

STATE OF FLORIDA

FLORIDA GEOLOGICAL SURVEY
Guy H. Means, *State Geologist and Director*



REPORT OF INVESTIGATION 123

Geologic Mapping in the Trail Ridge Placers, Florida Focus Area

By

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ACRONYMS AND ABBREVIATIONS

<i>Abbreviation</i>	Definition	<i>Abbreviation</i>	Definition
*	used as a special notation	<i>Ilm</i>	ilmenite
<i>*ilmenite</i>	ilmenite + Ti-silicate	<i>J</i>	joule
<i>*leucoxene</i>	altered ilmenite	<i>keV</i>	kiloelectron volt
<i>*rutile</i>	rutile + ilmenorutile + pseudorutile	<i>Ky</i>	kyanite
<i>Amp</i>	amphibole	<i>L</i>	liter
<i>3D</i>	three-dimension	<i>LA-ICP-MS</i>	Laser Ablation- Inductively Coupled Plasma -Mass Spectroscopy
<i>BLS</i>	below land surface	<i>lidar</i>	Light Detection and Ranging
<i>BSE</i>	backscattered electron	<i>LREE</i>	light rare earth element(s)
<i>cm</i>	centimeter	<i>Ma</i>	mega annum
<i>DEM</i>	Digital Elevation Model	<i>min</i>	minute
<i>DPT</i>	direct push technology	<i>mJ</i>	millijoule
<i>Earth-MRI</i>	Earth Mapping Resources Initiative	<i>mL</i>	milliliter
<i>EDX</i>	Energy Dispersive X-Ray	<i>mm</i>	millimeter
<i>EHM</i>	economic heavy mineral	<i>Mnz</i>	monazite
<i>EMRI-FFA</i>	Earth Mapping Resources Initiative Trail Ridge Placers, Florida Focus Area	<i>MSL</i>	mean sea level
<i>eTh</i>	Equivalent thorium	<i>nA</i>	nanoampere
<i>FC-1</i>	Fish Canyon Tuff reference material	<i>NCGMP</i>	National Cooperative Geologic Mapping Program
<i>FGS</i>	Florida Geological Survey	<i>NURE</i>	National Uranium Resource Evaluation
<i>Fsp</i>	feldspar	<i>ppm</i>	parts per million
<i>GeMs</i>	Geologic Mapping Schema	<i>PVC</i>	polyvinylchloride
<i>GEODES</i>	Geologic Data Enterprise System	<i>Px</i>	pyroxene
<i>Grt</i>	garnet	<i>Qbd</i>	Quaternary beach ridge and dune sediments
<i>HREE</i>	heavy rare earth element(s)	<i>Qtz</i>	quartz
<i>Hz</i>	hertz	<i>Qu</i>	Quaternary undifferentiated sediments
<i>ICP-OES-MS</i>	Inductively Coupled Plasma-Optical Emission Spectroscopy-Mass Spectroscopy	<i>REE</i>	rare earth element(s)
<i>ID-TIMS</i>	Isotope Dilution-Thermal Ionization Mass Spectrometry	<i>Rt</i>	rutile

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ABBREVIATIONS (CONTINUED)

<i>Abbreviation</i>	<i>Definition</i>
<i>SCF</i>	Florida Geologic Sample Collections Facility
<i>sec</i>	second
<i>SPT</i>	Standard Penetration Test Samples
<i>St</i>	Staurolite
<i>Tap</i>	Avon Park Formation
<i>Thc</i>	Coosawhatchie Formation, Hawthorn Group
<i>Thcc</i>	Charlton Member, Coosawhatchie Formation, Hawthorn Group
<i>THM</i>	total heavy mineral
<i>Thmh</i>	Marks Head Formation, Hawthorn Group
<i>Thpf</i>	Penney Farms Formation, Hawthorn Group
<i>THRM</i>	TIMA high resolution mapping
<i>TIMA</i>	TESCAN Integrated Mineral Analyzer
<i>TIMA-X</i>	TIMA with combined BSE and EDX analysis
<i>To</i>	Ocala Limestone
<i>TQc</i>	Cypresshead Formation
<i>TQsu</i>	Tertiary-Quaternary undifferentiated shelly sediments
<i>TQu</i>	Tertiary-Quaternary undifferentiated sediments
μm	micron
<i>USGS</i>	United States Geological Survey
<i>XRF</i>	X-ray fluorescence
<i>Zrn</i>	zircon

