3.5	104.0
08DH01A-53	256.1	6.4	248.5	21.1	177.0	215.0	256.1	6.4	144.7
08DH01A-54	496.0	2.4	505.2	16.7	547.1	91.3	496.0	2.4	90.7
08DH01A-55	499.2	7.2	499.4	12.5	500.1	61.2	499.2	7.2	99.8
08DH01A-56	495.8	8.8	488.6	14.6	454.8	72.8	495.8	8.8	109.0
08DH01A-57	518.9	4.1	517.6	14.3	511.7	75.7	518.9	4.1	101.4
08DH01A-58	246.6	1.6	238.0	9.9	154.4	107.9	246.6	1.6	159.7
08DH01A-60	508.0	2.4	504.4	9.7	488.4	52.6	508.0	2.4	104.0
08DH01A-61	252.0	1.2	248.9	6.9	219.7	71.5	252.0	1.2	114.7
08DH01A-62	309.2	3.2	314.1	8.9	351.0	70.5	309.2	3.2	88.1
08DH01A-63	233.0	2.2	223.7	13.5	127.4	156.3	233.0	2.2	182.8
08DH01A-64	319.7	2.0	328.4	49.0	390.4	393.8	319.7	2.0	81.9
08DH01A-65	309.3	2.4	308.9	2.9	305.7	16.3	309.3	2.4	101.2
08DH01A-66	302.3	3.2	300.6	5.4	287.3	40.4	302.3	3.2	105.2
08DH01A-67	786.4	7.9	780.5	18.7	763.6	68.6	786.4	7.9	103.0
08DH01A-68	258.3	2.6	250.2	9.7	174.8	99.1	258.3	2.6	147.7
08DH01A-69	489.6	8.5	483.0	13.3	451.9	65.4	489.6	8.5	108.3
08DH01A-70	238.3	3.2	244.9	17.3	309.2	178.3	238.3	3.2	77.1
08DH01A-71	410.5	4.3	378.8	35.8	189.4	262.6	410.5	4.3	216.8
08DH01A-72	1705.2	7.5	1763.2	17.4	1832.7	36.6	1832.7	36.6	93.0
08DH01A-73	305.7	2.0	302.4	4.5	277.0	36.4	305.7	2.0	110.4
08DH01A-74	296.9	4.1	299.0	15.7	315.4	134.3	296.9	4.1	94.1
08DH01A-75	523.7	3.6	518.2	11.3	493.6	59.6	523.7	3.6	106.1
08DH01A-76	267.5	2.1	245.9	23.8	44.8	260.3	267.5	2.1	597.1
08DH01A-77	516.7	2.5	534.4	18.6	610.9	96.2	516.7	2.5	84.6
08DH01A-78	1116.5	12.1	1286.3	13.7	1582.1	27.3	1582.1	27.3	70.6
08DH01A-79	484.8	7.0	481.6	11.2	466.5	55.7	484.8	7.0	103.9
08DH01A-80	307.0	3.6	304.4	8.4	284.6	67.4	307.0	3.6	107.9
08DH01A-81	462.9	2.2	463.5	5.7	466.3	32.0	462.9	2.2	99.3
08DH01A-82	472.8	3.1	470.0	6.7	456.4	36.3	472.8	3.1	103.6
08DH01A-83	294.5	1.8	287.9	10.8	234.7	98.5	294.5	1.8	125.5
08DH01A-84	1983.7	34.0	2013.3	33.1	2043.8	56.8	2043.8	56.8	97.1
08DH01A-86	262.5	1.7	255.4	8.5	190.5	86.0	262.5	1.7	137.8
08DH01A-87	2146.8	27.2	2281.0	19.0	2403.5	25.0	2403.5	25.0	89.3
08DH01A-88	497.1	5.9	472.8	30.4	356.6	179.7	497.1	5.9	139.4
08DH01A-89	244.3	1.6	243.3	5.0	233.1	50.9	244.3	1.6	104.8
08DH01A-90	952.9	4.4	962.9	17.3	986.0	55.8	952.9	4.4	96.6
08DH01A-91	250.6	2.3	242.8	12.0	167.5	127.9	250.6	2.3	149.6
08DH01A-92	237.6	1.5	234.0	5.9	197.9	64.3	237.6	1.5	120.1
08DH01A-93	363.6	11.1	360.0	11.3	337.1	44.9	363.6	11.1	107.9
08DH01A-94	520.8	9.1	514.2	15.1	485.0	72.5	520.8	9.1	107.4

08DH01

Isotope ratios

Analysis	U (ppm)	$^{206}\text{Pb}/$ ^{204}Pb	U/Th	$^{206}\text{Pb}^*/$ $^{207}\text{Pb}^*$	$\pm$ (%)	$^{207}\text{Pb}^*/$ $^{235}\text{U}^*$	$\pm$ (%)	$^{206}\text{Pb}^*/$ ^{238}U	$\pm$ (%)	error corr.
08DH01A-95	125	3879	1.8	18.6315	7.6	0.3486	7.7	0.0471	1.3	0.17
08DH01A-96	64	1857	0.8	20.6980	6.6	0.2459	6.7	0.0369	0.9	0.13
08DH01A-97	66	2862	1.0	19.8223	6.3	0.3100	6.4	0.0446	0.9	0.14
08DH01A-99	229	1593	1.1	19.8008	5.2	0.3271	5.3	0.0470	1.1	0.21
08DH01A-100	158	14703	1.4	17.7768	2.4	0.6307	2.5	0.0813	0.6	0.23

08DH01

Apparent Ages (Ma)

Analysis	$^{206}\text{Pb}^*/$ $^{238}\text{U}^*$	$\pm$ (Ma)	$^{207}\text{Pb}^*/$ ^{235}U	$\pm$ (Ma)	$^{206}\text{Pb}^*/$ $^{207}\text{Pb}^*$	$\pm$ (Ma)	Best age (Ma)	$\pm$ (Ma)	Conc (%)
08DH01A-95	296.7	3.9	303.6	20.2	357.3	171.1	296.7	3.9	83.0
08DH01A-96	233.6	2.0	223.2	13.4	114.6	156.9	233.6	2.0	203.8
08DH01A-97	281.1	2.5	274.2	15.3	215.7	146.3	281.1	2.5	130.3
08DH01A-99	295.9	3.2	287.3	13.4	218.2	120.8	295.9	3.2	135.6
08DH01A-100	504.0	2.9	496.5	9.9	462.4	54.2	504.0	2.9	109.0

08DH02

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH02-1	722	17751	1.0	19.6547	1.6	0.2913	1.7	0.0415	0.7	0.41
08DH02-2	372	7857	2.3	20.2796	2.5	0.1912	2.7	0.0281	0.9	0.34
08DH02-3	115	2517	2.8	20.1464	6.5	0.1777	6.6	0.0260	0.8	0.12
08DH02-4	59	1218	1.5	21.1901	17.5	0.1673	17.5	0.0257	0.6	0.04
08DH02-5	277	5865	0.5	19.1238	1.1	0.2986	1.3	0.0414	0.7	0.53
08DH02-6	106	3009	0.5	19.2102	4.4	0.3014	4.4	0.0420	0.7	0.16
08DH02-7	62	1683	2.7	22.6277	20.2	0.1516	20.3	0.0249	1.9	0.10
08DH02-8	821	51435	2.5	8.7134	2.4	4.9020	3.5	0.3098	2.5	0.73
08DH02-9	162	58428	2.2	5.7375	2.0	11.5414	2.3	0.4803	1.0	0.45
08DH02-10	56	1620	0.5	18.9039	7.4	0.2919	7.5	0.0400	1.4	0.18
08DH02-11	110	32514	1.1	8.6022	2.5	5.2689	2.7	0.3287	0.9	0.34
08DH02-12	160	4320	1.1	19.9643	4.9	0.2623	5.1	0.0380	1.2	0.24
08DH02-13	179	7974	1.9	18.9937	2.6	0.3697	3.1	0.0509	1.6	0.53
08DH02-14	846	1200	1.1	12.0646	13.5	0.4974	13.6	0.0435	1.4	0.10
08DH02-15	14	3816	1.8	8.4329	3.0	5.7693	3.3	0.3529	1.4	0.43
08DH02-16	153	5007	0.9	19.3498	2.8	0.3017	2.9	0.0423	0.7	0.23
08DH02-17	486	111381	2.9	8.1678	1.6	5.9394	1.8	0.3518	0.8	0.42
08DH02-18	184	3942	1.0	20.1606	4.1	0.1729	4.2	0.0253	1.2	0.28
08DH02-19	134	939	1.3	13.5808	7.7	0.2610	8.0	0.0257	2.1	0.27
08DH02-20	90	17106	1.4	9.4782	1.7	4.3671	1.8	0.3002	0.5	0.28
08DH02-21	287	13443	1.3	18.4272	1.3	0.4211	1.7	0.0563	1.0	0.60
08DH02-22	131	4779	0.8	19.3225	3.1	0.3055	3.2	0.0428	0.9	0.29
08DH02-23	141	53847	2.3	6.0772	1.5	9.7856	1.8	0.4313	1.1	0.58
08DH02-24	438	3993	0.8	18.4632	8.4	0.1868	8.5	0.0250	1.0	0.11
08DH02-25	479	15666	1.0	7.8663	1.4	5.6106	3.0	0.3201	2.6	0.88
08DH02-26	231	51723	2.7	5.6291	1.4	10.7669	2.4	0.4396	2.0	0.83
08DH02-27	393	104733	1.9	5.7718	0.8	11.0377	1.4	0.4620	1.1	0.80
08DH02-28	79	3678	0.8	19.6878	7.1	0.3243	7.1	0.0463	0.5	0.07
08DH02-29	193	4380	0.7	19.2768	2.8	0.2851	3.0	0.0399	1.3	0.41
08DH02-31	30	504	0.5	26.5321	25.2	0.1186	25.7	0.0228	4.9	0.19
08DH02-32	408	13473	1.2	19.1797	1.2	0.3300	1.4	0.0459	0.8	0.53
08DH02-33	433	13020	1.2	19.5314	2.1	0.2994	3.1	0.0424	2.3	0.74
08DH02-34	627	1530	4.1	12.7729	4.4	0.7591	4.6	0.0703	1.5	0.33
08DH02-35	387	10431	0.8	18.9681	4.7	0.3314	4.7	0.0456	0.6	0.13
08DH02-36	97	1821	1.1	21.3265	13.8	0.1635	13.9	0.0253	1.8	0.13
08DH02-37	394	10359	0.8	19.3616	3.3	0.3219	3.3	0.0452	0.5	0.15
08DH02-39	110	33420	2.6	8.7953	1.7	5.1788	2.1	0.3304	1.2	0.60
08DH02-40	280	5802	1.2	9.0562	1.4	3.8543	2.1	0.2532	1.5	0.73
08DH02-41	157	4047	0.6	19.4408	4.4	0.2832	4.6	0.0399	1.4	0.31
08DH02-42	508	2280	1.0	15.4178	3.8	0.3813	4.4	0.0426	2.2	0.50
08DH02-43	237	9039	1.6	19.5585	2.5	0.2997	2.8	0.0425	1.2	0.44
08DH02-44	107	2754	0.4	19.1113	4.5	0.2902	4.6	0.0402	0.9	0.19
08DH02-45	165	6546	1.2	19.3645	3.5	0.3154	3.6	0.0443	0.9	0.25
08DH02-46	538	125574	2.4	8.6638	1.8	5.2979	2.1	0.3329	1.0	0.49
08DH02-47	23	6699	1.6	8.8243	2.7	5.2906	2.9	0.3386	1.2	0.39

08DH02

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH02-1	262.3	1.8	259.6	3.9	235.3	35.8	262.3	1.8	111.4
08DH02-2	178.8	1.6	177.7	4.4	162.6	59.4	178.8	1.6	110.0
08DH02-3	165.2	1.3	166.1	10.1	178.0	152.4	165.2	1.3	92.8
08DH02-4	163.6	1.0	157.0	25.4	59.0	419.0	163.6	1.0	277.4
08DH02-5	261.6	1.7	265.3	2.9	298.2	24.2	261.6	1.7	87.7
08DH02-6	265.2	1.9	267.5	10.4	287.9	99.8	265.2	1.9	92.1
08DH02-7	158.4	3.0	143.3	27.2	-99.9	501.5	158.4	3.0	-158.6
08DH02-8	1739.6	38.4	1802.6	29.2	1876.2	42.7	1876.2	42.7	92.7
08DH02-9	2528.4	21.8	2567.9	21.4	2599.3	34.0	2599.3	34.0	97.3
08DH02-10	253.0	3.4	260.1	17.3	324.5	168.7	253.0	3.4	78.0
08DH02-11	1832.2	14.5	1863.8	22.8	1899.3	45.1	1899.3	45.1	96.5
08DH02-12	240.3	2.9	236.5	10.7	199.2	114.3	240.3	2.9	120.7
08DH02-13	320.2	5.1	319.4	8.5	313.7	59.9	320.2	5.1	102.1
08DH02-14	274.6	3.6	409.9	45.9	1266.6	265.5	274.6	3.6	21.7
08DH02-15	1948.2	23.5	1941.8	28.4	1935.0	53.2	1935.0	53.2	100.7
08DH02-16	267.4	1.7	267.8	6.7	271.3	63.8	267.4	1.7	98.6
08DH02-17	1943.4	12.9	1967.0	15.7	1991.9	29.2	1991.9	29.2	97.6
08DH02-18	160.9	1.9	161.9	6.3	176.3	94.9	160.9	1.9	91.3
08DH02-19	163.6	3.5	235.5	16.9	1031.4	156.7	163.6	3.5	15.9
08DH02-20	1692.3	7.4	1706.1	14.6	1723.1	31.1	1723.1	31.1	98.2
08DH02-21	352.9	3.4	356.8	5.0	382.2	29.7	352.9	3.4	92.4
08DH02-22	270.2	2.5	270.7	7.6	274.5	70.2	270.2	2.5	98.4
08DH02-23	2311.6	20.6	2414.8	16.9	2503.0	25.2	2503.0	25.2	92.4
08DH02-24	159.3	1.5	173.9	13.5	377.8	189.5	159.3	1.5	42.2
08DH02-25	1790.2	41.0	1917.7	25.6	2058.6	24.7	2058.6	24.7	87.0
08DH02-26	2348.7	39.2	2503.2	22.3	2631.0	22.4	2631.0	22.4	89.3
08DH02-27	2448.6	22.8	2526.3	13.0	2589.3	14.0	2589.3	14.0	94.6
08DH02-28	291.8	1.4	285.2	17.8	231.4	164.8	291.8	1.4	126.1
08DH02-29	252.0	3.1	254.7	6.9	280.0	63.4	252.0	3.1	90.0
08DH02-31	145.5	7.0	113.8	27.6	-507.0	680.0	145.5	7.0	-28.7
08DH02-32	289.4	2.1	289.6	3.6	291.5	27.7	289.4	2.1	99.3
08DH02-33	267.7	6.0	265.9	7.2	249.9	47.7	267.7	6.0	107.2
08DH02-34	438.1	6.4	573.5	20.3	1154.2	86.9	438.1	6.4	38.0
08DH02-35	287.4	1.7	290.7	11.9	316.7	106.5	287.4	1.7	90.7
08DH02-36	161.0	2.9	153.8	19.8	43.6	330.1	161.0	2.9	369.1
08DH02-37	285.0	1.4	283.3	8.3	269.9	75.9	285.0	1.4	105.6
08DH02-39	1840.1	19.8	1849.1	17.6	1859.3	30.0	1859.3	30.0	99.0
08DH02-40	1454.7	19.8	1604.2	16.8	1806.4	26.0	1806.4	26.0	80.5
08DH02-41	252.4	3.5	253.2	10.3	260.5	100.5	252.4	3.5	96.9
08DH02-42	269.2	5.9	328.0	12.3	769.8	80.1	269.2	5.9	35.0
08DH02-43	268.4	3.2	266.2	6.5	246.6	57.3	268.4	3.2	108.8
08DH02-44	254.2	2.2	258.7	10.4	299.6	102.2	254.2	2.2	84.8
08DH02-45	279.4	2.5	278.4	8.8	269.5	80.6	279.4	2.5	103.7
08DH02-46	1852.4	16.4	1868.5	17.7	1886.5	32.4	1886.5	32.4	98.2
08DH02-47	1879.9	18.8	1867.3	25.2	1853.4	49.1	1853.4	49.1	101.4

08DH02

Isotope ratios

Analysis	U (ppm)	206Pb/ 204Pb	U/Th	206Pb*/ 207Pb*	± (%)	207Pb*/ 235U*	± (%)	206Pb*/ 238U	± (%)	error corr.
08DH02-48	147	6345	0.9	19.3194	2.9	0.3335	3.0	0.0467	0.7	0.22
08DH02-49	24	6831	1.1	9.3916	2.0	4.3674	2.1	0.2975	0.5	0.24
08DH02-50	189	46275	1.9	8.8162	0.6	4.9636	1.2	0.3174	1.0	0.88
08DH02-51	250	8538	1.7	5.3374	7.0	9.5647	7.1	0.3703	1.0	0.13
08DH02-52	555	23136	5.9	18.4883	1.0	0.4157	1.2	0.0557	0.5	0.43
08DH02-53	890	525	0.6	5.9474	27.2	1.1134	27.3	0.0480	2.0	0.07
08DH02-54	180	8757	1.5	19.0208	2.0	0.3616	2.3	0.0499	1.1	0.50
08DH02-55	44	1641	1.0	20.3841	15.5	0.2695	15.6	0.0398	2.0	0.12
08DH02-56	249	7575	0.8	19.6230	3.4	0.2906	3.5	0.0414	1.1	0.32
08DH02-57	583	42951	5.5	17.3559	0.9	0.6161	1.2	0.0776	0.8	0.67
08DH02-58	235	49428	0.7	8.6677	1.7	5.2589	2.1	0.3306	1.3	0.59
08DH02-59	529	67593	2.3	6.2327	1.7	9.6914	2.1	0.4381	1.3	0.60
08DH02-60	244	1905	0.6	18.1888	23.3	0.2763	23.3	0.0364	0.7	0.03
08DH02-61	98	20631	1.1	8.6726	1.7	5.3019	1.9	0.3335	0.8	0.43
08DH02-62	48	1278	0.6	20.3143	15.9	0.2625	15.9	0.0387	0.8	0.05
08DH02-63	225	7854	0.9	19.5794	2.9	0.2810	3.0	0.0399	0.8	0.26
08DH02-64	277	10629	1.3	19.7932	3.4	0.2946	4.1	0.0423	2.3	0.56
08DH02-65	286	9462	0.7	19.2143	1.5	0.3188	1.6	0.0444	0.6	0.39
08DH02-66	92	3690	3.5	19.4369	4.9	0.2835	5.0	0.0400	0.5	0.10
08DH02-67	294	6582	0.6	19.4076	2.2	0.2909	2.6	0.0410	1.4	0.54
08DH02-68	265	6909	1.3	19.7392	2.5	0.2576	2.7	0.0369	1.0	0.36
08DH02-69	210	67071	2.5	8.6545	1.2	5.2899	1.9	0.3320	1.5	0.78
08DH02-70	406	92313	3.1	6.2587	1.3	9.9989	2.6	0.4539	2.3	0.88
08DH02-71	111	3834	0.7	19.0332	4.3	0.3226	4.5	0.0445	1.2	0.26
08DH02-73	422	125370	5.1	6.4466	1.0	9.1370	1.6	0.4272	1.3	0.79
08DH02-74	76	25656	2.4	9.4335	1.3	4.5002	1.7	0.3079	1.1	0.62
08DH02-75	594	13482	0.5	18.5788	4.0	0.3295	4.6	0.0444	2.4	0.52
08DH02-76	172	1962	1.3	13.8657	13.5	0.4687	13.6	0.0471	1.2	0.09
08DH02-77	404	12276	1.5	19.3101	2.0	0.3306	2.4	0.0463	1.3	0.55
08DH02-78	257	7875	0.8	19.3806	2.6	0.3200	2.8	0.0450	1.0	0.35
08DH02-79	150	5775	0.8	19.6150	3.8	0.2763	4.8	0.0393	2.8	0.59
08DH02-80	260	1791	2.3	13.7359	8.0	0.4549	8.5	0.0453	2.8	0.33
08DH02-81	87	16884	7.9	8.4540	0.9	5.5123	1.6	0.3380	1.3	0.84
08DH02-82	314	4251	0.8	17.7286	5.1	0.3327	5.2	0.0428	0.8	0.15
08DH02-83	185	39204	8.0	8.5513	1.5	5.0662	1.6	0.3142	0.5	0.31
08DH02-84	117	4692	1.1	19.2835	4.3	0.3095	4.5	0.0433	1.5	0.33
08DH02-85	275	10521	1.2	19.1817	2.4	0.3146	2.6	0.0438	1.1	0.43
08DH02-86	340	3459	1.0	17.5261	14.6	0.3288	14.7	0.0418	1.7	0.12
08DH02-87	36	1206	0.5	19.1342	11.5	0.2915	11.5	0.0405	0.5	0.04
08DH02-88	714	5178	2.7	7.9928	1.1	6.2960	2.9	0.3650	2.7	0.92
08DH02-89	269	8088	1.3	19.2791	1.5	0.2984	1.6	0.0417	0.6	0.34
08DH02-90	67	2901	0.9	21.1487	12.2	0.2460	12.2	0.0377	0.7	0.06
08DH02-91	208	57036	1.7	8.8361	1.0	5.0657	1.1	0.3246	0.5	0.47
08DH02-92	134	5547	1.6	19.4055	10.9	0.3021	10.9	0.0425	0.8	0.08
08DH02-93	96	2328	1.4	20.8678	10.0	0.1593	10.1	0.0241	1.8	0.17

08DH02

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH02-48	294.4	1.9	292.2	7.6	274.9	66.6	294.4	1.9	107.1
08DH02-49	1678.8	7.4	1706.2	17.4	1740.0	37.5	1740.0	37.5	96.5
08DH02-50	1776.9	16.0	1813.1	9.9	1855.0	10.1	1855.0	10.1	95.8
08DH02-51	2030.6	16.5	2393.8	65.1	2719.1	115.6	2719.1	115.6	74.7
08DH02-52	349.7	1.7	353.0	3.5	374.7	23.5	349.7	1.7	93.3
08DH02-53	302.4	5.8	759.8	147.0	2539.2	466.3	2539.2	466.3	11.9
08DH02-54	313.8	3.5	313.4	6.1	310.4	45.0	313.8	3.5	101.1
08DH02-55	251.9	4.8	242.3	33.7	150.6	364.9	251.9	4.8	167.3
08DH02-56	261.3	2.9	259.0	8.1	239.0	77.6	261.3	2.9	109.3
08DH02-57	481.5	3.7	487.4	4.6	515.2	19.3	481.5	3.7	93.5
08DH02-58	1841.3	20.0	1862.2	18.2	1885.7	31.2	1885.7	31.2	97.6
08DH02-59	2342.1	25.1	2405.9	19.5	2460.3	28.6	2460.3	28.6	95.2
08DH02-60	230.8	1.7	247.7	51.3	411.3	528.1	230.8	1.7	56.1
08DH02-61	1855.3	12.9	1869.2	15.9	1884.6	30.3	1884.6	30.3	98.4
08DH02-62	244.6	1.8	236.7	33.6	158.6	373.5	244.6	1.8	154.2
08DH02-63	252.3	2.0	251.5	6.7	244.2	66.5	252.3	2.0	103.3
08DH02-64	267.0	6.0	262.2	9.5	219.1	78.6	267.0	6.0	121.9
08DH02-65	280.2	1.7	281.0	3.9	287.4	33.7	280.2	1.7	97.5
08DH02-66	252.7	1.2	253.5	11.1	261.0	113.5	252.7	1.2	96.8
08DH02-67	258.7	3.6	259.3	6.0	264.4	50.7	258.7	3.6	97.8
08DH02-68	233.4	2.3	232.7	5.6	225.4	58.4	233.4	2.3	103.6
08DH02-69	1848.2	23.6	1867.2	16.0	1888.4	21.1	1888.4	21.1	97.9
08DH02-70	2412.4	45.5	2434.7	23.8	2453.3	21.1	2453.3	21.1	98.3
08DH02-71	280.9	3.2	283.9	11.0	309.0	97.9	280.9	3.2	90.9
08DH02-73	2293.1	24.3	2351.8	14.6	2403.1	16.7	2403.1	16.7	95.4
08DH02-74	1730.4	15.9	1731.0	14.0	1731.8	24.1	1731.8	24.1	99.9
08DH02-75	280.0	6.6	289.2	11.7	363.7	89.4	280.0	6.6	77.0
08DH02-76	296.9	3.6	390.3	44.0	989.3	276.3	296.9	3.6	30.0
08DH02-77	291.8	3.8	290.0	6.0	276.0	45.7	291.8	3.8	105.7
08DH02-78	283.6	2.7	281.9	6.8	267.6	59.5	283.6	2.7	106.0
08DH02-79	248.5	6.9	247.7	10.5	240.0	88.6	248.5	6.9	103.5
08DH02-80	285.7	7.8	380.7	26.9	1008.4	162.6	285.7	7.8	28.3
08DH02-81	1877.0	21.7	1902.5	13.6	1930.5	15.4	1930.5	15.4	97.2
08DH02-82	270.0	2.0	291.6	13.2	468.4	113.7	270.0	2.0	57.7
08DH02-83	1761.4	7.7	1830.5	13.5	1910.0	27.1	1910.0	27.1	92.2
08DH02-84	273.2	4.0	273.8	10.9	279.2	98.5	273.2	4.0	97.9
08DH02-85	276.2	3.1	277.8	6.4	291.2	53.9	276.2	3.1	94.8
08DH02-86	263.9	4.4	288.6	37.0	493.8	324.0	263.9	4.4	53.4
08DH02-87	255.7	1.3	259.8	26.4	296.9	263.6	255.7	1.3	86.1
08DH02-88	2005.7	46.2	2017.9	25.5	2030.4	19.9	2030.4	19.9	98.8
08DH02-89	263.5	1.4	265.1	3.8	279.7	35.0	263.5	1.4	94.2
08DH02-90	238.7	1.7	223.3	24.4	63.6	290.5	238.7	1.7	375.3
08DH02-91	1812.3	7.9	1830.4	9.1	1850.9	17.2	1850.9	17.2	97.9
08DH02-92	268.4	2.2	268.0	25.7	264.7	250.0	268.4	2.2	101.4
08DH02-93	153.6	2.7	150.1	14.2	95.4	237.0	153.6	2.7	161.0