CONVERSION FACTORS

<i>Unit</i>	<i>Conversion</i>	<i>To obtain</i>
<i>feet (ft)</i>	divide by 3.281	<i>meter (m)</i>
<i>mile (mi)</i>	multiply by 1.609	<i>kilometer (km)</i>
<i>square miles (mi²)</i>	multiply by 2.589	<i>square kilometers (km²)</i>

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GEOLOGIC MAPPING IN THE TRAIL RIDGE PLACERS, FLORIDA FOCUS AREA

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INTRODUCTION

In 2019, the United States Geological Survey (USGS) Earth Mapping Resources Initiative (Earth-MRI) was established to collect geophysical, geochemical, geologic, and topographic data in areas of critical mineral potential across the nation following Executive Order 13817 and Department of the Interior Secretarial Order 3359. The purpose of this initiative is to evaluate critical mineral independence and security and assist in the collection of two- and three-dimensional geospatial data to produce geologic maps per the National Geologic Mapping Act (Public Law 102-285) and the National Cooperative Geologic Mapping Program (NCGMP).

In 2020, the Florida Geological Survey (FGS) began a multi-year project, with cooperative funding from the USGS Earth MRI Program, (federal award number G20AC00169) focusing on the Trail Ridge heavy mineral placers in northeast Florida (Figure 1). During this study, several sites were targeted and sampled via direct push and rotary drilling methods (Figure 2 and Figure 3). Borehole samples were described and analyzed and subsamples were targeted, based on heavy mineral abundance, for quantitative mineralogy and geochemical analyses. In addition to the geochemical analyses, a surficial geologic map and geologic cross sections for the study area were constructed, and a geomorphic map provided with interpretations from the Florida Geomorphology Atlas (Williams et al., 2022).

The Earth Mapping Resources Initiative Trail Ridge Placers, Florida Focus Area, referred to herein as the EMRI-FFA or the study area, encompasses a large portion (approximately 2,500 square miles) of northeast Florida. It includes parts of the USGS Fernandina Beach, Okefenokee Swamp, Lake City, Jacksonville, Saint Augustine, and Gainesville 30 x 60-minute quadrangles (Figure 1). Three plates accompany this report and include a surficial geologic map of the EMRI-FFA (Plate 1), corresponding cross sections (Plate 2), and a geomorphology map of the EMRI-FFA (Plate 3). Geologic investigations and interpretations were completed by way of 1) detailed borehole sample descriptions and analyses, 2) field investigations, 3) a review of data from existing maps and field notes, 4) a review of historic aerial imagery, and 5) newly available statewide lidar data.

Keywords: Florida, geologic map, heavy mineral sands, heavy mineral placers, quantitative mineralogy, rare earth elements, Trail Ridge sands, geomorphology, Avon Park Formation, Ocala Limestone, Hawthorn Group, Penney Farms Formation, Marks Head Formation, Coosawhatchie Formation, Charlton Member, Statenville Formation, Tertiary/Quaternary undifferentiated shelly sediments, Tertiary/Quaternary undifferentiated sediments, Cypresshead Formation, hydrogeology, Floridan aquifer system, St. Marys River, St. Johns River, Alachua County, Baker County, Bradford County, Clay County, Duval County, Nassau County, Putnam County, St. Johns County, Union County, Baldwin, Macclenny, Starke, Fernandina Beach, Jacksonville, Gainesville, Lake City, Okefenokee Swamp, Palatka, St. Augustine.