08DH02

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH02-94	77	2499	2.0	21.9173	14.3	0.1701	14.3	0.0270	0.7	0.05
08DH02-95	141	35496	2.5	8.8086	1.5	4.5201	2.5	0.2888	2.0	0.81
08DH02-96	63	17250	0.3	8.5145	0.9	5.4537	1.6	0.3368	1.3	0.84
08DH02-97	198	45279	2.7	8.8846	1.0	4.6150	3.1	0.2974	2.9	0.95
08DH02-98	110	4395	1.2	20.6028	8.2	0.2537	8.4	0.0379	1.9	0.22
08DH02-99	884	106749	6.3	8.5452	1.9	4.8802	2.7	0.3025	1.9	0.71
08DH02-100	96	4020	0.8	19.0090	3.2	0.3300	3.7	0.0455	2.0	0.52
08DH02-101	183	74316	2.8	8.7320	0.5	5.0400	0.7	0.3192	0.5	0.69
08DH02-102	353	15705	1.3	18.9463	1.0	0.3711	1.6	0.0510	1.3	0.80
08DH02-103	844	16158	1.1	19.2964	1.7	0.2933	2.8	0.0411	2.3	0.80
08DH02-105	205	13005	1.9	17.3324	1.6	0.6229	1.7	0.0783	0.8	0.43
08DH02-106	356	7863	1.9	20.0707	1.7	0.1824	2.1	0.0266	1.2	0.60
08DH02-107	835	6342	2.2	5.7055	2.0	8.9366	2.4	0.3698	1.5	0.60
08DH02-108	190	5691	1.0	19.2457	4.1	0.3129	4.3	0.0437	1.1	0.25
08DH02-110	423	10050	2.2	20.0376	2.1	0.2188	2.7	0.0318	1.6	0.61
08DH02-111	154	5730	0.7	19.0679	2.0	0.3227	2.1	0.0446	0.8	0.36
08DH02-112	962	9423	1.7	17.7863	3.0	0.3463	3.2	0.0447	1.2	0.37
08DH02-114	82	2502	0.8	19.3716	6.7	0.3066	7.1	0.0431	2.1	0.30
08DH02-115	216	11295	1.4	5.2984	1.6	11.8956	2.7	0.4571	2.1	0.79
08DH02-117	178	50973	1.6	8.6683	1.8	5.3151	2.1	0.3342	0.9	0.44
08DH02-118	96	2013	1.0	20.7141	10.6	0.1704	10.7	0.0256	1.1	0.11
08DH02-119	864	9777	3.7	8.4152	7.6	4.6507	8.0	0.2838	2.3	0.28
08DH02-120	240	10047	1.5	19.1344	1.8	0.3356	1.9	0.0466	0.6	0.32

08DH02

Apparent ages (Ma)

Analysis	$^{206}\text{Pb}^*/^{238}\text{U}^*$	$\pm$ (Ma)	$^{207}\text{Pb}^*/^{235}\text{U}$	$\pm$ (Ma)	$^{206}\text{Pb}^*/^{207}\text{Pb}^*$	$\pm$ (Ma)	Best age (Ma)	$\pm$ (Ma)	Conc (%)
08DH02-94	172.0	1.2	159.5	21.1	-22.1	346.4	172.0	1.2	-779.2
08DH02-95	1635.4	29.5	1734.7	20.9	1856.6	26.6	1856.6	26.6	88.1
08DH02-96	1871.2	21.6	1893.3	13.6	1917.7	15.3	1917.7	15.3	97.6
08DH02-97	1678.3	43.0	1752.0	25.6	1841.1	17.6	1841.1	17.6	91.2
08DH02-98	239.9	4.4	229.6	17.3	125.5	193.8	239.9	4.4	191.1
08DH02-99	1703.5	28.3	1798.8	22.4	1911.3	33.6	1911.3	33.6	89.1
08DH02-100	286.8	5.5	289.6	9.4	311.9	72.8	286.8	5.5	92.0
08DH02-101	1785.7	7.8	1826.1	6.2	1872.3	9.6	1872.3	9.6	95.4
08DH02-102	320.6	4.0	320.5	4.4	319.4	21.8	320.6	4.0	100.4
08DH02-103	259.3	5.7	261.2	6.5	277.6	38.5	259.3	5.7	93.4
08DH02-105	486.0	3.5	491.7	6.7	518.2	34.2	486.0	3.5	93.8
08DH02-106	169.0	2.1	170.2	3.2	186.8	38.5	169.0	2.1	90.5
08DH02-107	2028.4	25.4	2331.5	22.4	2608.6	32.7	2608.6	32.7	77.8
08DH02-108	275.6	2.8	276.5	10.3	283.7	94.3	275.6	2.8	97.2
08DH02-110	201.8	3.2	200.9	4.8	190.7	48.9	201.8	3.2	105.8
08DH02-111	281.4	2.1	283.9	5.2	304.8	45.0	281.4	2.1	92.3
08DH02-112	281.8	3.3	302.0	8.4	461.2	66.6	281.8	3.3	61.1
08DH02-114	271.9	5.6	271.5	16.9	268.7	154.9	271.9	5.6	101.2
08DH02-115	2426.8	43.1	2596.2	25.1	2731.2	26.8	2731.2	26.8	88.9
08DH02-117	1858.5	14.7	1871.3	17.5	1885.5	33.1	1885.5	33.1	98.6
08DH02-118	163.0	1.8	159.8	15.8	112.9	251.7	163.0	1.8	144.4
08DH02-119	1610.7	32.1	1758.4	66.6	1938.7	136.9	1938.7	136.9	83.1
08DH02-120	293.4	1.7	293.8	4.8	296.9	40.5	293.4	1.7	98.8

08DH03

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH03-1	28	882	1.4	20.9752	23.6	0.1740	24.6	0.0265	7.1	0.29
08DH03-2	675	11004	0.9	19.0099	3.8	0.3146	4.1	0.0434	1.7	0.40
08DH03-3	235	4437	2.2	20.8421	7.6	0.1777	7.6	0.0269	1.1	0.15
08DH03-4	50	9726	1.8	8.8756	1.6	5.1793	1.8	0.3334	0.7	0.41
08DH03-5	90	1737	1.1	23.2990	24.0	0.1451	24.1	0.0245	2.6	0.11
08DH03-6	218	5460	0.5	18.5219	23.4	0.3056	23.6	0.0411	2.8	0.12
08DH03-7	144	5406	0.9	19.2901	4.9	0.3302	5.1	0.0462	1.2	0.23
08DH03-8	39	1212	1.9	19.7386	15.1	0.2763	15.2	0.0395	1.8	0.12
08DH03-9	614	4467	0.7	16.8316	3.3	0.3888	3.4	0.0475	0.9	0.27
08DH03-10	139	35829	2.1	8.4034	1.5	5.7923	1.7	0.3530	0.7	0.40
08DH03-11	397	12768	1.8	19.4001	1.9	0.2941	2.5	0.0414	1.7	0.66
08DH03-12	60	16878	0.8	7.9733	1.5	6.4532	1.7	0.3732	1.0	0.55
08DH03-13	214	53331	1.5	7.5634	0.7	7.0689	1.4	0.3878	1.2	0.85
08DH03-14	254	14796	1.0	17.3244	1.7	0.6689	2.0	0.0840	1.1	0.55
08DH03-15	358	87483	3.1	8.1472	1.2	5.9427	1.3	0.3511	0.5	0.39
08DH03-16	154	4437	0.5	19.8597	6.1	0.3007	6.1	0.0433	0.7	0.11
08DH03-18	81	2595	0.7	19.8788	10.9	0.3231	10.9	0.0466	1.0	0.09
08DH03-19	86	19689	1.2	5.8405	1.2	11.0095	2.6	0.4664	2.3	0.89
08DH03-20	203	65970	0.8	4.9518	1.1	15.5075	1.4	0.5569	0.9	0.64
08DH03-21	267	5643	0.7	18.9136	2.7	0.3488	3.5	0.0478	2.2	0.64
08DH03-22	207	6141	0.8	19.1462	3.2	0.3543	3.2	0.0492	0.6	0.18
08DH03-23	152	4851	0.7	19.4963	6.5	0.3443	6.9	0.0487	2.2	0.32
08DH03-24	176	3687	1.2	21.0257	8.0	0.1657	8.0	0.0253	1.0	0.12
08DH03-25	173	4113	1.4	21.0361	9.0	0.1839	9.1	0.0281	1.5	0.17
08DH03-26	226	7653	1.0	19.2837	3.6	0.3094	3.9	0.0433	1.3	0.33
08DH03-27	77	2328	0.7	18.8437	6.1	0.3440	6.3	0.0470	1.4	0.22
08DH03-28	25	471	1.2	33.4964	67.3	0.1002	67.4	0.0243	2.8	0.04
08DH03-29	376	6936	1.5	20.3594	3.1	0.1756	3.2	0.0259	0.5	0.16
08DH03-30	101	3849	0.8	19.1995	6.4	0.3886	6.5	0.0541	0.5	0.08
08DH03-31	142	5811	1.1	18.4475	2.3	0.4340	2.9	0.0581	1.7	0.59
08DH03-32	58	1521	2.2	22.8240	25.4	0.1567	25.5	0.0259	2.8	0.11
08DH03-33	124	31752	1.5	7.7482	0.9	6.7666	1.2	0.3803	0.8	0.65
08DH03-34	52	12105	0.4	7.6882	0.6	6.8603	1.9	0.3825	1.8	0.95
08DH03-35	186	4512	1.3	18.8299	3.2	0.3694	3.3	0.0505	0.8	0.23
08DH03-36	149	2625	0.9	20.9743	10.9	0.1860	10.9	0.0283	0.8	0.07
08DH03-37	174	4473	1.2	8.2382	1.8	4.5907	3.5	0.2743	3.1	0.87
08DH03-38	59	1638	1.1	19.8567	13.0	0.2976	13.1	0.0429	1.2	0.09
08DH03-39	592	8919	1.2	17.9464	8.2	0.4081	8.3	0.0531	1.2	0.14
08DH03-40	1042	129297	18.2	8.2064	1.1	6.0960	1.5	0.3628	1.0	0.67
08DH03-41	213	774	1.6	11.1611	10.0	0.3193	10.1	0.0258	1.6	0.16
08DH03-42	27	7485	1.2	8.0569	1.4	6.3437	1.5	0.3707	0.5	0.33
08DH03-43	75	2016	0.5	20.6324	14.7	0.3083	14.7	0.0461	0.5	0.03
08DH03-44	92	1479	1.3	19.9197	8.7	0.1886	8.8	0.0272	1.7	0.19
08DH03-45	73	1833	1.0	21.5712	14.9	0.1629	15.0	0.0255	1.7	0.11
08DH03-46	38	909	2.2	19.4718	14.6	0.1975	15.3	0.0279	4.8	0.31

08DH03

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH03-1	168.5	11.8	162.9	37.1	83.2	566.0	168.5	11.8	202.5
08DH03-2	273.7	4.4	277.7	10.0	311.7	85.9	273.7	4.4	87.8
08DH03-3	170.8	1.9	166.0	11.7	98.3	179.0	170.8	1.9	173.9
08DH03-4	1854.9	11.8	1849.2	15.0	1842.9	29.1	1842.9	29.1	100.6
08DH03-5	156.2	4.0	137.6	31.1	-172.2	604.9	156.2	4.0	-90.7
08DH03-6	259.4	7.2	270.8	56.1	370.6	533.8	259.4	7.2	70.0
08DH03-7	291.1	3.3	289.7	12.7	278.4	112.7	291.1	3.3	104.6
08DH03-8	250.0	4.3	247.7	33.4	225.5	350.2	250.0	4.3	110.9
08DH03-9	299.0	2.7	333.5	9.7	582.2	71.6	299.0	2.7	51.3
08DH03-10	1949.0	11.3	1945.3	14.5	1941.2	27.6	1941.2	27.6	100.4
08DH03-11	261.4	4.2	261.8	5.8	265.3	43.6	261.4	4.2	98.5
08DH03-12	2044.3	16.8	2039.5	15.4	2034.7	25.8	2034.7	25.8	100.5
08DH03-13	2112.5	21.6	2120.1	12.5	2127.6	12.8	2127.6	12.8	99.3
08DH03-14	520.2	5.4	520.0	8.0	519.2	36.4	520.2	5.4	100.2
08DH03-15	1940.1	8.5	1967.5	11.4	1996.4	21.5	1996.4	21.5	97.2
08DH03-16	273.3	1.8	266.9	14.3	211.3	141.0	273.3	1.8	129.3
08DH03-18	293.5	2.9	284.3	27.0	209.1	252.2	293.5	2.9	140.4
08DH03-19	2467.6	46.7	2523.9	23.8	2569.6	19.4	2569.6	19.4	96.0
08DH03-20	2853.9	20.5	2846.9	13.3	2842.0	17.6	2842.0	17.6	100.4
08DH03-21	301.3	6.6	303.8	9.1	323.3	60.3	301.3	6.6	93.2
08DH03-22	309.6	1.7	308.0	8.6	295.5	72.7	309.6	1.7	104.8
08DH03-23	306.4	6.6	300.4	17.8	254.0	149.3	306.4	6.6	120.7
08DH03-24	160.9	1.5	155.7	11.6	77.5	190.0	160.9	1.5	207.7
08DH03-25	178.4	2.7	171.4	14.4	76.3	214.3	178.4	2.7	233.9
08DH03-26	273.1	3.4	273.7	9.3	279.1	83.5	273.1	3.4	97.8
08DH03-27	296.2	4.0	300.2	16.4	331.7	139.4	296.2	4.0	89.3
08DH03-28	155.0	4.3	96.9	62.4	-1173.9	2311.7	155.0	4.3	-13.2
08DH03-29	165.0	0.8	164.2	4.8	153.4	73.5	165.0	0.8	107.5
08DH03-30	339.7	1.7	333.3	18.3	289.1	147.1	339.7	1.7	117.5
08DH03-31	363.8	6.1	366.0	8.9	379.7	52.4	363.8	6.1	95.8
08DH03-32	165.1	4.6	147.8	35.1	-121.1	634.5	165.1	4.6	-136.2
08DH03-33	2077.5	13.7	2081.4	10.5	2085.2	15.8	2085.2	15.8	99.6
08DH03-34	2088.1	31.6	2093.5	16.6	2098.9	10.5	2098.9	10.5	99.5
08DH03-35	317.3	2.3	319.2	9.0	333.4	72.9	317.3	2.3	95.2
08DH03-36	179.9	1.4	173.2	17.4	83.3	259.5	179.9	1.4	216.0
08DH03-37	1562.5	42.7	1747.6	29.6	1976.7	31.2	1976.7	31.2	79.0
08DH03-38	270.5	3.2	264.5	30.4	211.7	302.3	270.5	3.2	127.8
08DH03-39	333.6	3.9	347.5	24.5	441.3	183.7	333.6	3.9	75.6
08DH03-40	1995.5	17.5	1989.7	13.3	1983.6	20.1	1983.6	20.1	100.6
08DH03-41	164.5	2.6	281.3	24.9	1416.9	191.5	164.5	2.6	11.6
08DH03-42	2032.6	8.7	2024.5	13.4	2016.2	25.5	2016.2	25.5	100.8
08DH03-43	290.8	1.4	272.9	35.1	122.2	346.9	290.8	1.4	238.0
08DH03-44	173.3	2.9	175.4	14.2	204.3	201.8	173.3	2.9	84.8
08DH03-45	162.2	2.8	153.2	21.4	16.3	360.6	162.2	2.8	997.0
08DH03-46	177.3	8.3	183.0	25.7	256.9	336.1	177.3	8.3	69.0

08DH03

Isotope ratios

Analysis	U (ppm)	206Pb/ 204Pb	U/Th	206Pb*/ 207Pb*	± (%)	207Pb*/ 235U*	± (%)	206Pb*/ 238U	± (%)	error corr.
08DH03-47	27	1002	1.0	20.8906	20.6	0.2579	20.9	0.0391	3.6	0.17
08DH03-48	114	1881	1.1	20.4934	12.0	0.1923	12.1	0.0286	1.5	0.12
08DH03-49	121	2259	1.4	20.2387	9.5	0.2172	9.5	0.0319	0.5	0.06
08DH03-50	141	34533	1.3	8.2847	0.8	5.9385	1.2	0.3568	0.9	0.75
08DH03-51	38	825	0.9	21.5457	26.9	0.1641	27.3	0.0256	5.0	0.18
08DH03-52	131	1053	0.6	17.4973	9.3	0.2052	9.6	0.0260	2.4	0.25
08DH03-53	41	1392	0.5	20.1075	15.5	0.3215	15.6	0.0469	1.6	0.10
08DH03-54	114	32421	0.6	7.8296	1.1	6.6805	1.3	0.3794	0.7	0.53
08DH03-55	26	912	1.2	23.0648	34.9	0.2516	34.9	0.0421	1.3	0.04
08DH03-56	326	78765	1.6	5.4427	1.2	12.4938	2.7	0.4932	2.5	0.91
08DH03-57	90	2214	1.1	21.6715	14.7	0.1875	14.7	0.0295	1.0	0.07
08DH03-58	54	870	1.4	24.8087	37.7	0.1648	37.7	0.0296	2.0	0.05
08DH03-59	183	2634	0.9	20.3612	7.8	0.1797	7.8	0.0265	0.8	0.10
08DH03-60	95	1902	0.7	20.8074	12.6	0.1739	12.7	0.0262	1.7	0.13
08DH03-61	345	6021	1.0	19.8500	2.0	0.1923	2.1	0.0277	0.5	0.25
08DH03-62	227	4302	1.0	20.5128	7.0	0.1978	7.1	0.0294	1.1	0.16
08DH03-63	56	1161	1.4	21.7735	21.6	0.1691	21.6	0.0267	1.2	0.06
08DH03-64	230	5775	0.7	19.7293	4.1	0.2935	4.1	0.0420	0.5	0.12
08DH03-65	119	55110	0.9	3.9532	1.0	22.3935	1.2	0.6420	0.7	0.57
08DH03-67	146	4599	1.7	20.1203	6.6	0.2796	6.7	0.0408	1.4	0.21
08DH03-68	398	5331	0.4	19.8479	2.3	0.1864	2.4	0.0268	0.7	0.30
08DH03-69	529	12660	1.2	19.0344	1.4	0.3263	1.5	0.0451	0.5	0.34
08DH03-70	44	816	0.8	22.9604	13.7	0.1476	14.0	0.0246	2.6	0.19
08DH03-71	335	6369	0.8	19.1761	1.5	0.3187	1.6	0.0443	0.5	0.31
08DH03-72	51	11445	0.7	8.5669	3.5	5.6730	3.8	0.3525	1.4	0.37
08DH03-73	202	2883	0.8	17.2502	3.4	0.5085	4.0	0.0636	2.1	0.52
08DH03-74	116	2013	0.8	20.4253	9.5	0.1718	9.5	0.0254	0.5	0.05
08DH03-76	99	10863	1.1	14.8960	0.9	1.2592	2.0	0.1360	1.7	0.88
08DH03-77	62	1575	0.6	19.4044	10.1	0.3073	10.3	0.0432	2.2	0.21
08DH03-78	257	4485	2.1	19.4347	3.0	0.2839	3.0	0.0400	0.7	0.22
08DH03-79	455	6066	0.8	19.4508	2.3	0.2631	2.6	0.0371	1.1	0.44
08DH03-80	130	2472	0.4	19.2709	14.6	0.3255	14.6	0.0455	1.0	0.07
08DH03-81	162	3969	1.9	20.1121	5.9	0.2101	5.9	0.0306	0.5	0.08
08DH03-82	381	11145	1.3	19.4371	1.9	0.3105	2.0	0.0438	0.5	0.26
08DH03-83	260	45462	0.9	9.2478	1.4	3.9265	2.0	0.2634	1.5	0.74
08DH03-84	111	2394	0.8	19.0065	4.4	0.3218	4.4	0.0444	0.8	0.18
08DH03-85	845	101577	2.2	8.1889	1.0	5.9824	1.1	0.3553	0.5	0.46
08DH03-86	141	2616	1.2	20.4203	7.3	0.1749	7.3	0.0259	1.1	0.16
08DH03-87	161	5181	1.0	19.5655	4.8	0.3229	4.8	0.0458	0.6	0.12
08DH03-88	153	35964	1.9	9.4180	1.7	4.1670	4.9	0.2846	4.6	0.94
08DH03-89	167	8514	2.3	18.3538	4.4	0.4557	4.5	0.0607	1.2	0.27
08DH03-90	185	58044	1.9	8.5344	1.0	5.5744	1.6	0.3450	1.3	0.81
08DH03-91	332	9567	1.4	17.7129	1.5	0.5276	1.9	0.0678	1.3	0.66
08DH03-92	147	4314	1.8	19.1958	3.3	0.2875	3.4	0.0400	0.9	0.25
08DH03-93	72	1992	1.8	21.8786	17.0	0.1588	17.1	0.0252	1.5	0.09

08DH03

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH03-47	247.1	8.6	233.0	43.5	92.8	492.1	247.1	8.6	266.3
08DH03-48	181.6	2.6	178.6	19.8	138.1	283.3	181.6	2.6	131.6
08DH03-49	202.3	1.1	199.5	17.2	167.3	222.0	202.3	1.1	120.9
08DH03-50	1967.1	14.9	1966.9	10.2	1966.6	13.9	1966.6	13.9	100.0
08DH03-51	163.2	8.0	154.3	39.1	19.2	655.2	163.2	8.0	852.0
08DH03-52	165.7	3.9	189.5	16.6	497.4	204.8	165.7	3.9	33.3
08DH03-53	295.4	4.6	283.1	38.6	182.5	363.6	295.4	4.6	161.9
08DH03-54	2073.3	11.9	2070.0	11.2	2066.8	19.1	2066.8	19.1	100.3
08DH03-55	265.8	3.5	227.9	71.4	-147.1	889.2	265.8	3.5	-180.7
08DH03-56	2584.4	52.8	2642.3	25.7	2686.9	19.2	2686.9	19.2	96.2
08DH03-57	187.3	1.8	174.5	23.6	5.2	355.6	187.3	1.8	3633.9
08DH03-58	188.3	3.7	154.9	54.3	-331.1	999.6	188.3	3.7	-56.9
08DH03-59	168.8	1.3	167.8	12.1	153.2	182.2	168.8	1.3	110.2
08DH03-60	167.0	2.8	162.8	19.1	102.2	298.5	167.0	2.8	163.4
08DH03-61	176.1	0.9	178.6	3.4	212.4	46.6	176.1	0.9	82.9
08DH03-62	187.0	2.1	183.3	11.9	135.8	165.1	187.0	2.1	137.7
08DH03-63	169.9	2.1	158.6	31.8	-6.2	526.1	169.9	2.1	-2752.4
08DH03-64	265.2	1.3	261.3	9.5	226.6	94.8	265.2	1.3	117.0
08DH03-65	3197.1	17.6	3201.0	12.0	3203.4	16.1	3203.4	16.1	99.8
08DH03-67	257.8	3.5	250.4	14.9	181.0	152.9	257.8	3.5	142.4
08DH03-68	170.7	1.2	173.5	3.8	212.7	52.4	170.7	1.2	80.2
08DH03-69	284.1	1.4	286.8	3.6	308.8	31.0	284.1	1.4	92.0
08DH03-70	156.5	4.1	139.8	18.2	-135.9	340.9	156.5	4.1	-115.2
08DH03-71	279.6	1.4	280.9	4.0	291.9	35.2	279.6	1.4	95.8
08DH03-72	1946.4	23.9	1927.3	32.9	1906.7	63.6	1906.7	63.6	102.1
08DH03-73	397.6	8.0	417.4	13.7	528.7	75.4	397.6	8.0	75.2
08DH03-74	162.0	0.8	160.9	14.1	145.9	222.2	162.0	0.8	111.0
08DH03-76	822.2	13.3	827.5	11.0	841.9	19.2	822.2	13.3	97.7
08DH03-77	272.9	5.7	272.1	24.6	264.8	231.9	272.9	5.7	103.1
08DH03-78	253.0	1.6	253.8	6.8	261.2	68.3	253.0	1.6	96.8
08DH03-79	235.0	2.6	237.2	5.4	259.3	53.1	235.0	2.6	90.6
08DH03-80	286.8	2.7	286.2	36.5	280.7	335.5	286.8	2.7	102.2
08DH03-81	194.6	1.0	193.6	10.4	182.0	137.7	194.6	1.0	106.9
08DH03-82	276.1	1.4	274.5	4.7	261.0	43.3	276.1	1.4	105.8
08DH03-83	1507.0	20.3	1619.2	16.4	1768.2	24.8	1768.2	24.8	85.2
08DH03-84	279.8	2.1	283.3	11.0	312.1	99.6	279.8	2.1	89.6
08DH03-85	1959.9	8.4	1973.3	9.5	1987.4	17.3	1987.4	17.3	98.6
08DH03-86	164.8	1.9	163.6	11.1	146.5	170.3	164.8	1.9	112.5
08DH03-87	288.8	1.7	284.1	12.0	245.8	110.6	288.8	1.7	117.5
08DH03-88	1614.6	66.0	1667.5	40.3	1734.8	31.0	1734.8	31.0	93.1
08DH03-89	379.7	4.5	381.3	14.5	391.1	98.3	379.7	4.5	97.1
08DH03-90	1910.9	22.0	1912.2	14.1	1913.5	17.1	1913.5	17.1	99.9
08DH03-91	422.8	5.2	430.2	6.8	470.3	32.1	422.8	5.2	89.9
08DH03-92	253.0	2.1	256.6	7.7	289.6	75.4	253.0	2.1	87.4
08DH03-93	160.4	2.4	149.6	23.8	-17.8	413.7	160.4	2.4	-901.2

08DH03

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH03-94	139	3561	1.4	18.8692	3.6	0.3333	3.7	0.0456	0.5	0.14
08DH03-95	161	5271	0.7	19.8908	6.8	0.2994	6.8	0.0432	0.5	0.07
08DH03-96	161	3546	1.3	21.0009	9.6	0.1870	9.7	0.0285	1.1	0.11
08DH03-97	133	2451	0.8	20.1707	7.7	0.1908	7.7	0.0279	0.5	0.06
08DH03-98	203	8109	1.0	18.6344	3.2	0.4140	3.2	0.0560	0.5	0.15
08DH03-99	188	5760	1.1	19.1641	2.6	0.2978	2.6	0.0414	0.5	0.19
08DH03-100	559	15144	0.6	19.2689	2.0	0.3325	2.7	0.0465	1.8	0.67

08DH03

Apparent ages (Ma)

Analysis	²⁰⁶ Pb*/ ²³⁸ U*	± (Ma)	²⁰⁷ Pb*/ ²³⁵ U	± (Ma)	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH03-94	287.5	1.4	292.1	9.3	328.7	82.4	287.5	1.4	87.5
08DH03-95	272.6	1.4	266.0	16.0	207.7	157.9	272.6	1.4	131.3
08DH03-96	181.0	2.0	174.1	15.5	80.3	228.9	181.0	2.0	225.6
08DH03-97	177.5	0.9	177.3	12.6	175.2	180.2	177.5	0.9	101.3
08DH03-98	351.0	1.7	351.8	9.6	357.0	72.3	351.0	1.7	98.3
08DH03-99	261.5	1.3	264.7	6.1	293.3	59.0	261.5	1.3	89.1
08DH03-100	292.8	5.1	291.5	6.8	280.9	45.6	292.8	5.1	104.2

08DH29a

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH29A-1	51	1323	1.6	20.1513	13.3	0.1776	13.7	0.0260	3.4	0.24
08DH29A-2	158	71688	9.0	8.3115	1.7	5.7414	1.8	0.3461	0.6	0.34
08DH29A-3	40	13692	1.4	8.5897	1.1	5.5310	1.3	0.3446	0.7	0.52
08DH29A-4	144	34974	3.3	9.9779	2.0	3.0589	4.3	0.2214	3.8	0.88
08DH29A-5	281	16323	1.4	18.9731	2.8	0.3967	2.9	0.0546	0.6	0.21
08DH29A-6	57	4278	1.9	18.9824	5.3	0.4223	5.5	0.0581	1.2	0.22
08DH29A-7	289	19971	4.2	19.1301	2.0	0.3412	2.1	0.0473	0.7	0.34
08DH29A-8	87	3018	0.9	19.4711	5.3	0.2804	5.4	0.0396	0.5	0.10
08DH29A-9	65	23529	2.3	8.6695	1.9	5.4185	2.0	0.3407	0.6	0.30
08DH29A-10	97	36699	2.8	8.3834	1.8	5.8277	1.9	0.3543	0.5	0.27
08DH29A-11	465	8991	1.6	19.4775	1.6	0.2612	1.7	0.0369	0.5	0.30
08DH29A-12	45	13671	1.7	9.6266	3.5	4.3648	3.5	0.3047	0.5	0.14
08DH29A-13	209	6144	3.0	20.1855	2.6	0.1728	2.8	0.0253	0.8	0.30
08DH29A-14	335	166011	3.2	5.1874	1.4	14.0710	1.5	0.5294	0.5	0.34
08DH29A-15	480	14253	2.2	19.5393	2.2	0.2800	2.3	0.0397	0.5	0.22
08DH29A-16	29	10206	3.0	8.7044	2.0	5.3615	2.1	0.3385	0.6	0.26
08DH29A-17	177	60102	1.2	8.1340	3.0	6.1156	3.2	0.3608	1.1	0.33
08DH29A-18	50	1770	2.7	24.6056	27.8	0.1417	27.8	0.0253	1.7	0.06
08DH29A-19	158	4992	3.2	19.4342	2.1	0.2740	2.5	0.0386	1.4	0.57
08DH29A-20	699	190149	16.7	8.2605	2.4	5.7553	2.4	0.3448	0.6	0.24
08DH29A-21	249	87600	7.3	8.5441	2.0	5.6694	2.1	0.3513	0.5	0.24
08DH29A-22	40	2055	1.4	19.1546	10.3	0.3691	10.4	0.0513	1.5	0.14
08DH29A-23	91	3342	0.8	19.7730	5.4	0.2794	5.6	0.0401	1.5	0.26
08DH29A-24	48	15057	1.9	8.5903	2.2	5.5542	2.3	0.3460	0.5	0.22
08DH29A-25	153	5514	2.0	19.4894	4.6	0.2895	4.7	0.0409	0.8	0.17
08DH29A-26	26	9972	1.9	8.8077	3.1	5.1313	3.2	0.3278	0.8	0.26
08DH29A-27	83	22572	3.9	8.5505	2.4	5.2705	2.6	0.3268	0.8	0.32
08DH29A-28	103	43206	3.9	8.4812	2.9	5.6313	2.9	0.3464	0.5	0.17
08DH29A-29	148	31461	1.9	6.1999	2.4	8.6772	2.7	0.3902	1.1	0.42
08DH29A-31	21	1098	1.4	21.8810	25.6	0.2551	25.6	0.0405	1.6	0.06
08DH29A-32	93	3819	1.4	19.2490	4.1	0.3127	4.2	0.0437	0.5	0.12
08DH29A-33	55	19587	1.4	9.4158	2.6	4.4621	2.8	0.3047	1.1	0.38
08DH29A-34	53	20898	4.4	8.5154	1.7	5.6585	1.9	0.3495	1.0	0.51
08DH29A-35	149	56799	4.2	8.5494	1.8	5.4627	2.0	0.3387	1.0	0.47
08DH29A-36	117	2928	1.0	19.3036	3.3	0.2825	3.6	0.0396	1.3	0.37
08DH29A-37	188	47229	3.0	8.3239	2.4	5.5783	4.0	0.3368	3.3	0.81
08DH29A-38	347	9864	2.5	20.5465	3.0	0.1757	3.1	0.0262	0.7	0.21
08DH29A-39	249	87864	6.9	8.7147	2.5	5.2031	2.6	0.3289	0.6	0.23
08DH29A-40	94	6207	2.0	19.4239	4.7	0.3580	4.8	0.0504	0.9	0.20
08DH29A-41	247	98676	3.9	8.0012	1.5	6.2409	2.4	0.3622	1.9	0.80
08DH29A-42	234	114246	2.2	5.5799	1.2	11.6793	1.3	0.4727	0.5	0.37
08DH29A-43	252	6216	0.6	19.3364	2.3	0.3234	2.4	0.0454	0.6	0.24
08DH29A-44	66	2688	3.5	20.1664	7.3	0.2565	7.4	0.0375	0.7	0.10
08DH29A-45	63	1197	0.9	21.1291	18.5	0.1600	18.6	0.0245	1.8	0.09
08DH29A-46	289	85506	1.9	8.4853	1.6	5.6271	1.8	0.3463	0.7	0.42

08DH29a

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH29A-1	165.2	5.5	166.0	20.9	177.4	310.3	165.2	5.5	93.1
08DH29A-2	1915.9	10.3	1937.6	15.7	1960.9	30.5	1960.9	30.5	97.7
08DH29A-3	1908.6	11.2	1905.4	11.3	1901.9	20.2	1901.9	20.2	100.4
08DH29A-4	1289.1	43.8	1422.5	32.6	1628.2	37.4	1628.2	37.4	79.2
08DH29A-5	342.6	2.0	339.2	8.4	316.2	64.7	342.6	2.0	108.4
08DH29A-6	364.3	4.3	357.7	16.5	315.0	121.2	364.3	4.3	115.6
08DH29A-7	298.2	2.0	298.1	5.4	297.4	44.8	298.2	2.0	100.2
08DH29A-8	250.3	1.3	251.0	11.9	256.9	122.6	250.3	1.3	97.4
08DH29A-9	1890.0	9.7	1887.8	16.9	1885.3	33.9	1885.3	33.9	100.3
08DH29A-10	1955.3	8.4	1950.5	16.2	1945.5	32.2	1945.5	32.2	100.5
08DH29A-11	233.5	1.1	235.6	3.5	256.2	37.0	233.5	1.1	91.2
08DH29A-12	1714.8	7.5	1705.7	28.8	1694.5	63.6	1694.5	63.6	101.2
08DH29A-13	161.0	1.3	161.8	4.1	173.5	61.3	161.0	1.3	92.8
08DH29A-14	2738.9	11.2	2754.5	13.9	2766.0	22.6	2766.0	22.6	99.0
08DH29A-15	250.9	1.2	250.7	5.1	248.9	51.1	250.9	1.2	100.8
08DH29A-16	1879.3	9.0	1878.7	18.0	1878.1	36.6	1878.1	36.6	100.1
08DH29A-17	1985.9	18.1	1992.5	27.9	1999.3	53.5	1999.3	53.5	99.3
08DH29A-18	161.0	2.7	134.6	35.1	-310.0	723.3	161.0	2.7	-51.9
08DH29A-19	244.3	3.5	245.9	5.6	261.3	48.1	244.3	3.5	93.5
08DH29A-20	1909.7	9.6	1939.7	21.2	1971.9	42.4	1971.9	42.4	96.8
08DH29A-21	1940.9	8.4	1926.7	18.0	1911.5	36.3	1911.5	36.3	101.5
08DH29A-22	322.3	4.6	319.0	28.4	294.5	234.7	322.3	4.6	109.5
08DH29A-23	253.2	3.7	250.2	12.4	221.4	124.5	253.2	3.7	114.4
08DH29A-24	1915.7	8.3	1909.0	19.4	1901.8	39.6	1901.8	39.6	100.7
08DH29A-25	258.6	2.1	258.2	10.6	254.8	105.4	258.6	2.1	101.5
08DH29A-26	1827.6	13.2	1841.3	27.0	1856.8	55.3	1856.8	55.3	98.4
08DH29A-27	1823.1	13.0	1864.1	22.0	1910.2	43.9	1910.2	43.9	95.4
08DH29A-28	1917.3	8.3	1920.9	25.3	1924.7	51.8	1924.7	51.8	99.6
08DH29A-29	2123.6	20.1	2304.7	24.2	2469.2	40.7	2469.2	40.7	86.0
08DH29A-31	255.9	4.0	230.7	53.0	-18.1	627.9	255.9	4.0	-1415.9
08DH29A-32	275.5	1.3	276.3	10.1	283.3	94.7	275.5	1.3	97.2
08DH29A-33	1714.6	16.3	1723.9	23.4	1735.2	47.9	1735.2	47.9	98.8
08DH29A-34	1932.0	16.7	1925.1	16.8	1917.5	30.0	1917.5	30.0	100.8
08DH29A-35	1880.5	15.7	1894.7	17.6	1910.4	32.5	1910.4	32.5	98.4
08DH29A-36	250.1	3.2	252.6	8.0	276.8	76.6	250.1	3.2	90.3
08DH29A-37	1871.1	53.3	1912.7	34.8	1958.2	42.1	1958.2	42.1	95.5
08DH29A-38	166.6	1.1	164.4	4.7	132.0	71.6	166.6	1.1	126.3
08DH29A-39	1832.9	9.4	1853.1	22.2	1875.9	45.8	1875.9	45.8	97.7
08DH29A-40	317.2	2.9	310.8	12.8	262.5	107.5	317.2	2.9	120.8
08DH29A-41	1992.4	33.3	2010.2	21.3	2028.5	26.0	2028.5	26.0	98.2
08DH29A-42	2495.2	10.3	2579.0	12.5	2645.6	20.6	2645.6	20.6	94.3
08DH29A-43	285.9	1.7	284.5	6.0	272.8	53.8	285.9	1.7	104.8
08DH29A-44	237.4	1.6	231.8	15.3	175.7	171.2	237.4	1.6	135.1
08DH29A-45	156.1	2.7	150.7	26.0	65.8	443.2	156.1	2.7	237.2
08DH29A-46	1916.9	12.3	1920.3	15.1	1923.9	28.5	1923.9	28.5	99.6

08DH29a

Isotope ratios

Analysis	U (ppm)	206Pb/ 204Pb	U/Th	206Pb*/ 207Pb*	± (%)	207Pb*/ 235U*	± (%)	206Pb*/ 238U	± (%)	error corr.
08DH29A-47	95	28842	1.7	8.5247	1.1	5.5544	1.2	0.3434	0.5	0.41
08DH29A-48	83	4620	1.5	19.0774	4.7	0.3880	4.8	0.0537	1.1	0.23
08DH29A-49	47	1365	2.0	21.6424	16.5	0.1591	16.7	0.0250	2.6	0.15
08DH29A-50	36	13908	1.6	8.4765	1.1	5.5246	1.2	0.3396	0.5	0.41
08DH29A-51	334	82362	2.9	8.3889	1.6	5.1022	2.2	0.3104	1.5	0.67
08DH29A-53	187	59526	2.4	7.8229	1.3	6.4989	1.4	0.3687	0.6	0.42
08DH29A-54	50	1350	1.7	21.5464	20.4	0.1592	20.5	0.0249	1.0	0.05
08DH29A-55	221	6384	1.9	19.9207	3.2	0.1826	3.3	0.0264	0.7	0.22
08DH29A-56	161	47823	2.0	4.9841	2.2	13.9854	2.5	0.5055	1.1	0.44
08DH29A-57	131	4857	4.0	19.8481	5.2	0.2595	5.5	0.0374	1.7	0.30
08DH29A-58	57	23343	3.2	8.0839	1.7	6.2282	1.8	0.3652	0.5	0.28
08DH29A-59	47	1290	1.2	18.2070	5.5	0.2802	5.6	0.0370	1.0	0.19
08DH29A-60	68	1719	3.2	20.7938	13.1	0.1673	13.3	0.0252	2.5	0.18
08DH29A-62	88	3795	2.9	19.2904	6.8	0.3128	7.1	0.0438	2.2	0.31
08DH29A-63	602	150300	3.9	8.5091	1.0	5.4709	1.1	0.3376	0.5	0.47
08DH29A-64	96	13122	5.3	8.2062	3.6	5.7856	3.6	0.3443	0.5	0.14
08DH29A-65	530	17241	1.2	19.2876	1.2	0.2973	1.4	0.0416	0.7	0.52
08DH29A-66	302	71028	7.0	8.3907	2.3	5.7265	2.5	0.3485	0.9	0.35
08DH29A-67	235	83259	2.7	8.5203	1.7	5.5487	1.8	0.3429	0.7	0.40
08DH29A-68	100	27939	2.6	5.9552	1.2	10.4880	1.3	0.4530	0.5	0.37
08DH29A-69	94	2844	1.3	20.9843	10.2	0.1718	10.4	0.0261	1.6	0.16
08DH29A-70	136	7740	2.1	18.7567	2.6	0.4023	2.7	0.0547	0.5	0.19
08DH29A-71	229	74523	1.6	8.1056	1.8	6.0412	1.8	0.3551	0.5	0.27
08DH29A-72	1239	253995	6.0	8.5055	1.7	5.5036	1.7	0.3395	0.5	0.30
08DH29A-73	41	15612	2.3	8.7495	2.0	5.3766	2.1	0.3412	0.7	0.32
08DH29A-74	110	7875	1.7	19.2705	4.0	0.3730	4.1	0.0521	0.9	0.23
08DH29A-75	111	43272	1.8	8.0987	2.0	6.2685	2.1	0.3682	0.5	0.24
08DH29A-76	225	7833	2.1	20.1803	3.1	0.2206	3.2	0.0323	0.5	0.16
08DH29A-77	516	161814	3.5	7.8470	1.7	6.6092	2.0	0.3761	1.1	0.53
08DH29A-78	662	159552	6.7	8.3760	0.7	5.7945	0.9	0.3520	0.6	0.64
08DH29A-79	248	14583	2.9	10.6632	3.9	1.0781	10.2	0.0834	9.4	0.92
08DH29A-80	344	86253	2.3	8.2108	1.9	6.0452	2.0	0.3600	0.6	0.31
08DH29A-81	429	154320	5.5	5.9764	1.3	11.0623	1.4	0.4795	0.5	0.36
08DH29A-82	45	5427	1.6	8.2147	1.5	5.8704	1.7	0.3498	0.8	0.46
08DH29A-83	99	26049	1.3	8.4703	1.7	5.6132	1.9	0.3448	0.7	0.39
08DH29A-84	70	1887	1.8	22.6677	20.7	0.1577	20.8	0.0259	1.8	0.09
08DH29A-85	132	1566	1.3	17.3630	22.5	0.3757	22.6	0.0473	2.8	0.12
08DH29A-86	318	11529	3.1	19.7832	1.6	0.2511	1.6	0.0360	0.5	0.30
08DH29A-87	279	10509	1.2	19.4582	2.8	0.3026	2.8	0.0427	0.5	0.18
08DH29A-88	94	12849	3.7	8.4038	2.6	5.8733	2.7	0.3580	0.7	0.26
08DH29A-89	32	1008	2.6	22.5290	25.7	0.1570	25.8	0.0256	1.0	0.04
08DH29A-90	47	1527	3.1	20.5612	11.8	0.1720	12.0	0.0256	2.5	0.21
08DH29A-91	96	32475	2.9	8.6538	1.5	5.4061	1.6	0.3393	0.5	0.34
08DH29A-92	214	76653	5.0	8.3080	1.1	5.8572	1.3	0.3529	0.6	0.44
08DH29A-93	226	72117	1.4	8.1015	1.5	6.2974	1.6	0.3700	0.5	0.31

08DH29a

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH29A-47	1903.1	8.2	1909.1	10.6	1915.6	20.1	1915.6	20.1	99.3
08DH29A-48	337.1	3.6	332.9	13.6	303.7	106.5	337.1	3.6	111.0
08DH29A-49	159.0	4.0	149.9	23.3	8.3	398.9	159.0	4.0	1907.1
08DH29A-50	1884.9	8.2	1904.4	10.6	1925.7	20.2	1925.7	20.2	97.9
08DH29A-51	1742.8	22.4	1836.5	18.7	1944.3	29.3	1944.3	29.3	89.6
08DH29A-53	2023.4	10.4	2045.8	12.4	2068.3	22.6	2068.3	22.6	97.8
08DH29A-54	158.5	1.5	150.0	28.5	19.1	495.1	158.5	1.5	830.7
08DH29A-55	167.8	1.2	170.3	5.1	204.2	73.8	167.8	1.2	82.2
08DH29A-56	2637.6	23.8	2748.7	23.7	2831.4	36.5	2831.4	36.5	93.2
08DH29A-57	236.5	3.9	234.3	11.5	212.7	121.1	236.5	3.9	111.2
08DH29A-58	2006.6	8.6	2008.4	15.5	2010.3	30.2	2010.3	30.2	99.8
08DH29A-59	234.2	2.4	250.8	12.4	409.1	122.3	234.2	2.4	57.3
08DH29A-60	160.7	3.9	157.1	19.4	103.8	310.5	160.7	3.9	154.8
08DH29A-62	276.1	6.1	276.3	17.2	278.4	155.1	276.1	6.1	99.2
08DH29A-63	1875.2	8.5	1896.0	9.4	1918.9	17.4	1918.9	17.4	97.7
08DH29A-64	1907.5	8.3	1944.3	31.4	1983.6	63.9	1983.6	63.9	96.2
08DH29A-65	262.7	1.9	264.3	3.2	278.7	27.1	262.7	1.9	94.2
08DH29A-66	1927.4	14.2	1935.4	21.2	1943.9	41.1	1943.9	41.1	99.1
08DH29A-67	1900.5	11.9	1908.2	15.5	1916.5	29.6	1916.5	29.6	99.2
08DH29A-68	2408.5	10.0	2478.9	12.4	2537.0	20.8	2537.0	20.8	94.9
08DH29A-69	166.4	2.7	161.0	15.4	82.1	243.2	166.4	2.7	202.6
08DH29A-70	343.4	1.7	343.3	7.7	342.2	59.1	343.4	1.7	100.4
08DH29A-71	1959.1	8.4	1981.8	15.9	2005.5	31.2	2005.5	31.2	97.7
08DH29A-72	1884.3	8.5	1901.2	15.0	1919.6	29.9	1919.6	29.9	98.2
08DH29A-73	1892.4	11.2	1881.1	17.9	1868.7	35.7	1868.7	35.7	101.3
08DH29A-74	327.6	3.0	321.9	11.3	280.7	91.4	327.6	3.0	116.7
08DH29A-75	2020.9	8.7	2014.1	18.1	2007.0	35.7	2007.0	35.7	100.7
08DH29A-76	204.8	1.0	202.4	5.8	174.1	72.8	204.8	1.0	117.7
08DH29A-77	2058.2	18.5	2060.6	17.6	2062.9	30.0	2062.9	30.0	99.8
08DH29A-78	1944.2	10.1	1945.6	8.1	1947.1	12.9	1947.1	12.9	99.9
08DH29A-79	516.2	46.5	742.7	53.6	1503.7	74.3	1503.7	74.3	34.3
08DH29A-80	1982.2	10.4	1982.4	17.1	1982.6	33.1	1982.6	33.1	100.0
08DH29A-81	2525.1	10.4	2528.4	13.1	2531.0	22.0	2531.0	22.0	99.8
08DH29A-82	1933.4	13.4	1956.9	15.0	1981.8	27.2	1981.8	27.2	97.6
08DH29A-83	1909.9	12.1	1918.1	16.1	1927.0	30.8	1927.0	30.8	99.1
08DH29A-84	165.0	2.9	148.7	28.7	-104.2	513.1	165.0	2.9	-158.3
08DH29A-85	298.0	8.0	323.9	62.8	514.3	499.1	298.0	8.0	57.9
08DH29A-86	228.1	1.1	227.4	3.3	220.3	36.1	228.1	1.1	103.6
08DH29A-87	269.5	1.3	268.4	6.6	258.4	63.3	269.5	1.3	104.3
08DH29A-88	1972.6	11.9	1957.3	23.7	1941.1	47.3	1941.1	47.3	101.6
08DH29A-89	163.2	1.5	148.0	35.5	-89.1	640.4	163.2	1.5	-183.1
08DH29A-90	163.2	4.0	161.1	17.9	130.3	278.0	163.2	4.0	125.3
08DH29A-91	1883.3	8.8	1885.8	13.5	1888.6	26.6	1888.6	26.6	99.7
08DH29A-92	1948.6	9.4	1954.9	11.0	1961.6	20.3	1961.6	20.3	99.3
08DH29A-93	2029.5	8.7	2018.1	14.2	2006.4	27.3	2006.4	27.3	101.1

08DH29a

Isotope ratios

Analysis	U (ppm)	206Pb/ 204Pb	U/Th	206Pb*/ 207Pb*	± (%)	207Pb*/ 235U*	± (%)	206Pb*/ 238U	± (%)	error corr.
08DH29A-94	214	66417	2.3	7.9292	1.6	6.3659	1.9	0.3661	0.9	0.50
08DH29A-95	168	6810	1.6	18.9535	2.5	0.3394	2.5	0.0467	0.5	0.20
08DH29A-96	53	1467	2.2	23.2521	25.2	0.1594	25.3	0.0269	2.3	0.09
08DH29A-97	34	11142	1.5	8.8052	1.5	4.1877	2.9	0.2674	2.6	0.87
08DH29A-98	107	10161	2.1	17.4065	1.8	0.6532	1.9	0.0825	0.5	0.27
08DH29A-99	36	1167	1.8	21.7170	33.2	0.2245	33.3	0.0354	2.6	0.08
08DH29A-100	52	1707	1.0	20.0823	13.0	0.2732	13.0	0.0398	0.5	0.04
08DH29A-101	221	79002	3.3	8.3118	1.2	5.8758	1.4	0.3542	0.7	0.49
08DH29A-102	81	40902	2.9	5.2098	1.8	13.1242	1.9	0.4959	0.8	0.41
08DH29A-103	52	2484	0.7	20.2567	12.2	0.3051	12.2	0.0448	1.0	0.08
08DH29A-104	79	4677	1.6	19.1573	4.6	0.3752	4.6	0.0521	0.9	0.19
08DH29A-105	38	13047	0.8	8.5209	1.7	5.5361	1.8	0.3421	0.5	0.28
08DH29A-106	273	74766	3.5	8.0865	1.3	5.3042	3.1	0.3111	2.8	0.90
08DH29A-107	83	2586	2.1	20.4782	7.3	0.1798	7.4	0.0267	1.4	0.19
08DH29A-108	188	35832	1.6	6.3628	1.1	7.2257	7.4	0.3335	7.4	0.99
08DH29A-109	120	7347	1.6	18.7801	3.5	0.4176	3.5	0.0569	0.5	0.14
08DH29A-110	51	14955	1.7	8.6087	0.9	5.1735	1.1	0.3230	0.6	0.54
08DH29A-111	46	30585	3.2	4.6333	1.3	16.9433	1.4	0.5694	0.5	0.35
08DH29A-112	39	1590	4.8	19.5399	10.6	0.2722	10.7	0.0386	1.9	0.17
08DH29A-113	324	68802	1.3	5.3985	1.3	12.3440	1.4	0.4833	0.7	0.50
08DH29A-115	344	29004	3.7	17.6309	1.0	0.6145	1.2	0.0786	0.6	0.53
08DH29A-116	152	47355	5.2	8.2440	2.0	5.9162	2.1	0.3537	0.5	0.24
08DH29A-117	146	72807	1.7	4.7534	0.9	15.8347	1.1	0.5459	0.5	0.47
08DH29A-118	273	7980	17.1	20.3910	3.1	0.1855	3.2	0.0274	0.6	0.20
08DH29A-119	172	57222	2.2	8.3560	1.0	5.6719	1.1	0.3437	0.5	0.45

08DH29a

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH29A-94	2011.0	16.2	2027.6	16.6	2044.5	29.0	2044.5	29.0	98.4
08DH29A-95	294.0	1.4	296.8	6.5	318.5	56.1	294.0	1.4	92.3
08DH29A-96	171.0	3.8	150.2	35.3	-167.2	635.4	171.0	3.8	-102.3
08DH29A-97	1527.7	34.8	1671.6	24.2	1857.3	26.4	1857.3	26.4	82.3
08DH29A-98	510.8	2.5	510.5	7.5	508.8	39.9	510.8	2.5	100.4
08DH29A-99	224.0	5.8	205.7	62.2	0.1	821.1	224.0	5.8	244783.6
08DH29A-100	251.6	1.2	245.3	28.4	185.4	304.5	251.6	1.2	135.7
08DH29A-101	1954.7	11.6	1957.7	12.2	1960.8	21.8	1960.8	21.8	99.7
08DH29A-102	2596.1	16.9	2688.6	18.3	2758.9	29.1	2758.9	29.1	94.1
08DH29A-103	282.7	2.7	270.4	29.0	165.2	285.2	282.7	2.7	171.1
08DH29A-104	327.6	2.9	323.5	12.9	294.2	104.2	327.6	2.9	111.4
08DH29A-105	1896.9	8.2	1906.2	15.6	1916.4	31.2	1916.4	31.2	99.0
08DH29A-106	1746.1	42.1	1869.5	26.1	2009.7	23.8	2009.7	23.8	86.9
08DH29A-107	169.9	2.4	167.9	11.5	139.8	170.8	169.9	2.4	121.5
08DH29A-108	1855.1	118.7	2139.7	66.4	2425.3	17.8	2425.3	17.8	76.5
08DH29A-109	356.6	1.7	354.3	10.6	339.4	79.4	356.6	1.7	105.1
08DH29A-110	1804.4	9.4	1848.3	9.5	1897.9	17.0	1897.9	17.0	95.1
08DH29A-111	2905.2	11.7	2931.6	13.7	2949.8	21.6	2949.8	21.6	98.5
08DH29A-112	244.0	4.5	244.5	23.3	248.8	243.7	244.0	4.5	98.1
08DH29A-113	2541.7	15.3	2630.9	13.6	2700.3	20.6	2700.3	20.6	94.1
08DH29A-115	487.6	2.9	486.4	4.5	480.6	21.7	487.6	2.9	101.5
08DH29A-116	1952.4	8.4	1963.6	18.2	1975.4	36.3	1975.4	36.3	98.8
08DH29A-117	2808.1	11.4	2866.9	10.1	2908.4	15.1	2908.4	15.1	96.5
08DH29A-118	174.5	1.1	172.8	5.0	149.8	72.6	174.5	1.1	116.5
08DH29A-119	1904.6	8.2	1927.1	9.7	1951.4	17.9	1951.4	17.9	97.6