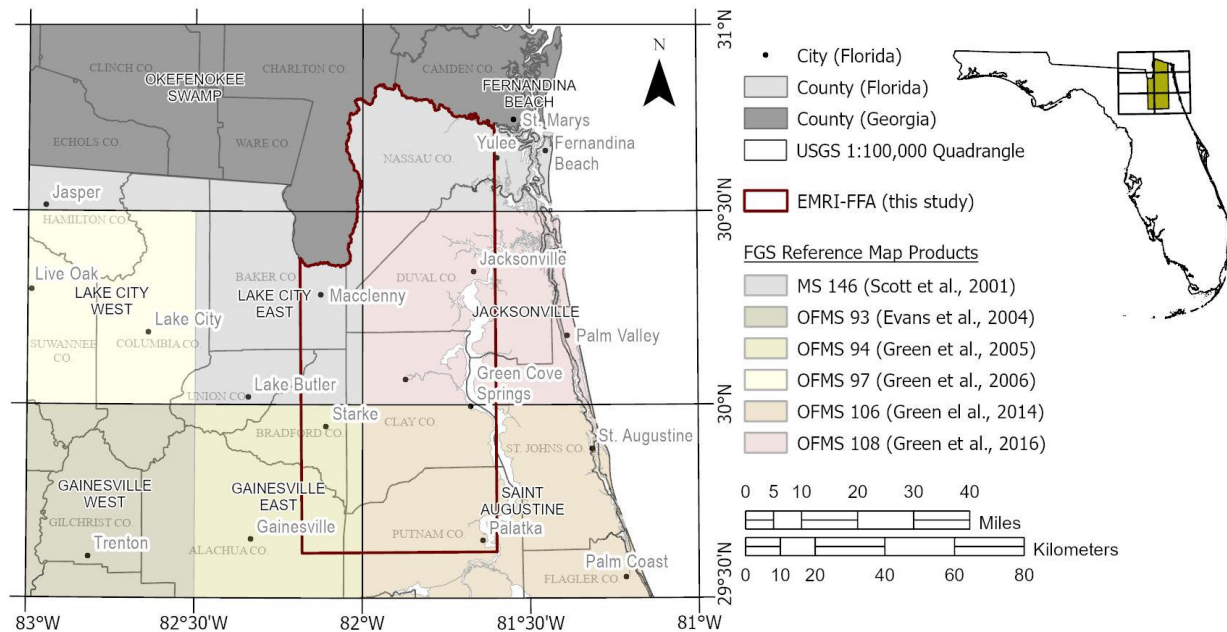


Figure 1. Reference map of northeast Florida highlighting previous work and associated FGS publications.

Objective and Scope

Monazite is a known host of rare earth elements (REE; Van Gosen et al., 2019), and it is identified as a Phase 1 strategic mineral resource by the USGS Earth-MRI working group (Hammarstrom et al., 2020). The group also lists titanium as a Phase 2 strategic mineral resource. As it is central to the mission of Earth-MRI, geochemical analyses reported here were conducted, in addition to surficial geologic mapping, to help characterize the critical mineral resources present within the EMRI-FFA. The geochemical analyses were conducted by the USGS and SGS (Société Générale de Surveillance) Canada Inc. The geochemical data enhances our understanding of the provenance, concentration, and deposition of heavy mineral placer deposits in northeast Florida.

Regional geologic maps for the current study area have been published at various scales from 1:750,000 and smaller. The detailed geologic maps generated for this project provide the information necessary to identify and manage critical mineral resources in this area. Furthermore, these maps will be useful tools for local land-use planners, resource managers, and environmental scientists when making decisions about future growth and development, groundwater allocation, resource conservation, and other issues affecting this part of Florida.

The results from this study support the ongoing FGS statewide 2D and 3D mapping initiative, inform natural resource managers about critical heavy mineral deposits, inform industry about the distribution of potential mineable resources, and improve our scientific understanding of the genesis of heavy mineral placer deposits in the EMRI-FFA. The geochemical, geologic, and topographic data reported here provide additional characterization of the surficial geologic units to improve our current understanding of the 3D framework and subsurface geology throughout northeast Florida.