08DH30a

Isotope ratios

Analysis	U (ppm)	206Pb/ 204Pb	U/Th	206Pb*/ 207Pb*	± (%)	207Pb*/ 235U*	± (%)	206Pb*/ 238U	± (%)	error corr.
08DH30A-1	109	3612	1.0	19.8821	6.1	0.2569	6.3	0.0370	1.6	0.26
08DH30A-2	61	894	0.7	18.5733	9.7	0.2882	9.8	0.0388	1.6	0.16
08DH30A-3	413	15360	1.4	19.5044	0.8	0.2841	3.4	0.0402	3.3	0.97
08DH30A-4	75	27270	2.4	8.8736	1.5	4.6354	1.9	0.2983	1.2	0.63
08DH30A-5	148	3645	1.0	19.2848	4.2	0.3337	4.3	0.0467	0.8	0.18
08DH30A-6	49	15342	1.1	8.6017	1.1	5.4792	2.1	0.3418	1.8	0.86
08DH30A-7	247	8811	0.9	19.5689	3.7	0.2988	4.1	0.0424	1.7	0.42
08DH30A-8	102	10128	2.8	8.5734	0.9	5.2483	2.7	0.3263	2.6	0.95
08DH30A-9	197	6252	1.1	18.8646	2.0	0.3399	3.0	0.0465	2.2	0.74
08DH30A-10	327	9762	5.4	18.0525	2.5	0.4153	3.4	0.0544	2.3	0.67
08DH30A-11	116	43116	1.1	5.3621	1.3	13.0750	1.7	0.5085	1.0	0.61
08DH30A-12	200	83694	10.1	5.1560	2.1	12.3458	3.2	0.4617	2.4	0.75
08DH30A-13	83	26484	2.2	8.6773	1.1	5.2871	1.7	0.3327	1.3	0.78
08DH30A-14	156	83937	2.9	5.3243	1.9	13.1298	2.6	0.5070	1.7	0.66
08DH30A-15	89	2661	1.1	19.2874	4.2	0.2965	4.4	0.0415	1.0	0.23
08DH30A-16	84	1926	1.2	20.2901	9.4	0.1720	10.3	0.0253	4.3	0.42
08DH30A-17	48	10863	2.2	8.5325	2.0	5.5279	2.6	0.3421	1.6	0.63
08DH30A-18	328	12168	0.8	19.3580	1.5	0.2937	3.1	0.0412	2.7	0.87
08DH30A-19	146	5784	0.9	19.1329	5.8	0.2934	6.6	0.0407	3.0	0.46
08DH30A-20	201	5322	1.3	18.7184	2.9	0.3550	2.9	0.0482	0.5	0.17
08DH30A-21	259	68766	4.5	8.9054	1.8	4.5551	2.0	0.2942	1.0	0.48
08DH30A-22	234	9096	1.0	19.4327	2.1	0.2965	3.2	0.0418	2.5	0.76
08DH30A-23	182	7635	0.7	18.8583	2.0	0.3479	2.0	0.0476	0.5	0.27
08DH30A-24	144	7140	2.1	19.3708	3.5	0.3285	3.7	0.0461	1.2	0.33
08DH30A-25	170	3726	1.0	16.9503	17.3	0.4376	17.3	0.0538	1.2	0.07
08DH30A-26	50	2037	3.4	20.7041	14.1	0.2658	14.2	0.0399	1.8	0.12
08DH30A-27	126	43683	4.0	8.4929	1.3	5.7204	2.2	0.3524	1.8	0.80
08DH30A-28	149	4785	0.8	19.4793	3.6	0.2882	3.9	0.0407	1.3	0.34
08DH30A-29	189	40677	2.2	8.6499	1.3	5.2505	1.5	0.3294	0.8	0.51
08DH30A-30	30	1269	1.1	23.4751	29.3	0.2175	29.4	0.0370	2.3	0.08
08DH30A-31	52	2295	0.6	21.5141	20.1	0.2515	20.2	0.0392	1.6	0.08
08DH30A-32	265	73908	2.9	6.8915	1.7	8.0954	1.8	0.4046	0.5	0.28
08DH30A-33	162	49101	2.4	5.9465	2.3	10.6175	2.9	0.4579	1.8	0.62
08DH30A-34	46	6264	0.6	8.3017	3.1	5.5011	3.4	0.3312	1.4	0.40
08DH30A-35	97	35073	1.7	8.2626	2.3	5.7438	2.7	0.3442	1.3	0.49
08DH30A-36	109	33471	1.5	8.8465	1.7	5.0859	3.6	0.3263	3.2	0.88
08DH30A-37	143	65043	0.8	8.2969	1.8	5.7476	2.1	0.3459	1.0	0.48
08DH30A-38	101	3363	1.9	20.2827	5.0	0.1697	5.3	0.0250	1.7	0.32
08DH30A-39	65	25254	2.1	8.3602	2.3	5.5316	2.6	0.3354	1.2	0.48
08DH30A-40	62	18324	1.7	9.4840	2.6	4.3948	4.4	0.3023	3.6	0.81
08DH30A-41	171	32652	1.8	8.9097	2.1	4.4330	3.4	0.2865	2.7	0.79
08DH30A-42	770	2700	0.6	15.7067	7.2	0.3836	8.1	0.0437	3.6	0.45
08DH30A-43	137	5061	14.1	20.3423	4.8	0.1791	5.5	0.0264	2.7	0.49
08DH30A-44	110	1815	0.6	19.9118	6.4	0.1744	6.8	0.0252	2.3	0.34
08DH30A-45	58	3435	1.2	20.4900	10.4	0.2868	10.6	0.0426	2.0	0.19

08DH30a

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH30A-1	234.5	3.8	232.2	13.1	208.7	141.3	234.5	3.8	112.3
08DH30A-2	245.5	3.9	257.1	22.3	364.4	219.2	245.5	3.9	67.4
08DH30A-3	254.0	8.1	253.9	7.5	253.0	18.7	254.0	8.1	100.4
08DH30A-4	1683.0	17.3	1755.7	15.6	1843.3	26.3	1843.3	26.3	91.3
08DH30A-5	294.1	2.3	292.4	10.9	279.0	96.4	294.1	2.3	105.4
08DH30A-6	1895.4	30.1	1897.3	18.3	1899.4	19.7	1899.4	19.7	99.8
08DH30A-7	267.8	4.5	265.5	9.6	245.4	85.6	267.8	4.5	109.1
08DH30A-8	1820.6	40.6	1860.5	23.0	1905.3	15.4	1905.3	15.4	95.6
08DH30A-9	293.0	6.3	297.1	7.7	329.2	45.7	293.0	6.3	89.0
08DH30A-10	341.4	7.6	352.7	10.1	428.1	56.0	341.4	7.6	79.7
08DH30A-11	2650.1	22.4	2685.1	15.9	2711.5	22.1	2711.5	22.1	97.7
08DH30A-12	2446.9	48.7	2631.1	29.8	2775.9	34.3	2775.9	34.3	88.1
08DH30A-13	1851.6	21.6	1866.8	14.7	1883.7	19.5	1883.7	19.5	98.3
08DH30A-14	2643.9	36.4	2689.0	24.1	2723.1	31.8	2723.1	31.8	97.1
08DH30A-15	262.0	2.6	263.7	10.1	278.7	97.3	262.0	2.6	94.0
08DH30A-16	161.1	6.8	161.1	15.4	161.4	220.2	161.1	6.8	99.8
08DH30A-17	1896.7	26.8	1904.9	22.3	1913.9	36.2	1913.9	36.2	99.1
08DH30A-18	260.4	6.9	261.4	7.2	270.3	34.8	260.4	6.9	96.4
08DH30A-19	257.2	7.6	261.2	15.1	297.1	133.0	257.2	7.6	86.6
08DH30A-20	303.4	1.5	308.5	7.8	346.8	65.0	303.4	1.5	87.5
08DH30A-21	1662.5	14.1	1741.1	16.8	1836.8	32.1	1836.8	32.1	90.5
08DH30A-22	263.9	6.4	263.6	7.5	261.5	48.0	263.9	6.4	100.9
08DH30A-23	299.6	1.6	303.1	5.3	329.9	44.3	299.6	1.6	90.8
08DH30A-24	290.8	3.5	288.4	9.3	268.8	80.0	290.8	3.5	108.2
08DH30A-25	337.8	3.8	368.6	53.5	567.0	378.2	337.8	3.8	59.6
08DH30A-26	252.3	4.3	239.3	30.3	114.0	333.9	252.3	4.3	221.3
08DH30A-27	1945.8	30.2	1934.5	19.3	1922.3	23.9	1922.3	23.9	101.2
08DH30A-28	257.2	3.3	257.1	8.8	255.9	83.8	257.2	3.3	100.5
08DH30A-29	1835.4	12.5	1860.9	12.9	1889.4	23.4	1889.4	23.4	97.1
08DH30A-30	234.4	5.3	199.8	53.4	-191.0	747.2	234.4	5.3	-122.7
08DH30A-31	248.1	3.8	227.8	41.2	22.6	487.7	248.1	3.8	1096.7
08DH30A-32	2190.3	9.3	2241.7	16.2	2289.0	29.6	2289.0	29.6	95.7
08DH30A-33	2430.4	37.3	2490.2	27.3	2539.5	38.6	2539.5	38.6	95.7
08DH30A-34	1844.3	21.8	1900.8	29.0	1963.0	55.1	1963.0	55.1	94.0
08DH30A-35	1906.9	21.6	1938.0	23.2	1971.4	41.7	1971.4	41.7	96.7
08DH30A-36	1820.5	50.0	1833.8	30.4	1848.8	30.9	1848.8	30.9	98.5
08DH30A-37	1914.8	16.4	1938.6	17.9	1964.0	32.5	1964.0	32.5	97.5
08DH30A-38	159.0	2.7	159.2	7.8	162.3	117.8	159.0	2.7	98.0
08DH30A-39	1864.5	19.9	1905.5	22.1	1950.5	40.4	1950.5	40.4	95.6
08DH30A-40	1702.7	53.3	1711.4	36.4	1722.0	47.6	1722.0	47.6	98.9
08DH30A-41	1623.8	38.8	1718.5	28.2	1835.9	37.5	1835.9	37.5	88.4
08DH30A-42	275.7	9.7	329.7	22.7	730.6	153.0	275.7	9.7	37.7
08DH30A-43	168.1	4.5	167.3	8.5	155.4	112.9	168.1	4.5	108.2
08DH30A-44	160.4	3.6	163.3	10.2	205.3	148.3	160.4	3.6	78.1
08DH30A-45	269.0	5.2	256.0	24.0	138.5	244.7	269.0	5.2	194.3

08DH30a

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH30A-46	123	5631	1.2	19.2239	2.9	0.3277	3.4	0.0457	1.8	0.54
08DH30A-47	140	3744	1.7	20.2929	5.5	0.1885	5.6	0.0277	1.0	0.17
08DH30A-48	389	17880	1.3	19.0924	1.5	0.3189	2.1	0.0442	1.4	0.69
08DH30A-49	84	2601	2.4	20.9106	10.4	0.1722	10.5	0.0261	1.5	0.14
08DH30A-50	798	31992	2.7	18.7117	5.1	0.3842	5.3	0.0521	1.2	0.22
08DH30A-51	104	1731	2.2	19.4541	8.4	0.1867	8.5	0.0263	1.5	0.18
08DH30A-53	36	1443	1.6	23.3977	29.1	0.2332	29.1	0.0396	1.2	0.04
08DH30A-54	231	12816	1.3	14.5429	2.5	1.2174	2.9	0.1284	1.5	0.49
08DH30A-55	203	9282	1.9	19.4287	2.8	0.3328	3.2	0.0469	1.7	0.52
08DH30A-56	182	8142	3.0	18.4662	2.2	0.4449	2.9	0.0596	1.8	0.63
08DH30A-57	249	8883	1.4	19.4414	2.7	0.2848	3.4	0.0402	2.0	0.58
08DH30A-58	232	5847	1.3	19.6549	3.5	0.2668	3.8	0.0380	1.5	0.38
08DH30A-59	354	4542	0.9	17.7729	3.3	0.3127	4.1	0.0403	2.4	0.58
08DH30A-60	37	1203	2.2	21.3169	19.9	0.1610	20.3	0.0249	3.9	0.19
08DH30A-61	282	5991	1.4	21.1615	7.1	0.1576	7.4	0.0242	2.2	0.29
08DH30A-62	142	5103	1.8	20.2297	3.8	0.2010	4.8	0.0295	2.9	0.61
08DH30A-63	211	6351	3.4	20.3780	3.7	0.1629	4.6	0.0241	2.7	0.59
08DH30A-64	841	50322	5.7	8.5770	1.7	5.0429	2.3	0.3137	1.6	0.70
08DH30A-65	1293	9192	3.4	16.9683	4.6	0.4928	5.2	0.0606	2.4	0.45
08DH30A-66	315	9732	1.3	19.2929	3.1	0.2781	3.9	0.0389	2.4	0.61
08DH30A-67	68	2025	3.2	20.8228	16.9	0.1765	17.0	0.0267	1.4	0.08
08DH30A-69	216	51411	4.5	8.6437	2.1	5.4961	2.3	0.3446	1.1	0.45
08DH30A-70	82	1935	1.5	20.0352	7.9	0.1757	8.5	0.0255	3.3	0.38
08DH30A-71	53	2130	1.9	20.0626	9.7	0.2700	10.1	0.0393	2.9	0.28
08DH30A-72	93	2304	2.1	20.8407	13.2	0.1787	13.2	0.0270	1.4	0.11
08DH30A-73	420	18705	1.6	18.9097	1.5	0.3597	2.5	0.0493	2.0	0.80
08DH30A-74	1023	23094	0.8	18.8592	1.4	0.3579	1.8	0.0489	1.1	0.62
08DH30A-75	148	459	3.0	7.7604	27.5	0.5116	27.9	0.0288	4.5	0.16
08DH30A-76	259	10428	1.4	19.3187	2.6	0.3211	3.0	0.0450	1.6	0.53
08DH30A-77	144	3300	0.8	20.4698	5.6	0.1666	5.7	0.0247	1.2	0.22
08DH30A-78	123	5427	0.9	19.2168	2.9	0.3309	3.6	0.0461	2.3	0.62
08DH30A-79	419	130029	17.4	8.2560	1.8	6.0021	2.1	0.3594	1.0	0.48
08DH30A-80	269	90669	5.9	8.4449	2.2	5.7642	2.4	0.3530	1.0	0.41
08DH30A-81	73	2730	3.1	20.5753	11.6	0.2399	11.7	0.0358	1.8	0.15
08DH30A-82	65	3420	1.0	20.6148	10.2	0.2579	10.3	0.0386	1.3	0.13
08DH30A-83	141	2205	1.8	19.2522	10.3	0.1890	10.4	0.0264	1.3	0.13
08DH30A-84	616	60606	2.3	8.7873	3.0	4.6537	3.4	0.2966	1.6	0.47
08DH30A-85	49	2004	3.5	20.3515	12.3	0.2495	13.3	0.0368	5.0	0.38
08DH30A-86	159	4131	4.3	22.1178	12.4	0.1500	12.6	0.0241	2.0	0.16
08DH30A-87	229	6900	0.8	18.4796	3.6	0.4048	4.1	0.0543	2.1	0.51
08DH30A-88	54	1824	3.6	24.4205	27.4	0.1438	27.4	0.0255	1.9	0.07
08DH30A-89	46	1587	2.2	22.1550	19.7	0.1645	19.7	0.0264	1.6	0.08
08DH30A-90	274	1461	1.2	12.4603	10.0	0.6661	10.1	0.0602	1.7	0.17
08DH30A-91	44	1881	0.7	19.7213	10.0	0.3031	10.1	0.0433	1.5	0.15
08DH30A-92	118	3876	1.4	20.9389	12.5	0.1824	12.5	0.0277	1.1	0.09

08DH30a

Apparent ages (Ma)

Analysis	$^{206}\text{Pb}^*/^{238}\text{U}^*$	$\pm$ (Ma)	$^{207}\text{Pb}^*/^{235}\text{U}$	$\pm$ (Ma)	$^{206}\text{Pb}^*/^{207}\text{Pb}^*$	$\pm$ (Ma)	Best age (Ma)	$\pm$ (Ma)	Conc (%)
08DH30A-46	288.0	5.2	287.8	8.6	286.2	66.3	288.0	5.2	100.6
08DH30A-47	176.4	1.7	175.3	9.0	161.1	128.7	176.4	1.7	109.5
08DH30A-48	278.6	3.9	281.1	5.0	301.9	33.8	278.6	3.9	92.3
08DH30A-49	166.2	2.4	161.3	15.7	90.5	247.8	166.2	2.4	183.7
08DH30A-50	327.7	3.8	330.1	14.9	347.6	116.3	327.7	3.8	94.3
08DH30A-51	167.6	2.5	173.8	13.6	258.9	193.1	167.6	2.5	64.7
08DH30A-53	250.2	2.9	212.9	56.0	-182.8	740.5	250.2	2.9	-136.9
08DH30A-54	778.8	10.6	808.6	16.3	891.6	52.6	778.8	10.6	87.3
08DH30A-55	295.5	4.8	291.7	8.2	261.9	63.5	295.5	4.8	112.8
08DH30A-56	373.1	6.6	373.7	9.0	377.4	50.1	373.1	6.6	98.9
08DH30A-57	253.8	4.9	254.4	7.6	260.5	62.8	253.8	4.9	97.4
08DH30A-58	240.6	3.4	240.1	8.2	235.3	81.6	240.6	3.4	102.3
08DH30A-59	254.7	5.9	276.3	9.8	462.9	73.4	254.7	5.9	55.0
08DH30A-60	158.5	6.1	151.6	28.6	44.7	480.9	158.5	6.1	354.4
08DH30A-61	154.0	3.3	148.6	10.2	62.1	168.3	154.0	3.3	247.9
08DH30A-62	187.4	5.4	186.0	8.1	168.4	88.7	187.4	5.4	111.3
08DH30A-63	153.3	4.1	153.2	6.5	151.3	86.9	153.3	4.1	101.3
08DH30A-64	1758.9	25.2	1826.6	19.7	1904.6	29.7	1904.6	29.7	92.4
08DH30A-65	379.6	8.7	406.8	17.4	564.6	100.8	379.6	8.7	67.2
08DH30A-66	246.1	5.7	249.1	8.5	278.1	70.2	246.1	5.7	88.5
08DH30A-67	169.6	2.3	165.0	25.9	100.5	402.7	169.6	2.3	168.7
08DH30A-69	1908.5	17.3	1900.0	20.2	1890.7	37.8	1890.7	37.8	100.9
08DH30A-70	162.5	5.2	164.4	12.9	190.9	183.0	162.5	5.2	85.1
08DH30A-71	248.4	6.9	242.7	21.8	187.7	226.1	248.4	6.9	132.3
08DH30A-72	171.8	2.4	166.9	20.4	98.4	312.4	171.8	2.4	174.6
08DH30A-73	310.4	6.1	312.0	6.7	323.8	34.5	310.4	6.1	95.9
08DH30A-74	308.1	3.4	310.6	4.9	329.8	32.8	308.1	3.4	93.4
08DH30A-75	183.0	8.2	419.5	96.1	2082.5	494.3	2082.5	494.3	8.8
08DH30A-76	283.7	4.5	282.8	7.5	275.0	58.9	283.7	4.5	103.2
08DH30A-77	157.5	1.9	156.5	8.3	140.8	130.8	157.5	1.9	111.9
08DH30A-78	290.7	6.4	290.3	9.2	287.0	65.5	290.7	6.4	101.3
08DH30A-79	1979.3	17.2	1976.1	18.3	1972.8	32.8	1972.8	32.8	100.3
08DH30A-80	1949.1	16.5	1941.0	20.9	1932.4	39.6	1932.4	39.6	100.9
08DH30A-81	226.8	3.9	218.4	23.0	128.7	272.9	226.8	3.9	176.2
08DH30A-82	243.9	3.1	233.0	21.4	124.1	241.1	243.9	3.1	196.5
08DH30A-83	167.9	2.2	175.8	16.7	282.9	235.8	167.9	2.2	59.3
08DH30A-84	1674.4	24.0	1759.0	28.8	1861.0	54.9	1861.0	54.9	90.0
08DH30A-85	233.2	11.5	226.2	27.0	154.3	289.6	233.2	11.5	151.1
08DH30A-86	153.3	3.0	141.9	16.6	-44.2	302.1	153.3	3.0	-347.0
08DH30A-87	340.6	7.0	345.1	12.1	375.8	80.1	340.6	7.0	90.6
08DH30A-88	162.1	3.1	136.4	35.0	-290.7	709.3	162.1	3.1	-55.8
08DH30A-89	168.2	2.7	154.7	28.3	-48.3	482.2	168.2	2.7	-348.5
08DH30A-90	376.8	6.1	518.3	41.0	1203.2	196.6	376.8	6.1	31.3
08DH30A-91	273.5	4.0	268.8	23.8	227.5	230.6	273.5	4.0	120.2
08DH30A-92	176.2	1.9	170.1	19.6	87.3	296.5	176.2	1.9	201.7

08DH30a

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH30A-93	258	3210	0.8	15.0411	18.8	0.4147	18.9	0.0452	1.8	0.10
08DH30A-94	339	20739	1.5	18.9521	2.5	0.3988	2.7	0.0548	1.0	0.37
08DH30A-95	507	5328	0.8	18.0581	4.2	0.3145	4.6	0.0412	1.9	0.41
08DH30A-96	111	17976	1.2	8.5040	1.6	5.5157	2.7	0.3402	2.3	0.82
08DH30A-97	86	4428	1.5	18.9655	3.4	0.3811	4.4	0.0524	2.9	0.65
08DH30A-98	75	3477	1.4	19.7910	6.6	0.2744	6.7	0.0394	1.3	0.20
08DH30A-99	682	933	0.8	10.5239	15.5	0.4750	15.7	0.0363	2.3	0.15
08DH30A-100	216	64089	2.5	8.7978	2.1	4.6585	3.9	0.2973	3.3	0.85

08DH30a

Apparent ages (Ma)

Analysis	²⁰⁶ Pb*/ ²³⁸ U*	± (Ma)	²⁰⁷ Pb*/ ²³⁵ U	± (Ma)	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH30A-93	285.2	5.1	352.2	56.3	821.7	395.9	285.2	5.1	34.7
08DH30A-94	344.0	3.4	340.7	7.8	318.7	56.9	344.0	3.4	107.9
08DH30A-95	260.2	4.8	277.7	11.1	427.4	92.6	260.2	4.8	60.9
08DH30A-96	1887.6	36.8	1903.0	23.5	1919.9	27.8	1919.9	27.8	98.3
08DH30A-97	329.3	9.2	327.8	12.4	317.1	76.7	329.3	9.2	103.9
08DH30A-98	249.0	3.2	246.2	14.6	219.3	151.8	249.0	3.2	113.5
08DH30A-99	229.6	5.2	394.6	51.3	1528.5	293.6	229.6	5.2	15.0
08DH30A-100	1677.7	49.0	1759.8	32.8	1858.8	37.6	1858.8	37.6	90.3

08DH32

Isotope ratios

Analysis	U (ppm)	206Pb/ 204Pb	U/Th	206Pb*/ 207Pb*	± (%)	207Pb*/ 235U*	± (%)	206Pb*/ 238U	± (%)	error corr.
08DH32-1	55	11562	1.8	8.3507	1.7	5.7807	1.9	0.3501	0.7	0.38
08DH32-2	611	20532	1.2	18.6452	1.1	0.4031	1.7	0.0545	1.3	0.76
08DH32-3	64	1656	1.1	19.8312	10.9	0.2617	11.0	0.0376	1.8	0.16
08DH32-4	76	2382	1.0	20.9836	13.8	0.2518	13.9	0.0383	0.9	0.06
08DH32-5	47	11256	2.3	8.4877	1.9	5.6868	2.1	0.3501	1.1	0.50
08DH32-6	45	12768	1.9	8.5417	2.3	5.6469	2.5	0.3498	1.0	0.40
08DH32-7	192	4869	1.2	19.6498	4.5	0.2772	4.7	0.0395	1.3	0.27
08DH32-8	241	6195	1.0	20.0288	4.7	0.2229	5.0	0.0324	1.5	0.30
08DH32-9	64	16266	1.0	8.2525	1.6	6.0212	1.7	0.3604	0.6	0.38
08DH32-10	170	5262	0.7	19.9835	7.3	0.3223	7.6	0.0467	2.0	0.26
08DH32-11	193	4461	1.8	20.8557	8.2	0.1861	8.3	0.0282	1.4	0.17
08DH32-12	176	33738	2.3	8.3353	1.9	5.9046	2.1	0.3570	0.9	0.41
08DH32-13	406	70707	5.0	8.5467	1.8	5.5182	1.9	0.3421	0.6	0.30
08DH32-14	112	29277	1.4	8.2002	1.2	6.0372	1.3	0.3591	0.5	0.40
08DH32-15	143	3765	2.2	18.5827	2.0	0.3374	2.1	0.0455	0.6	0.31
08DH32-16	277	6375	1.2	18.3069	11.5	0.3911	11.5	0.0519	1.2	0.11
08DH32-17	132	25737	1.7	8.1966	1.1	6.0628	1.5	0.3604	1.0	0.65
08DH32-18	89	3525	1.5	19.4616	6.3	0.3072	6.4	0.0434	1.1	0.17
08DH32-19	158	4926	1.4	19.0953	2.9	0.3248	3.2	0.0450	1.3	0.42
08DH32-20	84	17379	1.4	7.3870	0.9	7.3928	2.7	0.3961	2.5	0.94
08DH32-21	711	146892	9.8	8.3321	2.0	5.8893	2.4	0.3559	1.4	0.57
08DH32-22	123	3090	1.3	20.3598	6.5	0.1917	6.5	0.0283	1.1	0.16
08DH32-24	96	20439	0.7	8.6435	1.4	5.4508	1.5	0.3417	0.6	0.37
08DH32-25	283	4785	0.5	18.8521	5.2	0.3472	5.2	0.0475	0.7	0.13
08DH32-26	126	2382	2.3	18.8335	3.3	0.3028	3.5	0.0414	1.1	0.32
08DH32-27	181	4629	0.5	19.5379	4.7	0.3265	4.8	0.0463	0.8	0.18
08DH32-28	122	2382	0.5	19.7216	7.7	0.2727	7.9	0.0390	1.6	0.21
08DH32-29	269	6597	0.8	19.2708	3.9	0.3207	4.0	0.0448	1.1	0.28
08DH32-30	142	4788	1.4	20.0285	6.5	0.2811	6.6	0.0408	1.1	0.16
08DH32-31	114	3153	2.3	20.6748	7.7	0.1892	7.9	0.0284	1.8	0.23
08DH32-32	92	21063	1.2	8.3562	1.7	5.8497	2.3	0.3545	1.5	0.66
08DH32-33	90	2391	1.7	20.7389	8.6	0.1849	8.9	0.0278	2.3	0.26
08DH32-34	199	3705	3.9	20.6662	7.8	0.1848	7.9	0.0277	1.3	0.17
08DH32-35	372	80820	2.0	8.3726	1.3	5.8799	1.5	0.3571	0.6	0.43
08DH32-36	211	4071	1.7	20.0466	4.7	0.1923	5.2	0.0280	2.1	0.41
08DH32-37	281	63597	4.0	8.2402	1.1	5.9679	2.3	0.3567	2.0	0.87
08DH32-38	160	3003	0.7	19.5963	9.2	0.2633	9.7	0.0374	3.0	0.31
08DH32-39	104	29736	1.6	7.6925	1.2	6.9554	1.5	0.3880	1.0	0.64
08DH32-40	22	558	1.4	22.2553	95.5	0.1529	95.6	0.0247	3.1	0.03
08DH32-41	259	55836	1.5	6.6542	1.5	8.7685	1.6	0.4232	0.5	0.31
08DH32-42	175	46683	1.3	7.7985	1.5	6.6987	1.5	0.3789	0.5	0.34
08DH32-43	203	53817	2.1	5.1711	2.5	14.4586	3.1	0.5423	1.8	0.58
08DH32-44	29	864	0.6	31.5991	80.0	0.1340	80.5	0.0307	9.6	0.12
08DH32-45	825	139995	12.6	8.5288	1.9	5.4635	2.6	0.3380	1.8	0.70
08DH32-46	74	1467	0.8	20.6428	12.0	0.1626	12.2	0.0243	2.5	0.21