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Project Deliverables

The boundaries of the EMRI-FFA were defined to capture all the paleoshorelines between and including the relict Wicomico and Pamlico barrier island and lagoon sequences (Hails and Hoyt, 1969). Traditionally, much of the heavy mineral placer mining has occurred within this geographic region in northeast Florida and in sedimentary units interpreted here as the Cypresshead Formation. Due to the geometry of the geomorphic features in the study area, the boundaries do not coincide with specific USGS quadrangle boundaries. This study area includes portions of six 1:100,000 USGS quadrangles, three of which were previously mapped by the FGS STATEMAP program and include the Jacksonville, Saint Augustine, and Gainesville quadrangles (Evans et al., 2004; Green et al., 2005; Green et al., 2014a; Green et al., 2014b; Green et al., 2016a; Green et al., 2016b). In addition to the deliverables discussed below, new geologic mapping conducted for this study will contribute to the completion of three additional 1:100,000 geologic maps (Fernandina Beach, Lake City, and Okefenokee Swamp) to be published through the Florida Geologic State Mapping Initiative (FGSMI).

Project deliverables include the following:

1. Surficial geologic map provided at 1:100,000 scale with accompanying geologic cross sections. The cross sections are drawn with a 1:100 vertical exaggeration.
2. Geomorphology map overlain on a lidar-based digital elevation model (DEM) at 1:100,000 scale.
3. Report.
4. Results and a discussion of geochemical analyses (included in report).
5. Available information regarding heavy mineral placer mining (included in report).
6. High-resolution DEM of the EMRI-FFA built from the newly released lidar.
7. USGS Geologic Map Schema (GeMS) compliant geodatabase.

METHODS

The EMRI-FFA team spent several weeks scouting drill sites, locating and sampling exposures, collecting core samples with FGS drill rigs, processing new samples, and describing both newly collected and archived samples from the Florida Geologic Sample Collections Facility (SCF). The methods implemented during this investigation include standard field mapping techniques and geologic sample collection. Samples were selected for heavy mineral separation and subsequent geochemical analyses following microscopic review and detailed lithologic description. Borehole samples from throughout the study area, and those located within 10-miles of the EMRI-FFA boundary, were used to characterize the surficial and subsurface geology. The lithologic descriptions of borehole samples were used for modelling and correlating geologic units recognized within the EMRI-FFA. All data collected and generated for this project are represented herein. All information related to both legacy samples and newly collected samples reviewed and described for the completion of this project are recorded in the FGS Geologic Data Enterprise

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System (GEODES). Data used to construct the accompanying plates were delivered to the USGS in a GeMS format.

Field mapping was conducted at 1:24,000 scale. However, the corresponding geologic map deliverables, published as Plates 1 and 2 of this report, were delivered at 1:100,000 scale. The interpretations presented here are based on the results of the quantitative mineralogy and observations made and detailed in lithologic reports from this project. A list of all boreholes with samples that were reviewed and described for this project appear in Appendix A. Field data were collected using a customized version of Field Maps™ for ArcGIS™ designed specifically for geologic mapping. All fieldwork data have been logged in field books and scanned for permanent digital archival records.

Historic samples and records incorporated into this investigation were rigorously evaluated for location accuracy by project personnel. Borehole samples were collected using FGS drilling assets which include direct push technology (DPT; AMS PowerProbe™ 9120-RAP) and two rotary rigs (Mobile Drill B31 and Mobile Drill B37X). A total of 2,040 feet of core was collected for the purpose of this investigation. The total depth of each borehole was determined by drilling conditions, stratigraphy, and equipment limitations. Due to the paucity of data in the northern and western portions of the EMRI-FFA, boreholes drilled using rotary methods were strategically placed to provide information about lithology, to identify formation tops for regional formation surface modelling, and the construction of geologic cross sections to accompany Plate 1. Boreholes drilled via DPT were placed in targeted locations based on: 1) surficial geology and geomorphology; 2) anomalies in the eTh (equivalent Thorium) NURE (National Uranium Resource Evaluation) data (Duval et al., 2005); and 3) where surficial geologic controls were lacking. Radiometric eTh data have recently proven to be a useful tool for exploring heavy mineral sand deposits and REE resources (Bern et al., 2016; Shah et al., 2017). The eTh specifically has utility where monazite and xenotime are present.