08DH32

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH32-1	1935.1	12.0	1943.5	16.2	1952.5	30.9	1952.5	30.9	99.1
08DH32-2	342.1	4.3	343.9	4.9	355.7	24.9	342.1	4.3	96.2
08DH32-3	238.2	4.2	236.0	23.2	214.7	252.1	238.2	4.2	110.9
08DH32-4	242.4	2.1	228.0	28.3	82.2	329.4	242.4	2.1	294.9
08DH32-5	1934.9	17.9	1929.4	18.5	1923.4	33.4	1923.4	33.4	100.6
08DH32-6	1933.8	16.5	1923.3	21.5	1912.0	41.1	1912.0	41.1	101.1
08DH32-7	249.7	3.1	248.4	10.3	235.9	104.3	249.7	3.1	105.9
08DH32-8	205.4	3.0	204.3	9.2	191.7	110.0	205.4	3.0	107.2
08DH32-9	1984.0	10.9	1978.9	14.8	1973.6	28.0	1973.6	28.0	100.5
08DH32-10	294.3	5.8	283.7	18.7	196.9	169.7	294.3	5.8	149.5
08DH32-11	179.0	2.5	173.3	13.2	96.7	193.7	179.0	2.5	185.0
08DH32-12	1967.7	14.6	1961.9	18.2	1955.8	34.1	1955.8	34.1	100.6
08DH32-13	1896.6	9.4	1903.4	16.3	1910.9	32.5	1910.9	32.5	99.2
08DH32-14	1977.7	8.5	1981.2	10.9	1984.9	20.5	1984.9	20.5	99.6
08DH32-15	286.6	1.8	295.2	5.3	363.2	44.3	286.6	1.8	78.9
08DH32-16	326.4	3.9	335.2	33.0	396.9	258.0	326.4	3.9	82.2
08DH32-17	1984.1	16.4	1984.9	12.9	1985.7	20.1	1985.7	20.1	99.9
08DH32-18	273.7	2.9	272.0	15.3	258.1	145.2	273.7	2.9	106.0
08DH32-19	283.6	3.7	285.6	8.0	301.5	66.3	283.6	3.7	94.1
08DH32-20	2150.9	45.9	2160.1	23.9	2168.8	16.0	2168.8	16.0	99.2
08DH32-21	1962.7	23.4	1959.7	21.0	1956.5	35.4	1956.5	35.4	100.3
08DH32-22	179.9	1.9	178.1	10.7	153.4	151.4	179.9	1.9	117.3
08DH32-24	1894.9	9.4	1892.9	13.1	1890.7	25.4	1890.7	25.4	100.2
08DH32-25	299.0	2.0	302.6	13.7	330.7	117.5	299.0	2.0	90.4
08DH32-26	261.2	2.8	268.6	8.3	332.9	75.5	261.2	2.8	78.5
08DH32-27	291.6	2.4	286.9	11.9	249.0	108.1	291.6	2.4	117.1
08DH32-28	246.7	3.9	244.8	17.1	227.5	178.5	246.7	3.9	108.4
08DH32-29	282.7	3.2	282.4	10.0	280.7	88.8	282.7	3.2	100.7
08DH32-30	258.0	2.7	251.5	14.8	191.7	152.3	258.0	2.7	134.6
08DH32-31	180.3	3.2	175.9	12.7	117.3	181.3	180.3	3.2	153.7
08DH32-32	1956.1	25.5	1953.8	19.7	1951.3	30.4	1951.3	30.4	100.2
08DH32-33	176.9	4.0	172.3	14.1	110.0	202.9	176.9	4.0	160.8
08DH32-34	176.1	2.3	172.2	12.6	118.3	184.8	176.1	2.3	148.9
08DH32-35	1968.2	10.7	1958.3	12.7	1947.8	23.6	1947.8	23.6	101.0
08DH32-36	177.8	3.7	178.6	8.5	189.6	109.9	177.8	3.7	93.8
08DH32-37	1966.3	33.4	1971.2	19.6	1976.2	19.4	1976.2	19.4	99.5
08DH32-38	236.9	6.9	237.4	20.4	242.2	212.0	236.9	6.9	97.8
08DH32-39	2113.8	17.1	2105.8	13.2	2097.9	20.2	2097.9	20.2	100.8
08DH32-40	157.2	4.8	144.5	129.4	-59.3	1033.8	157.2	4.8	-265.3
08DH32-41	2274.9	9.6	2314.2	14.7	2349.1	26.2	2349.1	26.2	96.8
08DH32-42	2071.0	9.4	2072.5	13.6	2073.8	25.5	2073.8	25.5	99.9
08DH32-43	2792.9	41.0	2780.3	29.5	2771.1	41.3	2771.1	41.3	100.8
08DH32-44	195.1	18.5	127.7	96.9	-997.7	2838.9	195.1	18.5	-19.6
08DH32-45	1876.8	29.6	1894.9	22.5	1914.7	33.7	1914.7	33.7	98.0
08DH32-46	155.0	3.9	153.0	17.4	120.9	282.7	155.0	3.9	128.2

08DH32

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH32-47	94	26508	0.6	8.2172	0.8	6.0388	1.0	0.3599	0.5	0.52
08DH32-48	179	1698	0.7	18.2811	11.1	0.1979	11.3	0.0262	2.2	0.19
08DH32-49	207	4833	3.5	20.3665	5.5	0.2003	5.5	0.0296	0.5	0.09
08DH32-50	183	5205	0.9	19.5109	3.0	0.2910	3.1	0.0412	0.8	0.26
08DH32-51	110	2049	1.1	21.8088	14.4	0.1598	14.9	0.0253	3.8	0.25
08DH32-52	137	16854	1.1	9.1512	1.7	4.8865	1.8	0.3243	0.6	0.35
08DH32-53	305	60492	2.5	8.1661	1.6	6.1739	1.6	0.3657	0.5	0.30
08DH32-54	67	1719	2.1	25.3328	30.3	0.1424	30.7	0.0262	5.4	0.18
08DH32-55	57	1722	1.1	19.1071	6.2	0.2850	7.0	0.0395	3.3	0.46
08DH32-57	720	16554	1.2	19.6894	2.6	0.2976	2.9	0.0425	1.3	0.43
08DH32-58	175	4008	0.9	18.7270	12.2	0.3519	12.2	0.0478	1.2	0.10
08DH32-59	250	1338	1.7	14.5135	17.4	0.4912	17.8	0.0517	3.3	0.18
08DH32-60	39	912	2.6	21.4575	24.8	0.1695	25.4	0.0264	5.4	0.21
08DH32-61	260	71262	1.1	4.5024	1.6	18.2569	1.7	0.5962	0.7	0.42
08DH32-62	131	2691	1.4	23.4355	19.3	0.1416	20.0	0.0241	5.2	0.26
08DH32-63	220	25272	2.0	8.4984	1.6	4.8247	4.2	0.2974	3.9	0.93
08DH32-64	432	2781	1.1	18.8593	4.9	0.1866	5.2	0.0255	1.9	0.37
08DH32-65	275	5076	1.2	20.1143	3.1	0.1920	3.3	0.0280	1.0	0.31
08DH32-67	287	3948	2.0	19.9839	3.7	0.1984	4.0	0.0287	1.5	0.38
08DH32-68	355	87456	2.6	8.2203	1.3	6.0168	1.4	0.3587	0.5	0.35
08DH32-69	181	39417	2.8	4.3742	3.4	17.9202	3.7	0.5685	1.5	0.39
08DH32-70	106	2382	0.6	24.5071	26.0	0.1366	26.5	0.0243	5.4	0.20
08DH32-71	113	4407	1.3	19.2431	5.9	0.3721	6.5	0.0519	2.7	0.41
08DH32-72	133	2799	1.8	21.5465	12.2	0.1828	12.6	0.0286	3.0	0.24
08DH32-73	457	98784	2.9	8.0122	2.4	6.4218	3.0	0.3732	1.8	0.59
08DH32-74	167	8262	2.8	18.4658	2.6	0.4645	2.8	0.0622	1.1	0.39
08DH32-75	425	87723	2.5	7.8322	1.5	6.6566	1.6	0.3781	0.5	0.32
08DH32-76	78	1689	1.9	20.1127	10.5	0.1867	10.7	0.0272	2.1	0.20
08DH32-77	67	1329	1.2	19.8483	11.1	0.1931	11.4	0.0278	2.3	0.21
08DH32-78	291	18081	2.5	7.7171	1.8	6.9232	2.8	0.3875	2.1	0.76
08DH32-79	69	1533	1.4	19.1785	6.2	0.2099	6.2	0.0292	0.5	0.08
08DH32-80	535	2775	1.0	16.8239	9.1	0.2147	9.2	0.0262	1.3	0.14
08DH32-81	177	4170	1.6	19.3698	4.4	0.2983	4.6	0.0419	1.3	0.28
08DH32-82	168	37995	1.6	7.8196	1.1	6.7193	1.2	0.3811	0.5	0.42
08DH32-83	115	3405	0.9	19.8250	7.4	0.2997	7.5	0.0431	1.1	0.14
08DH32-84	234	62115	2.5	7.8483	1.1	6.6184	1.2	0.3767	0.7	0.53
08DH32-85	95	1845	1.6	20.3732	10.8	0.1869	10.9	0.0276	1.0	0.09
08DH32-86	886	23799	5.1	8.0768	1.2	6.1817	2.4	0.3621	2.1	0.86
08DH32-87	156	35784	2.8	6.5464	1.4	9.4003	1.7	0.4463	0.9	0.53
08DH32-88	121	43425	1.4	5.2135	1.0	14.1783	3.1	0.5361	2.9	0.95
08DH32-89	214	3132	0.8	20.6457	8.4	0.1804	8.5	0.0270	1.5	0.18
08DH32-90	55	1038	1.3	22.0525	22.3	0.1316	23.2	0.0210	6.3	0.27
08DH32-91	870	10563	0.9	19.6679	2.6	0.2837	2.9	0.0405	1.3	0.43
08DH32-92	56	8523	1.3	8.1978	3.1	6.1851	3.1	0.3677	0.5	0.16
08DH32-93	136	5025	0.9	19.1052	3.5	0.3504	3.6	0.0486	0.7	0.20

08DH32

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH32-47	1981.7	8.5	1981.5	8.4	1981.2	14.8	1981.2	14.8	100.0
08DH32-48	167.0	3.6	183.4	19.0	400.0	249.7	167.0	3.6	41.7
08DH32-49	187.9	0.9	185.3	9.4	152.6	129.4	187.9	0.9	123.1
08DH32-50	260.2	2.1	259.4	7.2	252.3	70.0	260.2	2.1	103.1
08DH32-51	161.0	6.0	150.6	20.9	-10.1	350.3	161.0	6.0	-1595.8
08DH32-52	1810.8	9.9	1799.9	15.2	1787.3	30.8	1787.3	30.8	101.3
08DH32-53	2008.9	8.6	2000.8	14.4	1992.3	27.9	1992.3	27.9	100.8
08DH32-54	166.5	8.9	135.2	38.9	-385.2	802.2	166.5	8.9	-43.2
08DH32-55	249.7	8.0	254.6	15.8	300.2	142.1	249.7	8.0	83.2
08DH32-57	268.3	3.3	264.5	6.8	231.2	61.1	268.3	3.3	116.0
08DH32-58	301.0	3.6	306.1	32.3	345.8	276.1	301.0	3.6	87.0
08DH32-59	325.0	10.4	405.7	59.4	895.8	362.6	325.0	10.4	36.3
08DH32-60	167.9	9.0	159.0	37.4	29.0	603.0	167.9	9.0	578.9
08DH32-61	3014.4	17.6	3003.4	16.8	2996.0	25.6	2996.0	25.6	100.6
08DH32-62	153.3	7.9	134.5	25.2	-186.8	485.8	153.3	7.9	-82.1
08DH32-63	1678.3	58.1	1789.2	35.6	1921.1	28.2	1921.1	28.2	87.4
08DH32-64	162.5	3.1	173.7	8.4	329.8	110.4	162.5	3.1	49.3
08DH32-65	178.1	1.8	178.3	5.4	181.7	73.0	178.1	1.8	98.0
08DH32-67	182.7	2.7	183.7	6.7	196.9	85.5	182.7	2.7	92.8
08DH32-68	1976.1	8.5	1978.3	12.3	1980.5	23.5	1980.5	23.5	99.8
08DH32-69	2901.7	34.3	2985.5	36.0	3042.3	55.1	3042.3	55.1	95.4
08DH32-70	154.6	8.2	130.0	32.4	-299.8	673.3	154.6	8.2	-51.6
08DH32-71	326.4	8.6	321.2	18.0	283.9	136.2	326.4	8.6	115.0
08DH32-72	181.6	5.4	170.5	19.8	19.1	294.8	181.6	5.4	952.9
08DH32-73	2044.3	30.8	2035.3	26.0	2026.1	42.2	2026.1	42.2	100.9
08DH32-74	389.0	4.2	387.4	9.1	377.4	58.7	389.0	4.2	103.1
08DH32-75	2067.5	8.8	2066.9	13.9	2066.2	26.3	2066.2	26.3	100.1
08DH32-76	173.2	3.7	173.8	17.2	181.9	245.9	173.2	3.7	95.2
08DH32-77	176.8	4.1	179.3	18.7	212.6	258.1	176.8	4.1	83.1
08DH32-78	2111.2	38.3	2101.6	24.9	2092.3	32.0	2092.3	32.0	100.9
08DH32-79	185.5	0.9	193.5	10.9	291.7	141.5	185.5	0.9	63.6
08DH32-80	166.7	2.1	197.5	16.6	583.2	198.8	166.7	2.1	28.6
08DH32-81	264.7	3.4	265.1	10.8	268.9	101.7	264.7	3.4	98.4
08DH32-82	2081.3	8.9	2075.2	10.4	2069.1	18.9	2069.1	18.9	100.6
08DH32-83	272.0	2.9	266.2	17.6	215.4	172.1	272.0	2.9	126.3
08DH32-84	2061.0	11.6	2061.8	11.0	2062.6	18.7	2062.6	18.7	99.9
08DH32-85	175.6	1.7	174.0	17.4	151.8	254.6	175.6	1.7	115.6
08DH32-86	1992.2	35.6	2001.9	21.1	2011.8	21.8	2011.8	21.8	99.0
08DH32-87	2378.9	17.9	2377.9	15.6	2377.0	24.5	2377.0	24.5	100.1
08DH32-88	2767.1	65.9	2761.7	29.4	2757.7	16.6	2757.7	16.6	100.3
08DH32-89	171.9	2.6	168.4	13.2	120.6	197.2	171.9	2.6	142.5
08DH32-90	134.3	8.4	125.5	27.4	-37.0	546.6	134.3	8.4	-363.1
08DH32-91	255.7	3.1	253.6	6.5	233.8	60.4	255.7	3.1	109.4
08DH32-92	2018.8	8.7	2002.3	27.3	1985.4	54.9	1985.4	54.9	101.7
08DH32-93	305.6	2.1	305.0	9.4	300.4	79.6	305.6	2.1	101.7

08DH32

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH32-94	107	5235	1.5	19.2944	5.8	0.3873	6.4	0.0542	2.6	0.41
08DH32-95	351	4716	1.7	20.3955	3.5	0.1675	3.6	0.0248	0.9	0.24
08DH32-96	155	45834	1.7	5.1278	1.2	14.5646	1.3	0.5417	0.5	0.39
08DH32-97	148	5943	1.1	18.9450	4.2	0.3878	4.5	0.0533	1.4	0.32
08DH32-98	223	66885	2.2	8.2240	1.2	6.0365	1.3	0.3601	0.5	0.38
08DH32-100	46	1338	0.8	19.8002	13.6	0.2552	14.2	0.0367	4.0	0.28
08DH32-102	67	2043	2.2	20.0654	12.4	0.3085	12.5	0.0449	1.6	0.13
08DH32-103	93	19728	1.8	8.2352	1.6	6.0040	1.7	0.3586	0.6	0.34
08DH32-104	272	45567	3.3	7.8909	1.4	6.5606	1.6	0.3755	0.8	0.48
08DH32-105	609	10575	4.5	8.1769	1.9	4.3816	4.8	0.2598	4.4	0.92
08DH32-106	154	3900	1.5	18.3627	2.9	0.4046	3.0	0.0539	1.0	0.32
08DH32-107	33	1068	0.5	18.9477	12.7	0.3233	12.7	0.0444	0.9	0.07
08DH32-109	104	2127	0.9	21.1265	11.7	0.1745	11.8	0.0267	1.1	0.10
08DH32-110	170	49356	2.6	8.1013	1.5	6.2430	1.9	0.3668	1.3	0.66

08DH32

Apparent ages (Ma)

Analysis	²⁰⁶ Pb*/ ²³⁸ U*	± (Ma)	²⁰⁷ Pb*/ ²³⁵ U	± (Ma)	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH32-94	340.2	8.7	332.4	18.1	277.9	133.2	340.2	8.7	122.4
08DH32-95	157.8	1.4	157.3	5.2	149.3	81.9	157.8	1.4	105.7
08DH32-96	2790.4	11.3	2787.2	12.1	2784.9	19.2	2784.9	19.2	100.2
08DH32-97	334.7	4.7	332.8	12.6	319.6	95.8	334.7	4.7	104.7
08DH32-98	1982.4	8.5	1981.1	11.5	1979.8	21.7	1979.8	21.7	100.1
08DH32-100	232.0	9.1	230.8	29.3	218.3	316.3	232.0	9.1	106.3
08DH32-102	283.1	4.5	273.0	29.9	187.4	288.9	283.1	4.5	151.1
08DH32-103	1975.5	9.9	1976.4	15.0	1977.3	28.9	1977.3	28.9	99.9
08DH32-104	2055.1	13.9	2054.1	14.4	2053.1	25.3	2053.1	25.3	100.1
08DH32-105	1489.1	58.2	1708.9	39.5	1990.0	34.0	1990.0	34.0	74.8
08DH32-106	338.3	3.2	345.0	8.8	390.0	64.1	338.3	3.2	86.7
08DH32-107	280.2	2.6	284.4	31.5	319.2	288.6	280.2	2.6	87.8
08DH32-109	170.1	1.9	163.3	17.8	66.1	280.0	170.1	1.9	257.3
08DH32-110	2014.4	22.1	2010.5	17.0	2006.5	25.9	2006.5	25.9	100.4

08DH33

Isotope ratios

Analysis	U (ppm)	206Pb/ 204Pb	U/Th	206Pb*/ 207Pb*	± (%)	207Pb*/ 235U*	± (%)	206Pb*/ 238U	± (%)	error corr.
08DH33-1	55	3828	1.9	17.1072	3.5	0.6900	3.7	0.0856	1.3	0.35
08DH33-2	615	14895	3.0	8.4158	6.7	5.2466	6.8	0.3202	1.1	0.16
08DH33-3	864	20412	2.4	7.3494	1.7	7.5898	1.8	0.4046	0.7	0.38
08DH33-4	135	44541	10.9	5.5633	1.5	12.6073	1.6	0.5087	0.5	0.31
08DH33-5	322	12345	1.4	17.4447	2.1	0.6590	2.1	0.0834	0.5	0.24
08DH33-6	232	14073	2.0	14.9527	1.6	1.2441	2.1	0.1349	1.4	0.65
08DH33-7	373	51996	0.5	8.5715	1.6	5.6209	1.8	0.3494	0.9	0.49
08DH33-8	368	53754	4.4	6.1547	1.7	9.6404	2.2	0.4303	1.4	0.62
08DH33-9	265	11604	2.0	8.8797	1.6	4.4713	4.2	0.2880	3.9	0.93
08DH33-10	344	56472	3.7	8.9652	1.2	4.6952	1.4	0.3053	0.8	0.53
08DH33-11	859	37605	1.2	17.3425	1.4	0.6939	1.5	0.0873	0.5	0.33
08DH33-12	187	5871	1.2	19.7932	5.3	0.2678	5.3	0.0384	0.5	0.09
08DH33-13	305	16353	3.0	17.7107	1.9	0.6152	2.2	0.0790	1.2	0.53
08DH33-14	195	14292	4.6	17.4694	1.9	0.6554	2.1	0.0830	0.7	0.35
08DH33-15	142	6891	1.4	17.9749	5.4	0.5648	5.6	0.0736	1.3	0.23
08DH33-16	264	15180	1.5	18.6681	12.2	0.5198	12.4	0.0704	2.6	0.21
08DH33-17	558	9006	2.2	18.4423	2.5	0.3838	3.2	0.0513	2.1	0.65
08DH33-18	103	12612	1.2	13.8807	2.0	1.6355	2.0	0.1647	0.5	0.24
08DH33-19	274	9285	1.4	19.9456	4.1	0.2653	4.3	0.0384	1.3	0.30
08DH33-20	112	4218	0.8	18.7513	7.7	0.3675	8.0	0.0500	2.4	0.30
08DH33-21	121	55620	1.9	5.2900	1.5	13.8642	1.6	0.5319	0.7	0.43
08DH33-22	121	7917	1.3	17.8291	3.2	0.5769	3.5	0.0746	1.5	0.41
08DH33-23	157	4629	0.9	19.7980	7.1	0.2964	7.2	0.0426	0.9	0.13
08DH33-24	240	14868	2.5	17.9854	1.7	0.5480	2.3	0.0715	1.5	0.66
08DH33-25	144	6912	1.5	19.5608	6.2	0.3678	6.4	0.0522	1.4	0.22
08DH33-26	501	15048	2.3	18.8958	1.6	0.3399	2.1	0.0466	1.4	0.64
08DH33-27	364	40614	1.8	8.9122	1.3	4.6859	1.7	0.3029	1.1	0.66
08DH33-29	575	15588	1.5	19.1734	2.5	0.3366	2.6	0.0468	0.7	0.27
08DH33-30	125	4968	1.3	19.6453	9.4	0.3349	9.5	0.0477	1.1	0.11
08DH33-32	115	7821	1.2	17.5109	3.5	0.6328	3.6	0.0804	0.9	0.25
08DH33-33	429	13203	0.7	19.5023	4.1	0.3172	4.3	0.0449	1.4	0.32
08DH33-34	440	17175	1.4	19.2632	2.9	0.3622	3.7	0.0506	2.2	0.61
08DH33-35	311	5775	1.1	19.0172	3.3	0.2674	5.0	0.0369	3.8	0.76
08DH33-36	650	29559	3.4	17.4213	1.8	0.6647	1.9	0.0840	0.5	0.29
08DH33-38	168	10221	1.1	17.5734	3.4	0.6461	3.4	0.0824	0.6	0.19
08DH33-39	101	3759	1.6	19.4419	5.3	0.3351	6.0	0.0472	2.8	0.47
08DH33-40	133	2790	1.4	20.5718	11.6	0.2539	12.0	0.0379	2.9	0.24
08DH33-41	203	10944	1.7	17.3544	2.0	0.6459	2.6	0.0813	1.6	0.63
08DH33-42	330	10560	1.5	19.1442	2.9	0.3517	3.0	0.0488	0.7	0.25
08DH33-43	129	5952	1.3	19.0699	7.5	0.4165	8.0	0.0576	2.8	0.35
08DH33-44	236	14931	2.1	17.4233	1.6	0.6275	1.9	0.0793	1.1	0.54
08DH33-45	338	11313	0.6	18.2850	3.3	0.4600	3.3	0.0610	0.5	0.15
08DH33-46	477	3771	0.8	19.1864	4.1	0.3436	4.1	0.0478	0.5	0.12
08DH33-47	92	5292	0.7	17.5191	4.8	0.6721	5.0	0.0854	1.3	0.26
08DH33-48	112	9342	1.1	14.6880	2.3	1.3805	2.3	0.1471	0.5	0.22

08DH33

Apparent ages (Ma)

Analysis	206Pb*/ 238U*	± (Ma)	207Pb*/ 235U	± (Ma)	206Pb*/ 207Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH33-1	529.5	6.7	532.8	15.3	546.8	75.6	529.5	6.7	96.8
08DH33-2	1790.9	17.5	1860.2	58.0	1938.6	120.1	1938.6	120.1	92.4
08DH33-3	2190.0	12.6	2183.7	16.3	2177.7	29.3	2177.7	29.3	100.6
08DH33-4	2651.0	10.9	2650.8	15.1	2650.5	25.4	2650.5	25.4	100.0
08DH33-5	516.3	2.5	514.0	8.5	504.0	45.3	516.3	2.5	102.4
08DH33-6	815.9	10.6	820.7	11.9	834.0	33.5	815.9	10.6	97.8
08DH33-7	1931.9	14.7	1919.3	15.4	1905.7	28.0	1905.7	28.0	101.4
08DH33-8	2307.2	26.4	2401.0	20.3	2481.6	29.3	2481.6	29.3	93.0
08DH33-9	1631.3	55.5	1725.7	34.5	1842.0	28.1	1842.0	28.1	88.6
08DH33-10	1717.5	11.3	1766.4	11.8	1824.7	21.8	1824.7	21.8	94.1
08DH33-11	539.4	2.6	535.1	6.2	516.9	31.0	539.4	2.6	104.3
08DH33-12	243.2	1.2	240.9	11.3	219.1	122.0	243.2	1.2	111.0
08DH33-113	490.3	5.5	486.8	8.6	470.6	41.6	490.3	5.5	104.2
08DH33-14	514.2	3.6	511.8	8.3	500.9	42.8	514.2	3.6	102.7
08DH33-15	458.0	5.6	454.7	20.5	437.7	121.2	458.0	5.6	104.6
08DH33-16	438.4	11.0	425.0	43.2	352.9	275.7	438.4	11.0	124.2
08DH33-17	322.7	6.7	329.8	9.1	380.3	55.1	322.7	6.7	84.8
08DH33-18	982.6	4.6	984.0	12.9	987.1	40.4	987.1	40.4	99.5
08DH33-19	242.7	3.0	238.9	9.1	201.3	94.7	242.7	3.0	120.6
08DH33-20	314.4	7.4	317.8	22.0	342.8	174.0	314.4	7.4	91.7
08DH33-21	2749.5	15.4	2740.5	15.3	2733.8	24.0	2733.8	24.0	100.6
08DH33-22	463.8	6.5	462.5	13.0	455.9	70.7	463.8	6.5	101.7
08DH33-23	268.7	2.4	263.6	16.7	218.5	165.0	268.7	2.4	122.9
08DH33-24	445.1	6.4	443.7	8.2	436.4	38.2	445.1	6.4	102.0
08DH33-25	327.9	4.5	318.1	17.4	246.4	142.9	327.9	4.5	133.1
08DH33-26	293.5	3.9	297.1	5.5	325.5	37.2	293.5	3.9	90.2
08DH33-27	1705.6	16.3	1764.7	13.9	1835.4	22.7	1835.4	22.7	92.9
08DH33-29	294.9	2.0	294.6	6.6	292.2	56.9	294.9	2.0	100.9
08DH33-30	300.5	3.1	293.3	24.1	236.4	217.4	300.5	3.1	127.1
08DH33-32	498.3	4.4	497.9	14.2	495.7	77.0	498.3	4.4	100.5
08DH33-33	283.0	3.8	279.8	10.6	253.3	94.0	283.0	3.8	111.7
08DH33-34	318.2	7.0	313.9	9.9	281.6	66.4	318.2	7.0	113.0
08DH33-35	233.5	8.8	240.6	10.8	310.9	75.0	233.5	8.8	75.1
08DH33-36	519.9	2.7	517.5	7.5	506.9	39.2	519.9	2.7	102.6
08DH33-38	510.2	3.1	506.1	13.7	487.8	74.7	510.2	3.1	104.6
08DH33-39	297.6	8.3	293.4	15.3	260.4	121.1	297.6	8.3	114.3
08DH33-40	239.7	6.8	229.7	24.6	129.1	273.5	239.7	6.8	185.7
08DH33-41	503.8	7.8	505.9	10.2	515.4	44.0	503.8	7.8	97.8
08DH33-42	307.3	2.2	306.0	7.9	295.7	65.9	307.3	2.2	103.9
08DH33-43	361.0	9.9	353.5	23.8	304.6	170.3	361.0	9.9	118.5
08DH33-44	491.9	5.0	494.5	7.6	506.7	35.7	491.9	5.0	97.1
08DH33-45	381.7	1.9	384.3	10.6	399.5	73.4	381.7	1.9	95.5
08DH33-46	301.1	1.5	299.9	10.6	290.7	92.7	301.1	1.5	103.6
08DH33-47	528.3	6.6	522.0	20.2	494.7	105.5	528.3	6.6	106.8
08DH33-48	884.5	4.1	880.6	13.7	871.1	46.9	884.5	4.1	101.5

08DH33

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH33-49	174	4416	0.8	19.8984	4.8	0.2729	4.9	0.0394	1.3	0.26
08DH33-51	195	7416	1.3	18.0813	2.8	0.5035	3.9	0.0660	2.8	0.71
08DH33-52	144	8241	1.7	17.8497	4.3	0.6254	4.5	0.0810	1.3	0.29
08DH33-53	877	17313	2.1	19.3015	1.6	0.2993	1.6	0.0419	0.5	0.31
08DH33-54	390	24201	2.1	17.2424	1.6	0.6790	1.6	0.0849	0.5	0.31
08DH33-55	66	6984	1.5	15.6746	2.9	1.0578	3.0	0.1202	0.7	0.23
08DH33-56	93	5715	2.0	17.2520	4.3	0.7127	4.4	0.0892	0.9	0.21
08DH33-57	837	918	1.2	9.0672	38.1	0.7549	38.3	0.0496	3.9	0.10
08DH33-58	151	4443	0.9	20.4352	8.6	0.2834	8.7	0.0420	1.1	0.13
08DH33-59	422	1731	1.4	13.5497	2.9	0.5495	3.0	0.0540	0.7	0.24
08DH33-60	605	15501	0.5	18.8501	1.7	0.3618	1.8	0.0495	0.6	0.33
08DH33-61	475	11823	1.6	16.9544	2.7	0.6626	3.0	0.0815	1.4	0.46
08DH33-62	255	20124	1.3	15.4425	1.8	1.0967	3.0	0.1228	2.4	0.80
08DH33-63	220	5421	0.9	19.8219	5.8	0.2719	6.2	0.0391	2.3	0.37
08DH33-64	112	14124	1.9	8.5373	2.7	4.7782	4.3	0.2959	3.3	0.78
08DH33-66	139	2133	0.8	18.9860	8.1	0.2779	8.2	0.0383	1.4	0.17
08DH33-67	404	11514	1.2	19.2885	2.5	0.3103	3.2	0.0434	2.1	0.65
08DH33-68	492	32514	1.3	15.1524	1.3	1.1905	1.4	0.1308	0.5	0.37
08DH33-69	496	13734	1.1	19.0769	2.4	0.3369	2.4	0.0466	0.5	0.21
08DH33-70	743	11718	0.6	16.4979	4.2	0.6664	4.3	0.0797	1.2	0.28
08DH33-71	79	2883	1.1	19.4573	7.4	0.3121	7.6	0.0440	1.7	0.22
08DH33-72	187	5052	0.8	19.5289	3.1	0.2896	3.4	0.0410	1.4	0.41
08DH33-73	1221	915	2.2	11.0964	4.4	0.4672	4.5	0.0376	1.0	0.23
08DH33-74	270	42708	0.8	9.3496	1.9	4.4939	2.2	0.3047	1.1	0.50
08DH33-75	102	2886	1.2	19.7210	6.9	0.2874	6.9	0.0411	0.5	0.07
08DH33-76	595	2955	0.8	15.3170	11.0	0.4222	11.2	0.0469	2.0	0.18
08DH33-77	145	5691	1.2	19.2778	4.8	0.3342	5.0	0.0467	1.1	0.22
08DH33-78	168	6417	1.3	19.3406	4.0	0.3438	4.0	0.0482	0.7	0.18
08DH33-79	821	23961	2.5	17.1464	1.7	0.6249	1.8	0.0777	0.6	0.35
08DH33-80	1165	4863	3.6	17.0247	2.7	0.3105	2.8	0.0383	0.8	0.29
08DH33-81	213	10689	1.5	17.3018	2.0	0.6563	2.1	0.0823	0.9	0.41
08DH33-82	189	7656	1.0	17.3443	4.2	0.6140	4.4	0.0772	1.3	0.31
08DH33-83	461	16638	1.4	18.8214	1.2	0.3679	1.4	0.0502	0.7	0.53
08DH33-84	172	5529	1.6	19.0847	4.4	0.3566	4.4	0.0494	0.7	0.15
08DH33-85	463	13854	1.6	19.0705	1.1	0.3428	1.4	0.0474	0.8	0.59
08DH33-86	107	5958	1.3	17.9530	3.5	0.5316	3.6	0.0692	0.5	0.14
08DH33-87	128	13971	2.4	11.1561	2.2	2.9691	2.2	0.2402	0.5	0.23
08DH33-88	442	7779	0.8	19.5348	1.7	0.2639	1.9	0.0374	0.7	0.37
08DH33-89	94	2367	1.0	19.9896	8.4	0.2499	8.6	0.0362	1.6	0.19
08DH33-90	179	4146	0.9	18.6796	2.1	0.3139	2.1	0.0425	0.6	0.28
08DH33-91	286	6888	0.5	19.2618	3.1	0.3436	3.2	0.0480	0.9	0.27
08DH33-92	367	23928	1.9	17.7310	1.7	0.6137	2.0	0.0789	1.1	0.53
08DH33-93	1027	7938	5.5	15.5272	5.8	0.8044	5.9	0.0906	0.5	0.09
08DH33-94	274	12957	1.2	17.2353	1.6	0.6684	2.0	0.0835	1.1	0.54
08DH33-95	109	3189	1.4	19.8252	7.8	0.2774	7.9	0.0399	1.6	0.20

08DH33

Apparent ages (Ma)

Analysis	$^{206}\text{Pb}^*/^{238}\text{U}^*$	$\pm$ (Ma)	$^{207}\text{Pb}^*/^{235}\text{U}$	$\pm$ (Ma)	$^{206}\text{Pb}^*/^{207}\text{Pb}^*$	$\pm$ (Ma)	Best age (Ma)	$\pm$ (Ma)	Conc (%)
08DH33-49	249.0	3.1	245.0	10.7	206.8	110.6	249.0	3.1	120.4
08DH33-51	412.1	11.2	414.0	13.4	424.6	61.6	412.1	11.2	97.1
08DH33-52	501.9	6.3	493.2	17.5	453.3	95.3	501.9	6.3	110.7
08DH33-53	264.6	1.3	265.9	3.8	277.0	35.6	264.6	1.3	95.5
08DH33-54	525.4	2.5	526.2	6.7	529.6	34.0	525.4	2.5	99.2
08DH33-55	732.0	4.8	732.7	15.8	734.9	62.2	732.0	4.8	99.6
08DH33-56	550.7	4.9	546.4	18.6	528.4	94.5	550.7	4.9	104.2
08DH33-57	312.3	12.0	571.1	168.9	1804.1	721.3	1804.1	721.3	17.3
08DH33-58	265.2	2.9	253.3	19.4	144.7	201.7	265.2	2.9	183.3
08DH33-59	339.1	2.4	444.7	10.9	1036.0	59.4	339.1	2.4	32.7
08DH33-60	311.2	1.8	313.6	4.8	331.0	38.3	311.2	1.8	94.0
08DH33-61	504.9	6.8	516.2	12.1	566.4	57.8	504.9	6.8	89.1
08DH33-62	746.8	16.6	751.8	15.7	766.4	37.3	746.8	16.6	97.4
08DH33-63	247.2	5.7	244.2	13.6	215.8	134.2	247.2	5.7	114.6
08DH33-64	1670.7	49.2	1781.1	36.1	1912.9	48.6	1912.9	48.6	87.3
08DH33-66	242.1	3.3	249.0	18.2	314.6	185.1	242.1	3.3	76.9
08DH33-67	273.9	5.7	274.4	7.8	278.6	56.1	273.9	5.7	98.3
08DH33-68	792.6	3.7	796.2	7.5	806.2	26.6	792.6	3.7	98.3
08DH33-69	293.7	1.4	294.8	6.2	303.7	54.3	293.7	1.4	96.7
08DH33-70	494.5	5.8	518.5	17.7	625.5	90.0	494.5	5.8	79.1
08DH33-71	277.8	4.5	275.8	18.3	258.6	170.1	277.8	4.5	107.4
08DH33-72	259.1	3.5	258.2	7.6	250.1	70.4	259.1	3.5	103.6
08DH33-73	238.0	2.4	389.3	14.5	1428.0	83.1	238.0	2.4	16.7
08DH33-74	1714.7	16.7	1729.8	18.4	1748.2	35.0	1748.2	35.0	98.1
08DH33-75	259.7	1.3	256.5	15.7	227.6	159.4	259.7	1.3	114.1
08DH33-76	295.4	5.8	357.6	33.8	783.6	232.2	295.4	5.8	37.7
08DH33-77	294.4	3.2	292.7	12.6	279.8	110.7	294.4	3.2	105.2
08DH33-78	303.6	2.2	300.0	10.4	272.4	90.6	303.6	2.2	111.5
08DH33-79	482.4	2.9	492.9	6.9	541.9	36.2	482.4	2.9	89.0
08DH33-80	242.5	2.0	274.6	6.8	557.4	59.1	242.5	2.0	43.5
08DH33-81	510.1	4.4	512.3	8.6	522.1	42.9	510.1	4.4	97.7
08DH33-82	479.6	6.2	486.1	16.9	516.7	91.2	479.6	6.2	92.8
08DH33-83	315.9	2.3	318.1	3.7	334.4	26.2	315.9	2.3	94.5
08DH33-84	310.6	2.0	309.7	11.8	302.8	99.3	310.6	2.0	102.6
08DH33-85	298.6	2.4	299.3	3.6	304.5	25.4	298.6	2.4	98.1
08DH33-86	431.5	2.1	432.9	12.6	440.4	78.7	431.5	2.1	98.0
08DH33-87	1387.9	6.2	1399.8	16.9	1417.8	41.3	1417.8	41.3	97.9
08DH33-88	236.6	1.6	237.8	4.0	249.4	40.0	236.6	1.6	94.9
08DH33-89	229.4	3.6	226.5	17.4	196.2	195.9	229.4	3.6	116.9
08DH33-90	268.4	1.6	277.2	5.2	351.5	46.5	268.4	1.6	76.4
08DH33-91	302.2	2.6	299.9	8.4	281.7	71.4	302.2	2.6	107.3
08DH33-92	489.7	5.0	485.9	7.7	468.1	37.5	489.7	5.0	104.6
08DH33-93	559.0	2.8	599.3	26.5	754.9	123.1	559.0	2.8	74.0
08DH33-94	517.3	5.2	519.7	7.9	530.6	36.0	517.3	5.2	97.5
08DH33-95	252.2	3.8	248.6	17.5	215.3	180.1	252.2	3.8	117.1

08DH33

Isotope ratios

Analysis	U (ppm)	²⁰⁶ Pb/ ²⁰⁴ Pb	U/Th	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (%)	²⁰⁷ Pb*/ ²³⁵ U*	± (%)	²⁰⁶ Pb*/ ²³⁸ U	± (%)	error corr.
08DH33-96	620	2175	1.0	12.5874	37.8	0.5244	37.8	0.0479	1.4	0.04
08DH33-99	180	28233	1.2	8.7651	2.1	5.4004	2.2	0.3433	0.5	0.24
08DH33-100	498	28593	1.9	16.4484	1.5	0.8519	1.8	0.1016	0.9	0.50
08DH33-101	523	30705	4.3	17.6232	2.2	0.6229	2.3	0.0796	0.7	0.31
08DH33-102	305	18792	1.9	17.6508	2.8	0.6455	2.9	0.0826	0.5	0.19
08DH33-103	560	22473	2.5	17.4683	4.3	0.5759	4.5	0.0730	1.2	0.26
08DH33-104	549	26469	6.2	17.4064	1.6	0.6421	1.7	0.0811	0.5	0.30
08DH33-105	172	5130	1.0	17.9483	7.0	0.4578	7.2	0.0596	1.5	0.21
08DH33-106	117	10350	8.1	17.2802	3.1	0.7347	3.1	0.0921	0.5	0.17
08DH33-107	469	21414	1.7	17.6552	1.2	0.6019	1.5	0.0771	0.8	0.53
08DH33-108	455	9837	1.4	18.8073	2.0	0.4048	2.2	0.0552	1.0	0.43
08DH33-109	185	12666	1.6	8.9235	1.8	4.8642	2.0	0.3148	0.8	0.39
08DH33-110	269	6378	1.0	18.8604	2.6	0.3531	2.6	0.0483	0.7	0.25

08DH33

Apparent ages (Ma)

Analysis	²⁰⁶ Pb*/ ²³⁸ U*	± (Ma)	²⁰⁷ Pb*/ ²³⁵ U	± (Ma)	²⁰⁶ Pb*/ ²⁰⁷ Pb*	± (Ma)	Best age (Ma)	± (Ma)	Conc (%)
08DH33-96	301.5	4.2	428.1	132.8	1183.2	774.6	301.5	4.2	25.5
08DH33-99	1902.6	8.9	1884.9	18.9	1865.5	38.6	1865.5	38.6	102.0
08DH33-100	624.0	5.2	625.7	8.3	632.1	33.0	624.0	5.2	98.7
08DH33-101	493.8	3.4	491.6	9.0	481.6	48.7	493.8	3.4	102.5
08DH33-102	511.8	2.7	505.7	11.5	478.1	62.8	511.8	2.7	107.1
08DH33-103	454.0	5.1	461.8	16.7	501.1	95.5	454.0	5.1	90.6
08DH33-104	502.5	2.5	503.6	6.8	508.8	35.7	502.5	2.5	98.7
08DH33-105	373.2	5.4	382.7	22.9	441.0	156.5	373.2	5.4	84.6
08DH33-106	567.8	2.9	559.3	13.4	524.8	67.1	567.8	2.9	108.2
08DH33-107	478.6	3.6	478.4	5.6	477.5	27.3	478.6	3.6	100.2
08DH33-108	346.5	3.3	345.1	6.5	336.1	45.6	346.5	3.3	103.1
08DH33-109	1764.3	11.9	1796.1	16.6	1833.1	32.8	1833.1	32.8	96.2
08DH33-110	304.1	2.0	307.1	7.0	329.7	57.9	304.1	2.0	92.2

Appendix 5: AGEPICK results for detrital zircon populations from this study and referenced from the literature. The number beside each location corresponds to location in Chapter 2, Figure 1. References listed in Chapter 2, Figure 6.

TRIASSIC DATA

Verkhoyansk range (1)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
263	373	25	290	17
407	646	46	360	7
1781	2104	9	440	16
2397	2508	5	482	23
			535	12
			582	9
			1844	6
			2036	4
			2454	4
			2494	4

Lower Yana - Kular (2)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
224	337	61	242	16
341	387	7	301	27
413	568	54	370	6
738	825	6	501	33
1759	2011	11	789	5
			1851	11

Chukotka (6)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
234	339	28	254	5
347	398	4	266	5
422	638	31	303	20
730	856	11	369	5
893	1241	8	460	9
1617	1984	5	471	12
			497	14
			592	7
			619	4
			809	7
			1052	8
			1829	5
			1955	4

Wrangel Island (7)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
220	335	19	252	9
382	472	9	285	13
976	1204	4	452	7
			1099	4

Lisburne Hills (8)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
206	282	23	227	5
290	510	41	237	6
580	714	7	258	14
722	819	4	274	11
1089	1500	7	326	12
1621	1945	6	369	10
			436	17
			486	4
			603	4
			642	5
			777	4
			1746	4

Sadlerochit range (9)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
402	701	65	419	5
848	1319	20	465	11
			531	28
			565	30
			680	4
			882	7
			1065	7
			1187	9

Sverdrup AE1 basin (10)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
434	482	6	455	5
954	1462	26	1214	17
1549	2058	40	1367	8
			1661	12
			1769	17
			1849	4
			1934	7
			1989	6

Sverdrup AE2 basin (11)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
416	699	69	433	4
1002	1365	12	474	6
1605	1693	4	569	44
1799	1908	5	661	5
			1072	6
			1133	7
			1256	7
			1655	4
			1836	5

JURASSIC DATAVerhoyansk range (1)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
169	198	4	175	4
201	335	53	190	4
430	565	25	219	6
1795	1971	10	232	8
			259	5
			281	20
			291	21
			312	6
			324	5
			481	18
			515	6
			549	4
			1861	8
			1930	4

Lower Yana - Kular (2)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
147	210	42	167	20
223	396	155	203	5
1639	2183	132	255	42
2281	3068	32	269	50
			287	46
			321	15
			339	19
			1921	91
			2544	12
			2739	13

In' Yali Debin (3)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
221	228	3	224	3
243	343	49	262	14
317	392	8	285	19
1814	2062	21	317	7
2332	2370	3	327	7
2528	2623	3	1872	17
			2574	5

Stobovoi Island (4)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
148	164	4	155	4
224	307	23	229	5
1710	2103	45	241	6
2562	2791	15	257	9
			282	10
			294	8
			1888	31
			2663	11
			2728	12

South Anyui Suture (5)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
157	179	6	164	4
223	275	10	174	4
294	306	4	243	5
1828	2096	55	258	4
2480	2734	14	299	4
			1925	36
			2517	5
			2601	5
			2665	7

Chukotka (6)

MIN AGE	MAX AGE	# GRAINS	PEAK AGE	# GRAINS
138	189	17	159	14
223	291	26	169	14
328	377	7	175	13
1690	2209	137	247	19
2650	2822	12	350	7
			1743	4
			1930	95
			2752	10

Appendix 6: Cathodoluminescence photomicrographs of zircons separated from igneous samples collected from the Bendeleben and Windy Creek plutons. Circles indicate spot location for U-Pb SHRIMP-RG analysis.

09BEN20-

09BEN26-

09BEN29-

09BEN61-

09BEN63-

09BEN73-

R33-

Appendix 7: Complete data from SHRIMP-RG analysis of zircons separated from igneous samples collected from the Bendeleben and Windy Creek plutons.

Errors are 1σ unless otherwise specified

09BEN20

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
09BEN20-9r	13 Sep, 2009 03:00	16.11	0	0.04	2.7E-4	73	.052	4.4	.154	3.7
09BEN20-6r	13 Sep, 2009 01:51	14.98	0	0.12	7.2E-4	60	.055	4.3	.174	3.4
09BEN20-12r	13 Sep, 2009 03:50	16.95	0	0.00	---	0	.050	3.9	.186	3.4
09BEN20-1r	13 Sep, 2009 00:09	13.27	0	0.26	4.6E-4	38	.054	2.4	.172	1.9
09BEN20-4r	13 Sep, 2009 01:00	14.13	0	0.06	3.1E-4	50	.046	4.2	.234	2.8
09BEN20-10r	13 Sep, 2009 03:16	16.39	0	0.08	3.2E-4	50	.048	4.1	.098	3.9
09BEN20-11r	13 Sep, 2009 03:33	16.67	0	0.00	---	0	.049	3.9	.199	2.8
09BEN20-8c	13 Sep, 2009 02:25	15.54	0	0.06	1.7E-4	50	.048	3.1	.071	3.6
09BEN20-2r	13 Sep, 2009 00:27	13.56	0	0.17	9.0E-4	38	.053	5.3	.247	2.8
09BEN20-5c	13 Sep, 2009 01:34	14.69	0	0.07	1.5E-4	50	.048	2.6	.182	2.0
09BEN20-7c	13 Sep, 2009 02:09	15.26	0	-0.06	-1.3E-4	50	.048	2.7	.191	3.3

Errors are 1 σ unless otherwise specified

09BEN20

Spot Name	Obs 206 /238	% err	248 /254	% err	254 /238	% err	238 /196	Pb/U: UO/U^2	% err	% comm 206	ppm U	ppm Th	232Th /238U
09BEN20-9r	.025	1.2	.418	0.8	5.35	0.4	.300	.00086	1.2	0.53	246	105	0.44
09BEN20-6r	.019	3.0	.471	0.6	4.64	0.7	.337	.00087	1.2	0.87	252	120	0.49
09BEN20-12r	.022	1.0	.575	0.9	5.05	0.3	.454	.00089	1.1	0.24	358	209	0.60
09BEN20-1r	.026	1.3	.457	0.3	5.31	0.2	.857	.00090	0.7	0.77	699	325	0.48
09BEN20-4r	.022	1.0	.675	0.7	5.01	0.3	.364	.00090	1.1	-0.18	286	196	0.71
09BEN20-10r	.023	1.0	.275	0.3	5.05	0.3	.472	.00090	1.0	0.08	373	104	0.29
09BEN20-11r	.022	1.3	.590	0.3	4.95	0.3	.472	.00090	1.0	0.10	368	221	0.62
09BEN20-8c	.023	1.2	.197	0.8	4.97	0.3	.718	.00091	0.8	0.06	561	112	0.21
09BEN20-2r	.022	1.1	.674	0.8	4.87	0.7	.347	.00092	1.1	0.62	268	183	0.71
09BEN20-5c	.022	1.1	.547	0.2	4.91	0.2	.895	.00092	0.7	0.03	694	386	0.57
09BEN20-7c	.020	1.0	.572	2.3	4.63	0.6	1.040	.00094	0.7	0.07	775	450	0.60

Errors are 1 σ unless otherwise specified

09BEN20

Spot Name	Ln UO/U	Ln Pb/U	Corr 206 /238	% err	ppm Rad 206Pb	Total 208Pb /232Th	% err	Age S-K comm Pb	C-Pb 206 /204	C-Pb 207 /206	C-Pb 208 /206	204corr 206Pb /238U Age	1 σ err
09BEN20-9r	1.677	-3.705	.013	1.2	2.7	.0045	3.9	82	18.58	0.841	2.071	81.6	1.0
09BEN20-6r	1.534	-3.988	.013	1.2	2.8	.0045	3.7	82	18.58	0.841	2.071	81.3	1.1
09BEN20-12r	1.619	-3.803	.013	1.1	4.0	.0040	3.7	84	18.58	0.841	2.071	84.1	0.9
09BEN20-1r	1.670	-3.677	.013	0.7	8.0	.0048	2.0	85	18.57	0.841	2.071	84.9	0.6
09BEN20-4r	1.611	-3.800	.013	1.1	3.3	.0044	3.0	85	18.57	0.841	2.071	84.4	0.9
09BEN20-10r	1.620	-3.774	.013	1.0	4.3	.0046	4.1	86	18.57	0.841	2.071	85.2	0.9
09BEN20-11r	1.600	-3.808	.013	1.0	4.2	.0043	3.0	86	18.57	0.841	2.071	85.8	0.9
09BEN20-8c	1.603	-3.794	.014	0.8	6.5	.0046	3.7	86	18.57	0.841	2.071	86.2	0.7
09BEN20-2r	1.582	-3.845	.014	1.1	3.1	.0048	3.1	87	18.57	0.841	2.071	85.7	1.1
09BEN20-5c	1.592	-3.812	.014	0.7	8.1	.0043	2.1	87	18.57	0.841	2.071	86.8	0.6
09BEN20-7c	1.532	-3.906	.014	0.7	9.2	.0044	4.1	89	18.57	0.841	2.071	89.1	0.6

Errors are 1 σ unless otherwise specified

09BEN20

Spot Name	% Discordant	4corr 208r /232	% err	7corr 206Pbr /238U	1 σ err	8corr 206Pbr /238U	1 σ err
09BEN20-9r	16	.0042	6.5	.0127	.0002	.0127	.0002
09BEN20-6r	-240	.0038	11.9	.0127	.0002	.0127	.0002
09BEN20-12r	111	.0040	3.6	.0131	.0001	.0132	.0002
09BEN20-1r	-42	.0043	4.8	.0133	.0001	.0132	.0001
09BEN20-4r	-388	.0042	4.0	.0133	.0001	.0132	.0002
09BEN20-10r	-251	.0040	8.2	.0134	.0001	.0133	.0001
09BEN20-11r	48	.0043	3.0	.0134	.0001	.0134	.0002
09BEN20-8c	-121	.0042	6.3	.0135	.0001	.0135	.0001
09BEN20-2r	-568	.0041	6.9	.0135	.0002	.0134	.0002
09BEN20-5c	-116	.0042	2.7	.0136	.0001	.0136	.0001
09BEN20-7c	131	.0045	3.7	.0139	.0001	.0139	.0001

Errors are 1σ unless otherwise specified

09BEN20														204 corrected													
Total 238 /206		% err		Total 207 /206		% err		238/ 206r		% err		207r /206r		% err		207r /235		% err		206r /238		% err		err corr			
09BEN20-9r		78.09	1.2	.0519	4.4	78.48		1.3	.0479	7.7	78.83		1.4	.0439	15.6	0.08		7.8	.0127	1.3	.163						
09BEN20-6r		77.77	1.2	.0546	4.3	76.18		1.1	.0496	3.9	75.44		0.7	.0470	6.1	0.09		4.1	.0131	1.1	.262						
09BEN20-12r		76.18	1.1	.0496	3.9	75.84		1.1	.0417	7.2	75.17		1.1	.0437	7.1	0.08		7.3	.0132	1.1	.155						
09BEN20-1r		74.79	0.7	.0538	2.4	74.66		1.0	.0486	3.9	74.25		0.8	.0457	4.2	0.09		4.0	.0134	1.0	.261						
09BEN20-4r		75.41	1.1	.0463	4.2	74.73		1.3	.0392	15.0	73.74		0.7	.0458	3.7	0.08		4.3	.0135	0.8	.192						
09BEN20-10r		74.73	1.0	.0484	4.1	73.48		1.1	.0527	5.3	71.83		0.7	.0502	3.2	0.07		15.1	.0134	1.3	.085						
09BEN20-11r		74.66	1.0	.0486	3.9	73.53		0.7	.0480	2.6	72.01		0.7			0.09		3.8	.0136	0.7	.190						
09BEN20-8c		74.01	0.8	.0482	3.1	72.01		0.7	.0483	2.7						0.10		3.3	.0139	0.7	.219						
09BEN20-2r		73.48	1.1	.0527	5.3																						
09BEN20-5c		73.53	0.7	.0480	2.6																						
09BEN20-7c		72.01	0.7	.0483	2.7																						

Errors are 1σ unless otherwise specified

09BEN26

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
09BEN26-1c	12 Sep, 2009 20:23	9.51	0	0.08	3.8E-4	45	.050	4.0	.140	3.5
09BEN26-6r	12 Sep, 2009 22:03	11.17	0	0.06	2.2E-4	64	.046	3.6	.079	3.8
09BEN26-9r	13 Sep, 2009 07:44	20.86	0	-0.10	-4.7E-4	64	.048	4.1	.068	4.8
09BEN26-3c	12 Sep, 2009 20:57	10.06	0	0.06	1.9E-4	50	.047	3.2	.147	2.7
09BEN26-4r	12 Sep, 2009 21:13	10.34	0	0.03	1.0E-4	64	.051	3.3	.096	3.3
09BEN26-8r	12 Sep, 2009 22:36	11.72	0	0.04	2.4E-4	50	.048	4.4	.080	7.0
09BEN26-10c	13 Sep, 2009 08:01	21.13	0	0.06	3.3E-4	50	.046	4.2	.172	3.2
09BEN26-2r	12 Sep, 2009 20:40	9.78	0	0.00	---	0	.048	3.0	.153	2.5
09BEN26-5c	12 Sep, 2009 21:47	10.90	0	-0.11	-1.4E-3	50	.046	6.9	.100	6.3
09BEN26-7r	12 Sep, 2009 22:20	11.45	0	0.00	---	0	.093	1.1	.137	1.2