Cross sections were constructed using new and existing lithologic description reports and the most recently collected lidar data (Florida Geographic Information Office, 2022). Lithologic data incorporated into the models and generated by previous studies were reviewed and revised by project geologists. Cross sections were drawn so that the cross-section lines in unmapped areas would be contiguous to lines in adjacent mapped areas.

Samples containing heavy mineral placers were selected for geochemical analyses. In total, heavy mineral samples from 21 discrete intervals at 15 locations were selected. These subsamples, also referred to in the text as secondary samples, were submitted to SGS Canada Inc. for heavy liquid mineral separation and quantitative mineralogy analysis. The quantitative mineralogy was performed via TESCAN Integrated Mineral Analyzer (TIMA-X). Sample separates, or splits, were divided into two fractions where sample volume allowed for multiple analyses. One fraction was mounted in epoxy resin and prepared for quantitative mineralogy, and the second fraction was prepared for bulk geochemical analyses. Sample separates prepared for bulk geochemical analyses were sent to the USGS Denver Laboratory. These analyses include the evaluation of major oxides using X-ray fluorescence (XRF), and trace elements with special emphasis on REE using Inductively Coupled Plasma-Optical Emission Spectroscopy-Mass Spectroscopy (ICP-OES-MS).

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Sample Collection

Samples were collected by FGS project personnel who worked with various county, city, and state agencies, as well as private landowners, to secure and coordinate site access within road right-of-way areas, parks, state forests, and privately-owned parcels. Selected sites were cleared for underground utilities and other hazards before drilling commenced. All samples collected were boxed, dried, and catalogued into the SCF and entered into the FGS GEODES geodatabase prior to conducting any secondary sample analyses.

Samples collected with the DPT facilitated rapid shallow continuous core acquisition and served as the preferred method of obtaining samples of the surficial geologic strata (Figure 4). This system drives a dual-tube drill string into the ground consisting of 2.375-inch steel outer rods with a 1.5-inch polyvinylchloride (PVC) sample tube on a string of 1.25-inch steel inner rods in four-foot runs (Figure 5). In conditions where sands are unconsolidated and saturated, a piston rod assembly is installed as the lead rod. This system allows the drillers to drive back down to the previous depth, remove the center rod, and capture undisturbed sediments within the PVC sample tube. Thirty sites were sampled with DPT totaling 979 feet of continuous core collected in the EMRI-FFA study area.

Three deeper stratigraphic cores were drilled and sampled via rotary methods in areas within and directly adjacent to the EMRI-FFA study area and provided deeper subsurface stratigraphic controls. Access to sites located on private land was acquired from landowners and provided sampling opportunities in areas where large timber companies often prohibit access. The Mobile Drill B37X and Mobile Drill B31 (Figure 6) collect two-inch diameter continuous core samples via an N-sized wireline core system. The FGS uses a bentonite clay-based drilling mud to cool and flush the bit, flush cuttings out of the borehole, minimize fluid loss to the formation, and maintain the integrity of the borehole. Using rotary drill rigs, 1,060 feet of continuous core from three sites was collected.

Legacy Samples and Geologic Data

The FGS curates legacy, non-digital geologic data and several geologic sample collections. Collections accessed for the benefit of this study included surface samples and exposures (M-Series), borehole samples (W-Series), drillers logs, and field books. Project personnel verified existing data used to supplement the interpretations presented in this report. This included verifying the accuracy of reported locations for borehole samples stored in the SCF and lithologic reports stored in GEODES. The FGS EMRI project team confirmed the location for more than 100 boreholes in northeast Florida and improved the accuracy of more than 60 of these sample sets using public records. Select boreholes from our legacy collection were processed for secondary sampling, mineralogic, and geochemical analyses. Legacy samples provide comparative data from sites previously mined and those collected along paleoshorelines identified east of Trail Ridge.