Errors are 1σ unless otherwise specified

09BEN26

Spot Name	Obs 206 /238	% err	248 /254	% err	254 /238	% err	238 /196	Pb/U: UO/U^2	% err	% comm 206	ppm U	ppm Th	232Th /238U
09BEN26-1c	.027	1.1	.385	0.3	5.27	0.3	.301	.00098	1.1	0.28	245	96	0.40
09BEN26-6r	.026	0.9	.198	0.9	5.21	0.3	.474	.00098	0.9	-0.26	382	77	0.21
09BEN26-9r	.026	1.0	.177	0.4	5.12	0.4	.366	.00098	1.1	0.03	291	52	0.19
09BEN26-3c	.027	1.0	.433	0.3	5.22	0.3	.516	.00100	0.9	-0.06	416	183	0.46
09BEN26-4r	.026	0.8	.268	0.9	5.11	0.4	.492	.00101	0.9	0.33	391	107	0.28
09BEN26-8r	.026	1.1	.213	3.9	5.09	0.4	.300	.00101	1.2	0.04	238	51	0.22
09BEN26-10c	.025	1.8	.513	0.3	4.91	0.8	.358	.00102	1.1	-0.26	278	145	0.54
09BEN26-2r	.023	0.8	.464	0.6	4.74	0.4	.966	.00103	0.7	0.05	731	345	0.49
09BEN26-5c	.024	2.9	.283	0.6	4.87	0.5	.152	.00103	1.7	-0.28	117	34	0.30
09BEN26-7r	.451	0.9	.455	0.6	5.07	0.5	.156	.01751	0.7	0.01	124	57	0.48

Errors are 1σ unless otherwise specified

09BEN26

Spot Name	Ln UO/U	Ln Pb/U	Corr 206 /238	% err	ppm Rad 206Pb	Total 208Pb /232Th	% err	Age S-K comm Pb	C-Pb 206 /204	C-Pb 207 /206	C-Pb 208 /206	204corr 206Pb /238U Age	1σ err
09BEN26-1c	1.663	-3.605	.015	1.1	3.1	.0050	3.7	93	18.56	0.842	2.072	92.3	1.1
09BEN26-6r	1.650	-3.640	.014	0.9	4.7	.0055	4.0	93	18.56	0.842	2.072	92.2	0.9
09BEN26-9r	1.633	-3.648	.015	1.1	3.7	.0053	4.9	93	18.56	0.842	2.072	94.2	1.1
09BEN26-3c	1.653	-3.609	.015	0.9	5.3	.0048	2.8	94	18.56	0.842	2.072	94.1	0.8
09BEN26-4r	1.631	-3.645	.015	0.9	5.0	.0051	3.6	95	18.56	0.842	2.072	95.5	0.9
09BEN26-8r	1.627	-3.644	.015	1.2	3.1	.0053	8.1	96	18.56	0.842	2.072	95.3	1.1
09BEN26-10c	1.591	-3.707	.015	1.1	3.6	.0048	3.4	97	18.56	0.842	2.072	96.2	1.1
09BEN26-2r	1.555	-3.769	.015	0.7	9.6	.0048	2.7	97	18.56	0.842	2.072	97.3	0.7
09BEN26-5c	1.583	-3.692	.015	1.7	1.5	.0051	6.6	97	18.55	0.842	2.072	99.7	2.1
09BEN26-7r	1.624	-0.796	.259	0.7	27.6	.0745	1.5	1487	16.18	0.952	2.214	1487.0	9.9

Errors are 1σ unless otherwise specified

09BEN26

Spot Name	% Discordant	4corr 208r /232	% err	7corr 206Pbr /238U	1 σ err	8corr 206Pbr /238U
09BEN26-1c	-188	.0045	6.4	.0145	.0002	.0144
09BEN26-6r	-307	.0049	8.5	.0145	.0001	.0144
09BEN26-9r	339	.0067	14.5	.0146	.0002	.0145
09BEN26-3c	-179	.0045	3.8	.0148	.0001	.0147
09BEN26-4r	58	.0049	4.4	.0149	.0001	.0149
09BEN26-8r	-176	.0047	9.6	.0150	.0002	.0149
09BEN26-10c	-399	.0045	5.2	.0152	.0002	.0151
09BEN26-2r	20	.0048	2.6	.0152	.0001	.0152
09BEN26-5c	691	.0078	18.5	.0152	.0003	.0151
09BEN26-7r	0	.0745	1.4	.2594	.0021	.2599

Errors are 1 σ unless otherwise specified

09BEN26

----- 204 corrected -----

Spot Name	1σ err	Total			Total			238/ 206r			207r /206r			207r /235			206r /238			err corr		
		Total 238 /206	% err	Total 207 /206	% err	238/ 206r	% err	207r /206r	% err	207r /235	% err	206r /238	% err	err corr	% err	err corr						
09BEN26-1c	.0002	68.88	1.1	.0501	4.0	69.37	1.2	.0445	7.3	0.09	7.4	.0144	1.2	.0144	1.2	.158						
09BEN26-6r	.0001	69.17	0.9	.0458	3.6	69.45	1.0	.0426	6.2	0.08	6.2	.0144	1.0	.0144	1.0	.156						
09BEN26-9r	.0002	68.55	1.1	.0481	4.1	67.96	1.2	.0550	8.8	0.11	8.8	.0147	1.2	.0147	1.2	.137						
09BEN26-3c	.0001	67.78	0.9	.0474	3.2	68.01	0.9	.0447	4.7	0.09	4.7	.0147	0.9	.0147	0.9	.187						
09BEN26-4r	.0001	66.87	0.9	.0506	3.3	66.99	0.9	.0491	3.9	0.10	4.0	.0149	0.9	.0149	0.9	.226						
09BEN26-8r	.0002	66.81	1.2	.0482	4.4	67.11	1.2	.0447	6.2	0.09	6.3	.0149	1.2	.0149	1.2	.191						
09BEN26-10c	.0002	66.14	1.1	.0459	4.2	66.55	1.2	.0410	7.6	0.08	7.7	.0150	1.2	.0150	1.2	.150						
09BEN26-2r	.0001	65.74	0.7	.0484	3.0	65.74	0.7	.0484	3.0	0.10	3.0	.0152	0.7	.0152	0.7	.222						
09BEN26-5c	.0003	65.81	1.7	.0458	6.9	64.19	2.1	.0654	15.4	0.14	15.6	.0156	2.1	.0156	2.1	.136						
09BEN26-7r	.0021	3.85	0.7	.0930	1.1	3.85	0.7	.0930	1.1	3.33	1.3	.2594	0.7	.2594	0.7	.577						

Errors are 1σ unless otherwise specified

09BEN29

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
09BEN29-1c	13 Sep, 2009 04:23	17.51	0	0.16	3.4E-4	41	.049	2.7	.193	2.0
09BEN29-3r	13 Sep, 2009 04:56	18.06	0	0.11	2.5E-4	45	.048	2.7	.062	3.4
09BEN29-2r	13 Sep, 2009 04:40	17.78	0	0.28	5.7E-4	33	.055	2.5	.091	2.7
09BEN29-6r	13 Sep, 2009 06:04	19.19	0	-0.05	-1.1E-4	64	.048	2.9	.153	2.3
09BEN29-9c	13 Sep, 2009 07:11	20.31	0	0.06	1.9E-4	50	.048	3.3	.173	2.5
09BEN29-10r	13 Sep, 2009 07:28	20.58	0	0.04	1.9E-4	50	.050	3.7	.122	3.3
09BEN29-4r	13 Sep, 2009 05:13	18.34	0	-0.13	-6.0E-4	50	.052	3.9	.087	5.2
09BEN29-8r	13 Sep, 2009 06:38	19.75	0	0.05	1.6E-4	50	.047	3.3	.247	2.1
09BEN29-5c	13 Sep, 2009 05:47	18.90	0	0.03	6.2E-5	64	.047	2.7	.119	2.4
09BEN29-7r	13 Sep, 2009 06:21	19.47	0	0.12	1.8E-4	50	.047	2.3	.033	3.8

Errors are 1σ unless otherwise specified

09BEN29

Obs		206		248		254		238		Pb/U:		206		ppm		ppm		232Th	
Spot Name	/238	%	err	/254	%	err	%	err	/196	UO/U^2	%	err	%	U	Th	U	Th	/238U	
09BEN29-1c	.024	1.5	.544	.544	1.4	5.29	0.2	.907	.00084	0.7	0.24	739	409	739	409	739	409	0.57	
09BEN29-3r	.021	1.3	.171	.171	0.3	4.97	0.3	1.083	.00085	0.7	0.08	845	147	845	147	845	147	0.18	
09BEN29-2r	.020	1.9	.226	.226	0.3	4.77	0.4	1.116	.00087	0.7	0.98	849	195	849	195	849	195	0.24	
09BEN29-6r	.021	4.0	.454	.454	0.4	4.94	1.5	.861	.00086	0.8	0.04	670	309	670	309	670	309	0.48	
09BEN29-9c	.022	1.7	.505	.505	0.9	4.99	0.5	.711	.00087	0.9	0.03	557	286	557	286	557	286	0.53	
09BEN29-10r	.024	1.0	.347	.347	0.3	5.25	0.3	.461	.00088	1.0	0.24	373	132	373	132	373	132	0.36	
09BEN29-4r	.022	1.0	.244	.244	0.4	4.99	0.5	.428	.00088	1.1	0.57	335	83	335	83	335	83	0.26	
09BEN29-8r	.021	2.4	.707	.707	0.3	4.92	0.6	.677	.00088	0.9	-0.06	526	378	526	378	526	378	0.74	
09BEN29-5c	.023	0.7	.348	.348	0.2	5.05	0.3	.993	.00091	0.7	-0.14	784	277	784	277	784	277	0.37	
09BEN29-7r	.022	0.7	.084	.084	0.3	4.87	0.3	1.479	.00091	0.6	-0.04	1140	98	1140	98	1140	98	0.09	

Errors are 1σ unless otherwise specified

09BEN29

Age		204corr		206Pb		206Pb		206Pb		206Pb		206Pb		206Pb		206Pb		206Pb	
Spot Name	UO/U	Ln	Pb/U	Ln	err	%	err	ppm	Rad	206Pb	232Th	Total	Age	S-K	comm	Pb	206	204	206
09BEN29-1c	1.666	-3.747	.013	.013	0.7	7.9	.0042	2.5	80	18.58	0.841	2.071	79.7	0.6	0.6	0.6	0.6	0.6	0.6
09BEN29-3r	1.603	-3.866	.013	.013	0.7	9.2	.0044	3.5	81	18.58	0.841	2.071	80.6	0.6	0.6	0.6	0.6	0.6	0.6
09BEN29-2r	1.562	-3.930	.013	.013	0.7	9.4	.0049	2.8	82	18.58	0.841	2.071	81.6	0.6	0.6	0.6	0.6	0.6	0.6
09BEN29-6r	1.598	-3.846	.013	.013	0.8	7.4	.0041	2.5	82	18.58	0.841	2.071	82.0	0.6	0.6	0.6	0.6	0.6	0.6
09BEN29-9c	1.607	-3.830	.013	.013	0.9	6.2	.0042	2.8	83	18.58	0.841	2.071	82.5	0.7	0.7	0.7	0.7	0.7	0.7
09BEN29-10r	1.658	-3.728	.013	.013	1.0	4.2	.0044	3.5	83	18.58	0.841	2.071	82.9	0.8	0.8	0.8	0.8	0.8	0.8
09BEN29-4r	1.607	-3.820	.013	.013	1.1	3.8	.0044	5.3	83	18.58	0.841	2.071	84.6	1.0	1.0	1.0	1.0	1.0	1.0
09BEN29-8r	1.594	-3.845	.013	.013	0.9	5.9	.0044	2.3	84	18.58	0.841	2.071	83.6	0.7	0.7	0.7	0.7	0.7	0.7
09BEN29-5c	1.620	-3.767	.013	.013	0.7	9.0	.0044	2.5	86	18.57	0.841	2.071	85.9	0.6	0.6	0.6	0.6	0.6	0.6
09BEN29-7r	1.583	-3.840	.013	.013	0.6	13.2	.0049	3.8	86	18.57	0.841	2.071	86.0	0.5	0.5	0.5	0.5	0.5	0.5

Errors are 1 σ unless otherwise specified

09BEN29

Spot Name	SqIdNum	SqIdRej	207corr		SqIdEr	flags	208corr		204corr		204corr		208corr		204corr		204corr		208corr		204corr		204corr	
			206Pb	/238U			Age	1 σ err			Age	1 σ err			Age	1 σ err			Age	1 σ err			Age	1 σ err
09BEN29-1c	1	rej		80.0		1.2		0.6			79.7	0.7			-87	136			80				80	3
09BEN29-3r	2	rej		80.9		1.2		0.6			80.7	0.6			-76	116			75				75	7
09BEN29-2r	3			81.6		1.2		0.6			81.8	0.6			51	159			76				76	8
09BEN29-6r	4			81.8		1.3		0.6			81.8	0.7			179	82			85				85	3
09BEN29-9c	5			82.7		1.4		0.7			82.6	0.8			-50	114			81				81	3
09BEN29-10r	6			83.0		1.7		0.9			82.9	0.9			39	118			83				83	4
09BEN29-4r	7			83.2		1.8		0.9			83.4	0.9			638	169			113				113	13
09BEN29-8r	8			83.9		1.5		0.7			83.3	0.9			-63	107			86				86	2
09BEN29-5c	9	rej		86.4		1.2		0.6			85.8	0.6			-18	73			86				86	2
09BEN29-7r	10	rej		86.3		1.0		0.5			86.1	0.5			-67	93			78				78	11

Hi U

Errors are 1σ unless otherwise specified

09BEN29

Spot Name	% Discordant	4corr 208r /232	% err	7corr 206Pbr /238U	1 σ err	8corr 206Pbr /238U
09BEN29-1c	-209	.0039	3.7	.0125	.0001	.0124
09BEN29-3r	-195	.0037	8.9	.0126	.0001	.0126
09BEN29-2r	-37	.0038	10.9	.0127	.0001	.0128
09BEN29-6r	118	.0042	3.0	.0128	.0001	.0128
09BEN29-9c	-161	.0040	3.4	.0129	.0001	.0129
09BEN29-10r	-53	.0041	4.7	.0130	.0001	.0129
09BEN29-4r	655	.0056	11.9	.0130	.0001	.0130
09BEN29-8r	-175	.0042	2.6	.0131	.0001	.0130
09BEN29-5c	-121	.0043	2.8	.0134	.0001	.0134
09BEN29-7r	-178	.0039	14.1	.0135	.0001	.0134

Errors are 1 σ unless otherwise specified

09BEN29

----- 204 corrected -----

Spot Name	1 σ err	Total			238/ 206r			207r /206r			207r /235			206r /238			err corr		
		Total 238 /206	% err	Total 207 /206	% err	Total 238/ 206r	% err	207r /206r	% err	207r /235	% err	206r /238	% err	206r /238	% err	err corr			
09BEN29-1c	.0001	79.90	0.7	.0495	2.7	80.41	0.8	.0444	5.5	0.08	5.6	.0124	0.8	.0124	0.8	.137			
09BEN29-3r	.0001	79.15	0.7	.0483	2.7	79.52	0.8	.0446	4.7	0.08	4.8	.0126	0.8	.0126	0.8	.157			
09BEN29-2r	.0001	77.72	0.7	.0554	2.5	78.55	0.8	.0470	6.6	0.08	6.7	.0127	0.8	.0127	0.8	.116			
09BEN29-6r	.0001	78.24	0.8	.0480	2.9	78.07	0.8	.0497	3.5	0.09	3.6	.0128	0.8	.0128	0.8	.214			
09BEN29-9c	.0001	77.39	0.9	.0479	3.3	77.67	0.9	.0451	4.7	0.08	4.8	.0129	0.9	.0129	0.9	.183			
09BEN29-10r	.0001	77.00	1.0	.0495	3.7	77.27	1.0	.0468	4.9	0.08	5.0	.0129	1.0	.0129	1.0	.204			
09BEN29-4r	.0001	76.58	1.1	.0522	3.9	75.73	1.2	.0610	7.9	0.11	7.9	.0132	1.2	.0132	1.2	.151			
09BEN29-8r	.0001	76.39	0.9	.0472	3.3	76.62	0.9	.0449	4.4	0.08	4.5	.0131	0.9	.0131	0.9	.198			
09BEN29-5c	.0001	74.50	0.7	.0466	2.7	74.58	0.7	.0457	3.0	0.08	3.1	.0134	0.7	.0134	0.7	.226			
09BEN29-7r	.0001	74.20	0.6	.0475	2.3	74.45	0.6	.0448	3.8	0.08	3.9	.0134	0.6	.0134	0.6	.159			

Errors are 1σ unless otherwise specified

09BEN61

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
09BEN61-4r	12 Sep, 2009 18:15	7.37	0	0.00	---	0	.051	4.2	.189	3.2
09BEN61-5r	12 Sep, 2009 19:40	8.78	0	0.05	2.9E-4	66	.048	4.4	.248	2.9
09BEN61-1r	12 Sep, 2009 17:24	6.52	0	0.00	---	0	.051	4.3	.171	4.6
09BEN61-7r	12 Sep, 2009 19:06	8.22	0	0.04	3.8E-4	73	.049	5.6	.213	3.8
09BEN61-8r	12 Sep, 2009 19:23	8.50	0	0.11	6.4E-4	45	.047	4.5	.155	3.7
09BEN61-2r	12 Sep, 2009 17:41	6.80	0	0.11	1.2E-3	41	.047	6.3	.197	4.5
09BEN61-6c	12 Sep, 2009 18:49	7.94	0	0.11	5.8E-4	50	.046	4.3	.180	3.2
09BEN61-3r	12 Sep, 2009 17:58	7.08	0	0.00	---	0	.050	3.9	.263	2.5

Errors are 1σ unless otherwise specified

09BEN61

Spot Name	Obs 206 /238	% err	248 /254	% err	254 /238	% err	238 /196	Pb/U: UO/U^2	% err	% comm 206	ppm U	ppm Th	232Th /238U
09BEN61-4r	.021	2.4	.564	2.6	4.98	0.6	.350	.00084	1.2	0.49	274	157	0.59
09BEN61-5r	.024	1.1	.692	0.4	5.27	0.4	.296	.00086	1.2	0.07	240	169	0.73
09BEN61-1r	.022	1.1	.475	0.4	5.08	0.6	.315	.00087	1.2	0.46	250	121	0.50
09BEN61-7r	.022	1.4	.623	0.4	5.02	0.5	.230	.00087	1.5	0.14	181	115	0.65
09BEN61-8r	.021	1.6	.452	0.3	4.85	0.6	.361	.00088	1.2	-0.02	277	127	0.47
09BEN61-2r	.021	1.6	.540	1.4	4.87	0.5	.172	.00089	1.7	-0.04	133	73	0.57
09BEN61-6c	.022	1.1	.558	1.4	4.98	0.3	.393	.00090	1.1	-0.19	308	175	0.59
09BEN61-3r	.021	1.0	.769	0.8	4.84	0.4	.531	.00091	1.0	0.24	407	318	0.81

Errors are 1 σ unless otherwise specified

09BEN61

Spot Name	Ln UO/U	Ln Pb/U	Corr 206 /238	% err	ppm Rad 206Pb	Total 208Pb /232Th	% err	Age S-K comm Pb	C-Pb 206 /204	C-Pb 207 /206	C-Pb 208 /206	204corr 206Pb /238U Age	1 σ err
09BEN61-4r	1.605	-3.868	.012	1.2	2.9	.0040	4.3	80	18.58	0.841	2.071	80.1	0.9
09BEN61-5r	1.661	-3.739	.013	1.2	2.6	.0044	3.2	82	18.58	0.841	2.071	81.3	1.0
09BEN61-1r	1.626	-3.810	.013	1.2	2.8	.0044	4.8	82	18.58	0.841	2.071	82.5	1.0
09BEN61-7r	1.614	-3.827	.013	1.5	2.0	.0042	4.1	82	18.58	0.841	2.071	82.0	1.3
09BEN61-8r	1.578	-3.888	.013	1.2	3.1	.0042	3.9	84	18.58	0.841	2.071	82.5	1.1
09BEN61-2r	1.584	-3.875	.013	1.7	1.5	.0046	5.0	85	18.57	0.841	2.071	82.8	1.6
09BEN61-6c	1.606	-3.810	.013	1.1	3.5	.0041	3.6	86	18.57	0.841	2.071	84.7	1.0
09BEN61-3r	1.577	-3.851	.013	1.0	4.7	.0044	2.8	86	18.57	0.841	2.071	86.0	0.8

Errors are 1 σ unless otherwise specified

09BEN61

Spot Name	SqidNum	SqidRej	Age	1 σ err	SqidEr	flags	Age	1 σ err	204corr 207Pb /206Pb Age	1 σ err	204corr 208Pb /232Th Age	1 σ err
09BEN61-4r	4	rej	79.7	0.9	1.9	Hi 204	80.0	1.1	261	96	81	3
09BEN61-5r	2		81.7	1.0	2.0		81.0	1.1	-115	199	84	4
09BEN61-1r	3		82.1	1.0	2.0		82.0	1.1	253	99	89	4
09BEN61-7r	4		82.4	1.2	2.5		82.3	1.4	-164	289	79	5
09BEN61-8r	5		83.5	1.0	2.0		83.3	1.1	-485	336	72	7
09BEN61-2r	6		84.7	1.4	2.9		83.9	1.6			71	10
09BEN61-6c	7		85.8	1.0	2.0	discordant	85.9	1.1	-514	340	73	6
09BEN61-3r	8		85.8	0.9	1.7	Hi U	85.7	1.0	176	90	88	2

Errors are 1σ unless otherwise specified

09BEN61

Spot Name	% Discordant	4corr 208r /232	% err	7corr 206Pbr /238U	1 σ err	8corr 206Pbr /238U
09BEN61-4r	227	.0040	3.4	.0124	.0001	.0125
09BEN61-5r	-241	.0042	4.4	.0127	.0002	.0126
09BEN61-1r	206	.0044	4.8	.0128	.0002	.0128
09BEN61-7r	-300	.0039	6.8	.0129	.0002	.0129
09BEN61-8r	-687	.0036	9.3	.0130	.0002	.0130
09BEN61-2r		.0035	13.5	.0132	.0002	.0131
09BEN61-6c	-707	.0036	7.8	.0134	.0002	.0134
09BEN61-3r	105	.0044	2.6	.0134	.0001	.0134

Errors are 1σ unless otherwise specified

09BEN61

----- 204 corrected -----

Spot Name	1 σ err	Total 238 /206	% err	Total 207 /206	% err	238/ 206r	% err	207r /206r	% err	207r /235	% err	206r /238	% err	err corr
09BEN61-4r	.0002	80.00	1.2	.0515	4.2	80.00	1.2	.0515	4.2	0.09	4.3	.0125	1.2	.266
09BEN61-5r	.0002	78.39	1.2	.0482	4.4	78.81	1.2	.0439	8.1	0.08	8.2	.0127	1.2	.151
09BEN61-1r	.0002	77.63	1.2	.0513	4.3	77.63	1.2	.0513	4.3	0.09	4.4	.0129	1.2	.265
09BEN61-7r	.0002	77.59	1.5	.0488	5.6	78.15	1.6	.0431	11.6	0.08	11.7	.0128	1.6	.133
09BEN61-8r	.0002	76.72	1.2	.0475	4.5	77.64	1.3	.0380	12.6	0.07	12.7	.0129	1.3	.103
09BEN61-2r	.0003	75.62	1.7	.0474	6.3	77.35	1.9	.0293	27.8	0.05	27.9	.0129	1.9	.068
09BEN61-6c	.0002	74.82	1.1	.0462	4.3	75.63	1.2	.0376	12.7	0.07	12.8	.0132	1.2	.097
09BEN61-3r	.0002	74.48	1.0	.0496	3.9	74.48	1.0	.0496	3.9	0.09	4.0	.0134	1.0	.246

Errors are 1σ unless otherwise specified

09BEN63

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
09BEN63-6c	12 Sep, 2009 16:10	5.28	0	0.01	2.9E-5	99	.049	4.1	.072	4.7
09BEN63-1r	12 Sep, 2009 14:28	3.59	0	0.05	2.2E-4	50	.048	4.1	.056	5.3
09BEN63-7r	12 Sep, 2009 16:27	5.56	0	0.08	4.4E-4	50	.050	4.4	.166	3.5
09BEN63-8r	12 Sep, 2009 16:43	5.84	0	0.05	6.0E-4	50	.051	6.1	.111	5.9
09BEN63-5r	12 Sep, 2009 15:53	5.00	0	0.07	3.1E-4	68	.048	3.8	.125	3.4
09BEN63-2c	12 Sep, 2009 14:45	3.87	0	0.12	1.1E-3	50	.049	6.0	.180	4.2
09BEN63-3c	12 Sep, 2009 15:02	4.14	0	0.06	2.2E-4	45	.049	3.7	.174	2.9
09BEN63-4r	12 Sep, 2009 15:18	4.43	0	0.12	3.3E-4	45	.052	2.9	.061	3.8

Errors are 1σ unless otherwise specified

09BEN63

Spot Name	Obs 206 /238	% err	248 /254	% err	254 /238	% err	238 /196	Pb/U: UO/U^2	% err	% comm 206	ppm U	ppm Th	232Th /238U
09BEN63-6c	.023	1.0	.184	0.8	5.10	0.4	.420	.00087	1.1	0.14	334	62	0.19
09BEN63-1r	.023	1.0	.144	0.8	5.19	0.3	.365	.00087	1.1	0.07	293	43	0.15
09BEN63-7r	.021	1.7	.431	0.3	4.89	0.5	.377	.00088	1.2	0.32	291	128	0.45
09BEN63-8r	.017	1.6	.282	0.6	4.33	0.7	.243	.00089	1.6	0.45	173	50	0.30
09BEN63-5r	.022	1.8	.368	3.3	4.98	0.4	.492	.00090	1.0	0.07	384	144	0.39
09BEN63-2c	.021	1.4	.531	1.4	4.84	0.4	.226	.00090	1.5	0.15	174	94	0.56
09BEN63-3c	.021	0.9	.478	5.3	4.82	0.3	.508	.00091	1.0	0.12	389	189	0.50
09BEN63-4r	.021	1.3	.164	1.2	4.75	0.3	.713	.00092	0.8	0.50	541	90	0.17

Errors are 1 σ unless otherwise specified

09BEN63

Spot Name	Ln UO/U	Ln Pb/U	Corr 206 /238	% err	ppm Rad 206Pb	Total 208Pb /232Th	% err	Age S-K comm Pb	C-Pb 206 /204	C-Pb 207 /206	C-Pb 208 /206	204corr 206Pb /238U Age	1 σ err
09BEN63-6c	1.630	-3.781	.013	1.1	3.7	.0048	4.9	83	18.58	0.841	2.071	82.9	0.9
09BEN63-1r	1.647	-3.755	.013	1.1	3.3	.0048	5.4	83	18.58	0.841	2.071	82.7	0.9
09BEN63-7r	1.588	-3.863	.013	1.2	3.3	.0048	3.7	83	18.58	0.841	2.071	83.1	1.0
09BEN63-8r	1.466	-4.107	.013	1.6	2.0	.0049	6.1	84	18.58	0.841	2.071	83.1	1.4
09BEN63-5r	1.604	-3.812	.013	1.0	4.4	.0043	4.8	85	18.57	0.841	2.071	84.6	0.9
09BEN63-2c	1.577	-3.879	.013	1.5	2.0	.0043	4.6	85	18.57	0.841	2.071	83.7	1.5
09BEN63-3c	1.572	-3.852	.014	1.0	4.5	.0047	6.1	87	18.57	0.841	2.071	86.3	0.8
09BEN63-4r	1.557	-3.884	.014	0.8	6.3	.0048	4.0	87	18.57	0.841	2.071	86.5	0.7

Errors are 1 σ unless otherwise specified

09BEN63

Spot Name	SqidNum	SqidRej	207corr 206Pb /238U Age	1 σ err	SqidEr	flags	208corr 206Pb /238U Age	1 σ err	204corr 207Pb /206Pb Age	1 σ err	204corr 208Pb /232Th Age	1 σ err
09BEN63-6c	1		82.9	0.9	1.8		82.5	0.9	116	100	96	5
09BEN63-1r	2		82.9	0.9	1.9		82.7	0.9	-56	140	82	9
09BEN63-7r	3		83.5	1.0	2.0		82.8	1.1	-123	223	87	6
09BEN63-8r	4		83.6	1.4	2.8		83.3	1.4	-204	324	79	11
09BEN63-5r	5		85.1	0.9	1.8		85.0	0.9	-125	203	78	6
09BEN63-2c	6		85.3	1.3	2.6		85.3	1.4	-916	794	67	11
09BEN63-3c	7		86.6	0.9	1.7		86.0	1.0	-31	123	90	3
09BEN63-4r	8		86.6	0.7	1.4	Hi U	86.8	0.7	42	135	77	9

Errors are 1 σ unless otherwise specified

09BEN63

Spot Name	% Discordant	4corr 208r /232	% err	7corr 206Pbr /238U	1 σ err	8corr 206Pbr /238U	1 σ err
09BEN63-6c	39	.0048	5.1	.0129	.0001	.0129	.0001
09BEN63-1r	-168	.0041	10.4	.0129	.0001	.0129	.0001
09BEN63-7r	-248	.0043	6.8	.0130	.0002	.0129	.0002
09BEN63-8r	-346	.0039	14.4	.0131	.0002	.0130	.0002
09BEN63-5r	-248	.0039	8.0	.0133	.0001	.0133	.0001
09BEN63-2c	-1194	.0033	15.9	.0133	.0002	.0133	.0002
09BEN63-3c	-136	.0045	3.8	.0135	.0001	.0134	.0002
09BEN63-4r	-52	.0038	12.3	.0135	.0001	.0136	.0001

Errors are 1 σ unless otherwise specified

09BEN63

09BEN63

204 corrected

Spot Name	Total			238/206r			207r/206r			207r/235			206r/238			err	
	Total 238 /206	% err	Total 207 /206	% err	238/ 206r	% err	207r /206r	% err	207r /235	% err	206r /238	% err	err corr				
09BEN63-6c	77.18	1.1	.0488	4.1	77.22	1.1	.0483	4.2	0.09	4.4	.0129	1.1	.249				
09BEN63-1r	77.17	1.1	.0482	4.1	77.49	1.1	.0450	5.7	0.08	5.8	.0129	1.1	.192				
09BEN63-7r	76.47	1.2	.0503	4.4	77.10	1.3	.0438	9.0	0.08	9.1	.0130	1.3	.137				
09BEN63-8r	76.25	1.6	.0513	6.1	77.11	1.7	.0424	12.9	0.08	13.0	.0130	1.7	.131				
09BEN63-5r	75.24	1.0	.0483	3.8	75.67	1.1	.0437	8.2	0.08	8.3	.0132	1.1	.130				
09BEN63-2c	74.97	1.5	.0489	6.0	76.52	1.8	.0325	27.3	0.06	27.3	.0131	1.8	.065				
09BEN63-3c	73.86	1.0	.0487	3.7	74.16	1.0	.0455	5.1	0.08	5.2	.0135	1.0	.192				
09BEN63-4r	73.54	0.8	.0517	2.9	73.99	0.8	.0469	5.7	0.09	5.7	.0135	0.8	.147				

Errors are 1σ unless otherwise specified

09BEN73

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
09BEN73-5r	12 Sep, 2009 12:50	1.96	0	0.09	2.0E-4	50	.048	2.7	.225	1.8
09BEN73-1r	12 Sep, 2009 11:22	0.48	0	-0.03	-1.1E-4	68	.051	3.7	.232	3.5
09BEN73-8r	12 Sep, 2009 13:41	2.80	0	0.24	5.6E-4	35	.052	2.7	.253	2.0
09BEN73-4r	12 Sep, 2009 12:12	1.31	0	0.03	1.0E-4	64	.047	3.4	.330	1.9
09BEN73-2r	12 Sep, 2009 11:38	0.75	0	0.00	---	0	.047	3.7	.187	2.8
09BEN73-7r	12 Sep, 2009 13:23	2.51	0	-0.03	-3.4E-5	99	.049	2.1	.360	1.2
09BEN73-6r	12 Sep, 2009 13:07	2.23	0	0.12	1.9E-4	41	.049	2.3	.248	1.5
09BEN73-3c	12 Sep, 2009 11:55	1.04	0	-0.03	-4.3E-5	50	.048	2.4	.276	1.5

Errors are 1σ unless otherwise specified

09BEN73

Spot Name	Obs 206 /238	% err	248 /254	% err	254 /238	% err	238 /196	Pb/U: UO/U^2	% err	% comm 206	ppm U	ppm Th	232Th /238U
09BEN73-5r	.027	1.2	.663	0.3	5.21	0.3	.776	.00098	0.7	0.06	625	421	0.70
09BEN73-1r	.026	1.8	.648	0.3	5.11	0.3	.405	.00100	1.0	0.33	322	212	0.68
09BEN73-8r	.026	1.9	.721	0.6	5.07	0.4	.723	.00100	0.8	0.57	572	419	0.76
09BEN73-4r	.024	1.9	1.007	0.5	4.88	0.5	.563	.00101	0.9	-0.15	435	445	1.06
09BEN73-2r	.024	2.5	.560	0.6	4.82	0.7	.484	.00102	1.0	-0.11	370	211	0.59
09BEN73-7r	.027	0.8	1.069	0.3	5.10	0.6	1.281	.00102	0.6	0.14	1018	1105	1.12
09BEN73-6r	.026	1.4	.731	0.4	5.00	0.4	1.129	.00103	0.6	0.11	885	657	0.77
09BEN73-3c	.025	2.4	.835	0.2	4.87	0.5	1.108	.00104	0.6	0.06	854	725	0.88

Errors are 1 σ unless otherwise specified

09BEN73

Spot Name	Ln UO/U	Ln Pb/U	Corr 206 /238	% err	ppm Rad 206Pb	Total 208Pb /232Th	% err	Age S-K comm Pb	C-Pb 206 /204	C-Pb 207 /206	C-Pb 208 /206	204corr 206Pb /238U Age	1 σ err
09BEN73-5r	1.650	-3.628	.015	0.7	7.8	.0047	2.0	93	18.56	0.842	2.072	92.8	0.7
09BEN73-1r	1.631	-3.646	.015	1.0	4.1	.0050	3.6	94	18.56	0.842	2.072	94.6	0.9
09BEN73-8r	1.623	-3.667	.015	0.8	7.3	.0050	2.3	95	18.56	0.842	2.072	94.2	0.8
09BEN73-4r	1.585	-3.720	.015	0.9	5.6	.0047	2.2	96	18.56	0.842	2.072	96.0	0.9
09BEN73-2r	1.572	-3.741	.015	1.0	4.8	.0048	3.1	97	18.56	0.842	2.072	96.4	0.9
09BEN73-7r	1.629	-3.628	.015	0.6	13.2	.0049	1.4	97	18.56	0.842	2.072	96.9	0.6
09BEN73-6r	1.609	-3.662	.015	0.6	11.6	.0049	1.7	97	18.56	0.842	2.072	97.1	0.6
09BEN73-3c	1.583	-3.697	.015	0.6	11.3	.0049	1.6	98	18.55	0.842	2.072	98.6	0.6

Errors are 1 σ unless otherwise specified

09BEN73

Spot Name	SqidNum	SqidRej	207corr 206Pb /238U Age	1 σ err	SqidEr	flags	208corr 206Pb /238U Age	1 σ err	204corr 207Pb /206Pb Age	1 σ err	204corr 208Pb /232Th Age	1 σ err
09BEN73-5r	4		93.1	0.7	1.4		93.0	0.8	-36	106	92	2
09BEN73-1r	2		94.1	1.0	1.9		93.7	1.1	290	94	103	4
09BEN73-8r	3		94.6	0.7	1.5	Hi 204	94.5	0.9	-106	185	92	4
09BEN73-4r	4		96.3	0.9	1.8		96.5	1.1	-43	100	93	2
09BEN73-2r	5		96.6	1.0	1.9		96.4	1.1	53	87	96	3
09BEN73-7r	6		96.7	0.6	1.1		96.6	0.7	174	54	98	1
09BEN73-6r	7		97.3	0.6	1.2		97.2	0.7	0	83	96	2
09BEN73-3c	8		98.5	0.6	1.3		98.6	0.8	151	57	98	2

Errors are 1 σ unless otherwise specified

09BEN73

Spot Name	% Discordant	4corr 208r /232	% err	7corr 206Pbr /238U	1 σ err	8corr 206Pbr /238U	1 σ err
09BEN73-5r	-139	.0045	2.7	.0146	.0001	.0145	.0001
09BEN73-1r	206	.0051	3.8	.0147	.0002	.0146	.0002
09BEN73-8r	-213	.0046	4.0	.0148	.0001	.0148	.0001
09BEN73-4r	-145	.0046	2.3	.0151	.0001	.0151	.0002
09BEN73-2r	-45	.0048	3.0	.0151	.0002	.0151	.0002
09BEN73-7r	79	.0049	1.4	.0151	.0001	.0151	.0001
09BEN73-6r	-100	.0048	2.0	.0152	.0001	.0152	.0001
09BEN73-3c	53	.0049	1.7	.0154	.0001	.0154	.0001

Errors are 1 σ unless otherwise specified

09BEN73

----- 204 corrected -----

Spot Name	Total				238/206r				207r/206r				207r/235				206r/238				err	
	238 /206	% err	207 /206	% err	238/ 206r	% err	207r /206r	% err	207r /235	% err	206r /238	% err	err	corr								
09BEN73-5r	68.69	0.7	.0483	2.7	68.94	0.8	.0454	4.4	0.09	4.4	.0145	0.8	.170									
09BEN73-1r	67.75	1.0	.0505	3.7	67.62	1.0	.0521	4.1	0.11	4.2	.0148	1.0	.238									
09BEN73-8r	67.24	0.8	.0524	2.7	67.95	0.9	.0441	7.5	0.09	7.6	.0147	0.9	.113									
09BEN73-4r	66.54	0.9	.0467	3.4	66.67	0.9	.0452	4.1	0.09	4.2	.0150	0.9	.215									
09BEN73-2r	66.34	1.0	.0471	3.7	66.34	1.0	.0471	3.7	0.10	3.8	.0151	1.0	.257									
09BEN73-7r	66.08	0.6	.0490	2.1	66.04	0.6	.0495	2.3	0.10	2.4	.0151	0.6	.241									
09BEN73-6r	65.69	0.6	.0488	2.3	65.92	0.6	.0460	3.4	0.10	3.5	.0152	0.6	.179									
09BEN73-3c	64.93	0.6	.0484	2.4	64.88	0.6	.0491	2.4	0.10	2.5	.0154	0.6	.254									

Errors are 1 σ unless otherwise specified

R33

Spot Name	Date/Time	Hours	Pb/U const #rej	204 cts /sec	204 /206	% err	207 /206	% err	208 /206	% err
R33-1	12 Sep, 2009 10:53	0.00	0	0.04	1.5E-4	50	.055	3.2	.165	2.7
R33-2	12 Sep, 2009 12:28	1.59	0	0.00	---	0	.055	3.4	.119	3.3
R33-3	12 Sep, 2009 13:58	3.08	0	0.15	4.4E-4	41	.057	2.9	.219	2.2
R33-4	12 Sep, 2009 15:36	4.72	0	0.08	2.3E-4	88	.057	3.1	.210	2.2
R33-5	12 Sep, 2009 17:00	6.12	0	0.00	---	0	.053	3.0	.235	2.1
R33-6	12 Sep, 2009 18:32	7.65	0	0.08	4.0E-4	50	.057	4.0	.149	3.5
R33-7	12 Sep, 2009 19:57	9.06	0	0.00	---	0	.057	2.8	.207	2.1
R33-8	12 Sep, 2009 21:30	10.62	0	0.00	---	0	.054	2.3	.204	1.8
R33-9	12 Sep, 2009 22:53	12.00	0	0.00	---	0	.056	2.9	.234	2.1
R33-10	13 Sep, 2009 01:17	14.40	0	0.00	---	0	.055	2.6	.219	1.9
R33-11	13 Sep, 2009 02:42	15.82	0	-0.12	-2.4E-4	50	.056	2.4	.229	1.7
R33-12	13 Sep, 2009 04:07	17.23	0	0.16	3.4E-4	41	.055	2.6	.261	1.7
R33-13	13 Sep, 2009 05:30	18.62	0	0.14	5.5E-4	45	.055	3.5	.139	3.1
R33-14	13 Sep, 2009 06:55	20.03	0	0.03	9.4E-5	65	.056	3.0	.139	2.7

Errors are 1σ unless otherwise specified

R33

Spot Name	Obs		248		254		238		238		SqIdNum		SqIdRej	
	/238	% err	/254	% err	/238	% err	/196	% err	/196	% err				
R33-1	.112	1.0	.497	0.5	4.89	0.6	.110	0.6	.110	0.6	4		rej	
R33-2	.106	1.7	.344	0.6	4.74	0.6	.106	0.6	.106	0.6	2		rej	
R33-3	.105	1.2	.646	0.4	4.84	0.5	.144	0.5	.144	0.5	3			
R33-4	.118	0.9	.620	0.5	5.12	0.9	.124	0.9	.124	0.9	4			
R33-5	.115	1.0	.689	0.5	5.08	0.5	.145	0.5	.145	0.5	5			
R33-6	.107	1.7	.429	0.7	4.88	0.7	.082	0.7	.082	0.7	6			
R33-7	.106	1.6	.633	0.9	4.86	0.5	.171	0.5	.171	0.5	7			
R33-8	.110	1.1	.636	0.4	4.93	0.5	.234	0.5	.234	0.5	8			
R33-9	.108	2.2	.710	0.4	4.87	0.5	.164	0.5	.164	0.5	9			
R33-10	.102	2.4	.653	0.4	4.66	0.8	.177	0.8	.177	0.8	10			
R33-11	.112	1.4	.692	0.4	4.91	0.4	.202	0.4	.202	0.4	11			
R33-12	.097	3.0	.822	0.4	4.69	0.7	.196	0.7	.196	0.7	42		rej	
R33-13	.117	1.1	.402	0.6	5.11	0.6	.098	0.6	.098	0.6	13			
R33-14	.112	2.4	.415	0.5	4.91	0.5	.127	0.5	.127	0.5	14			

Errors are 1σ unless otherwise specified

R33

Spot Name	207-corr Pb/U: UO/U^2	SqidEr	% err	Age Ma	±		% comm 206	ppm U	ppm Th	232Th /238U
R33-1	.00469	.00011	1.1	433	5	9.6	0.27	85	43	0.52
R33-2	.00470	.00011	1.2	434	5	10.1	0.00	81	28	0.36
R33-3	.00447	.00009	1.0	414	4	8.4	0.80	111	73	0.68
R33-4	.00450	.00010	1.1	416	4	8.7	0.42	98	62	0.65
R33-5	.00447	.00009	1.0	413	4	8.3	0.00	115	81	0.72
R33-6	.00450	.00013	1.4	416	6	11.5	0.71	64	28	0.45
R33-7	.00448	.00009	1.0	415	4	8.1	0.00	132	85	0.67
R33-8	.00455	.00008	0.8	421	3	6.8	0.00	182	118	0.67
R33-9	.00452	.00009	1.0	418	4	8.3	0.00	126	91	0.75
R33-10	.00467	.00014	1.5	432	6	12.5	0.00	132	88	0.69
R33-11	.00461	.00008	0.9	426	4	7.2	-0.43	157	110	0.73
R33-12	.00437	.00008	0.9	404	4	7.1	0.62	147	123	0.86
R33-13	.00449	.00011	1.2	415	5	10.0	0.98	78	32	0.42
R33-14	.00463	.00010	1.1	428	5	9.0	0.17	98	41	0.44

Errors are 1 σ unless otherwise specified

R33

Spot Name	Ln		Ln Pb/U	204 overcts /sec (fr. 207)		204 overcts /sec (fr. 208)		208Pb* /206Pb* (fr. 207)	204 /206 (fr. 208)	7-corr		8-corr		4-corr	
	UO/U									Pb/U: UO/U ²	delta%	Pb/U: UO/U ²	delta%	Uncorr Pb/U: UO/U ²	age /206
R33-1	1.587	-2.193		+0.05	+0.03			0.163	-8.6E-6	6.5E-5	+0.29%	+0.15%	.00469	322.2	89.7
R33-2	1.557	-2.245		+0.01	-0.05			0.113	-4.5E-5	1.8E-4	+0.08%	-0.33%	.00470	392.3	76.5
R33-3	1.577	-2.259		+0.12	+0.08			0.212	1.0E-4	2.2E-4	+0.61%	+0.40%	.00448	204.9	145.1
R33-4	1.633	-2.142		+0.04	+0.01			0.203	1.1E-4	2.1E-4	+0.21%	+0.04%	.00450	348.6	145.9
R33-5	1.625	-2.163		+0.05	-0.10			0.226	-1.5E-4	2.6E-4	+0.27%	-0.47%	.00445	327.6	67.1
R33-6	1.584	-2.238		+0.05	+0.03			0.140	1.1E-4	2.4E-4	+0.52%	+0.29%	.00450	239.1	167.3
R33-7	1.581	-2.243		-0.04	+0.00			0.207	1.1E-4	-3.2E-6	-0.20%	+0.01%	.00449	483.5	61.7
R33-8	1.595	-2.203		+0.04	+0.06			0.208	-6.5E-5	-1.1E-4	+0.12%	+0.20%	.00454	380.0	52.4
R33-9	1.583	-2.229		-0.02	-0.02			0.232	4.4E-5	4.8E-5	-0.08%	-0.09%	.00452	444.9	64.0
R33-10	1.539	-2.283		+0.00	-0.06			0.214	-7.0E-6	1.5E-4	+0.01%	-0.26%	.00467	414.8	58.5
R33-11	1.592	-2.189		-0.17	-0.16			0.227	8.1E-5	6.5E-5	-0.57%	-0.55%	.00462	596.8	79.4
R33-12	1.546	-2.341		+0.15	+0.27			0.269	1.6E-5	-2.5E-4	+0.59%	+1.08%	.00437	212.7	115.6
R33-13	1.632	-2.153		+0.14	+0.09			0.132	2.5E-6	1.9E-4	+0.99%	+0.64%	.00449	57.7	208.0
R33-14	1.591	-2.193		+0.01	+0.00			0.136	5.4E-5	8.3E-5	+0.07%	+0.02%	.00463	394.7	78.2

	Unnormalized Major Elements (Weight %):							
	Kb-pegmatite	Kb-af	Kb-mo	Kb-ga	Kb-af	Kwc	PzPh	Ocs
	BEN20	BEN26	BEN29	BEN61	BEN63	BEN73b	BEN13	BEN76
SiO₂	73.91	71.47	71.49	59.84	69.84	65.76	67.99	54.23
TiO₂	0.109	0.410	0.377	1.412	0.416	0.360	0.993	0.843
Al₂O₃	14.17	14.43	14.68	17.60	15.61	16.00	14.48	19.21
FeO*	0.53	1.78	1.99	5.39	2.47	2.66	6.95	8.46
MnO	0.015	0.022	0.044	0.078	0.049	0.077	0.104	0.121
MgO	0.22	0.31	0.52	1.57	0.58	0.74	2.76	5.33
CaO	1.79	1.06	1.88	4.35	1.68	2.24	0.39	1.11
Na₂O	3.38	2.92	3.56	4.14	3.95	4.60	0.24	1.77
K₂O	4.02	6.17	4.41	3.81	3.73	5.31	3.09	3.60
P₂O₅	0.123	0.115	0.108	0.597	0.203	0.133	0.184	0.149
Sum	98.26	98.68	99.07	98.78	98.52	97.89	97.19	94.81

[illegible]

		Kb- pegmatite	Kb-af	Kb-mo	Kb-ga	Kb-af	Kwc	PzPh	Ocs
		BEN20	BEN26	BEN29	BEN61	BEN63	BEN73b	BEN13	BEN76
Unnormalized Trace Elements (ppm):	Ni	6	5	4	7	3	8	57	104
	Cr	27	18	18	13	12	18	116	144
	Sc	2	2	4	7	5	3	18	24
	V	4	9	18	51	22	36	145	144
	Ba	231	1062	1034	3055	863	1237	502	595
	Rb	185	296	196	106	260	254	167	146
	Sr	109	275	428	1604	401	876	25	92
	Zr	124	305	195	474	205	308	289	168
	Y	6	9	18	19	27	23	43	30
	Nb	7.6	13.2	12.9	24.7	21.5	30.0	16.7	13.1
	Ga	20	22	20	23	30	21	20	25
	Cu	11	4	2	6	1	3	18	77
	Zn	20	57	46	123	91	47	123	125
	Pb	31	50	38	25	28	29	6	12
	La	8	109	53	134	80	94	45	33
	Ce	8	201	96	271	149	168	92	70
	Th	4	77	29	21	31	58	14	11
	Nd	4	65	37	100	53	57	40	30
	U	3	5	6	4	5	5	5	2
	Cs	10	6	5	4	5	8	18	6
	sum tr.	834	2612	2290	6114	2343	3335	1819	1893
	in %	0	0	0	1	0	0	0.18	0
	sum m+tr	98	99	99	99	99	98	97.37	95
	M+Toxides	98.36	98.99	99.34	99.49	98.79	98.27	97.41	95.04

Major elements are normalized on a volatile-free basis, with total Fe expressed as FeO:

	Kb- pegmatite	Kb-af	Kb-mo	Kb-ga	Kb-af	Kwc	PzPh	Ocs
	BEN20	BEN26	BEN29	BEN61	BEN63	BEN73b	BEN13	BEN76
NiO	7.0	6.1	5.0	9.3	3.8	9.8	72.7	132.2
Cr₂O₃	39.9	25.9	25.7	18.7	18.0	26.6	169.4	211.1
Sc₂O₃	3.7	3.2	6.6	10.1	7.1	4.3	26.8	36.7
V₂O₃	5.1	13.8	25.7	74.4	32.8	52.4	213.6	211.3
BaO	257.4	1185.9	1154.2	3411.1	963.1	1381.2	560.1	664.8
Rb₂O	202.0	323.9	213.9	115.6	284.8	277.4	182.8	159.1
SrO	129.0	325.6	506.6	1897.4	474.6	1036.2	29.3	108.4
ZrO₂	167.9	412.4	262.9	640.7	277.2	415.9	390.8	226.7
Y₂O₃	8.0	11.7	23.2	23.6	34.5	28.6	54.1	37.8
Nb₂O₅	10.9	18.9	18.5	35.3	30.8	42.9	23.9	18.7
Ga₂O₃	27.2	29.6	26.6	31.1	40.3	28.0	26.3	33.2
CuO	14.0	4.9	2.0	7.1	0.9	3.6	23.0	96.1
ZnO	25.3	70.9	57.1	153.9	114.1	59.2	153.7	156.9
PbO	33.2	53.4	41.4	27.4	30.2	30.8	6.9	12.9
La₂O₃	9.7	127.7	62.3	157.4	94.2	110.6	52.7	38.8
CeO₂	9.7	246.6	118.1	332.8	183.4	206.5	113.1	85.7
ThO₂	4.4	84.6	31.9	23.3	34.6	64.4	15.4	12.6
Nd₂O₃	4.4	75.5	43.0	117.0	62.3	66.4	46.9	35.0
U₂O₃	3.0	5.8	7.0	4.4	5.7	5.4	5.6	2.1
Cs₂O	10.7	6.3	5.3	3.7	4.9	8.8	19.5	6.6
As₂O₅	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W₂O₃	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sum tr.	972	3033	2637	7094	2697	3859	2187	2287
in %	0.10	0.30	0.26	0.71	0.27	0.39	0.22	0.23

Plate 1: Geologic Map of SE Bendeleben Mountains, northern Bendeleben (A-2) quadrangle, Seward Peninsula, Alaska

Dan Harris, Jaime Toro, Kalin McDannell
West Virginia University, 2010

Cretaceous intrusions

- Kwc** - Windy Creek pluton - Alkali-feldspar granite. Mostly perthitic feldspar with some quartz. Minor amounts of biotite, garnet, sphene, apatite, plagioclase, chlorite and zircon.
- Kb-af** - Bendeleben pluton - Granodiorite. High plagioclase content with commonly zoned albite twins. Subequal feldspar and quartz content. Biotite also common with accessory sphene, zircon, apatite and muscovite.
- Kb-gr** - Bendeleben pluton - Gabbro. Almost entirely plagioclase and biotite. Minor amounts of quartz, sphene, epidote, hornblende and apatite.
- Kb-ga** - Bendeleben pluton - Monzogranite. High feldspar content. Subequal plagioclase and quartz content. Minor amounts of biotite, muscovite, zircon, sphene and apatite.
- Kb-mo** - Bendeleben pluton - Monzogranite. High feldspar content. Subequal plagioclase and quartz content. Minor amounts of biotite, muscovite, zircon, sphene and apatite.

- Qs** - Quaternary surficial cover
- myl** - Mylonite - Mostly rubble, in-place outcrop difficult to find.
- PzPh** - Biotite-garnet schist - Coarse garnet common. Also contains biotite, feldspar, plagioclase, sillimanite, cordierite, chlorite, muscovite, apatite and zircon. Often displays top-down shear.
- PzPm** - Marble - Well foliated, coarse, gray colored, crumbly marble. Contains diopside.
- DOxm** - Vein-rich quartzite - Black, hard quartzite. Contains very high quartz vein content.
- DOx** - Graphitic quartzite - Black, metasilicious, hard crystalline quartzite.
- Ocs** - Muscovite-chlorite schist - Rich in muscovite and quartz. Also contains albite, epidote, chlorite and biotite. Shiny texture, often crenulated.
- DOxm** - Marble - Strong marble unit composed of millimeter-sized grains. Sugary texture common. Minor amounts of diopside.

Gravity Modelling and Cross Section

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References: Till, A.B., Dumoulin, J.A., Gamble, B.M., Kaufman, D.S., and Carroll, P.I., 1986, Preliminary Geologic Map and Fossil Data, Solomon, Bendeleben, and Southern Kotzebue Quadrangles, Seward Peninsula, Alaska, United States Department of the Interior Geological Survey, p. 9.

Mapping performed by Harris, Toro and McDannell in 2009
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Topography contours calculated from the National Elevation Dataset (NED) clipped to the Seward Peninsula
Geology modified from Till, et al., 1986.
Projection: Transverse Mercator, zone 3N, 1927 North American Datum