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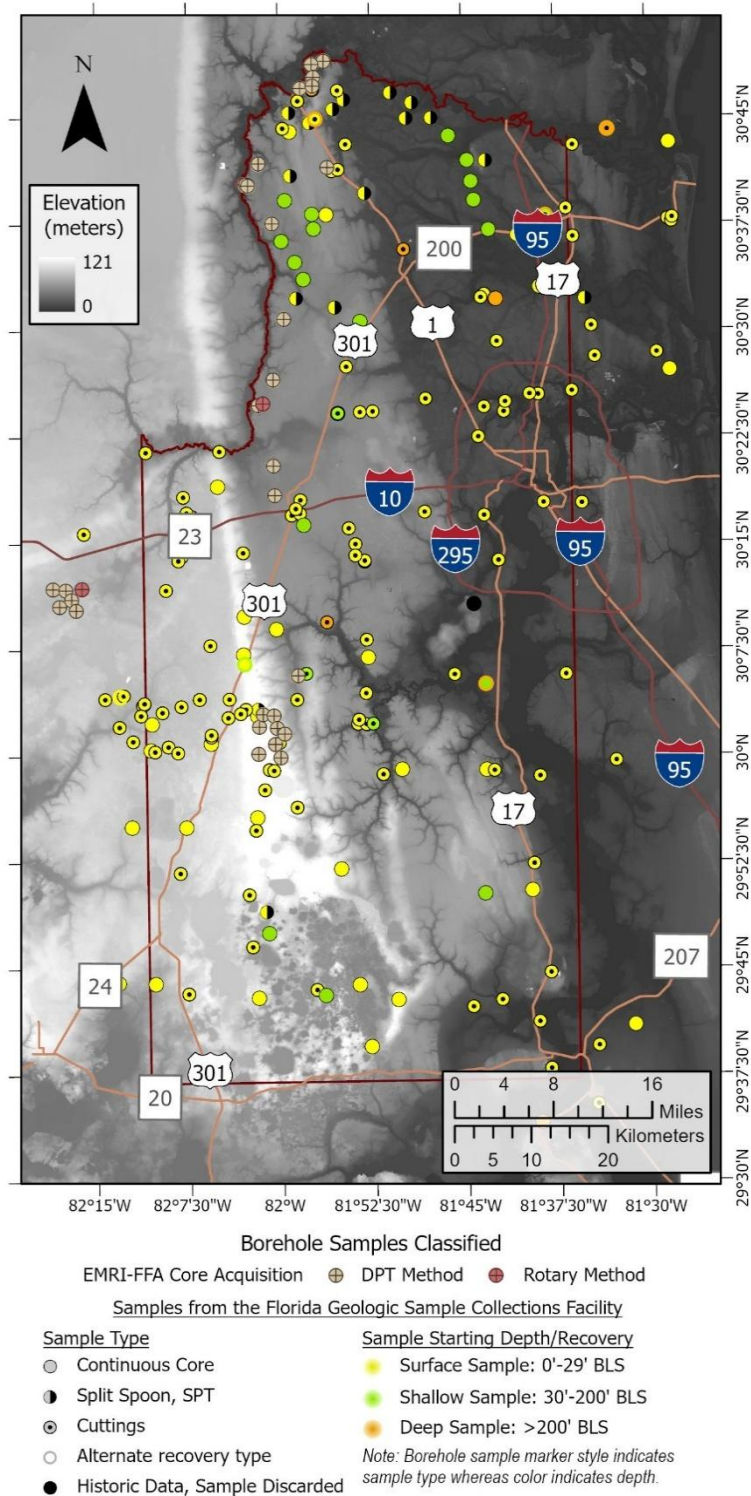


Figure 2. Distribution of samples reviewed from the Florida Geologic Sample Collections Facility and those acquired for the purposes of this study. Samples are classified above based on their sampling method and starting depth below land surface (BLS). All newly acquired samples are continuous and capture the entire stratigraphic package from land surface to total depth.

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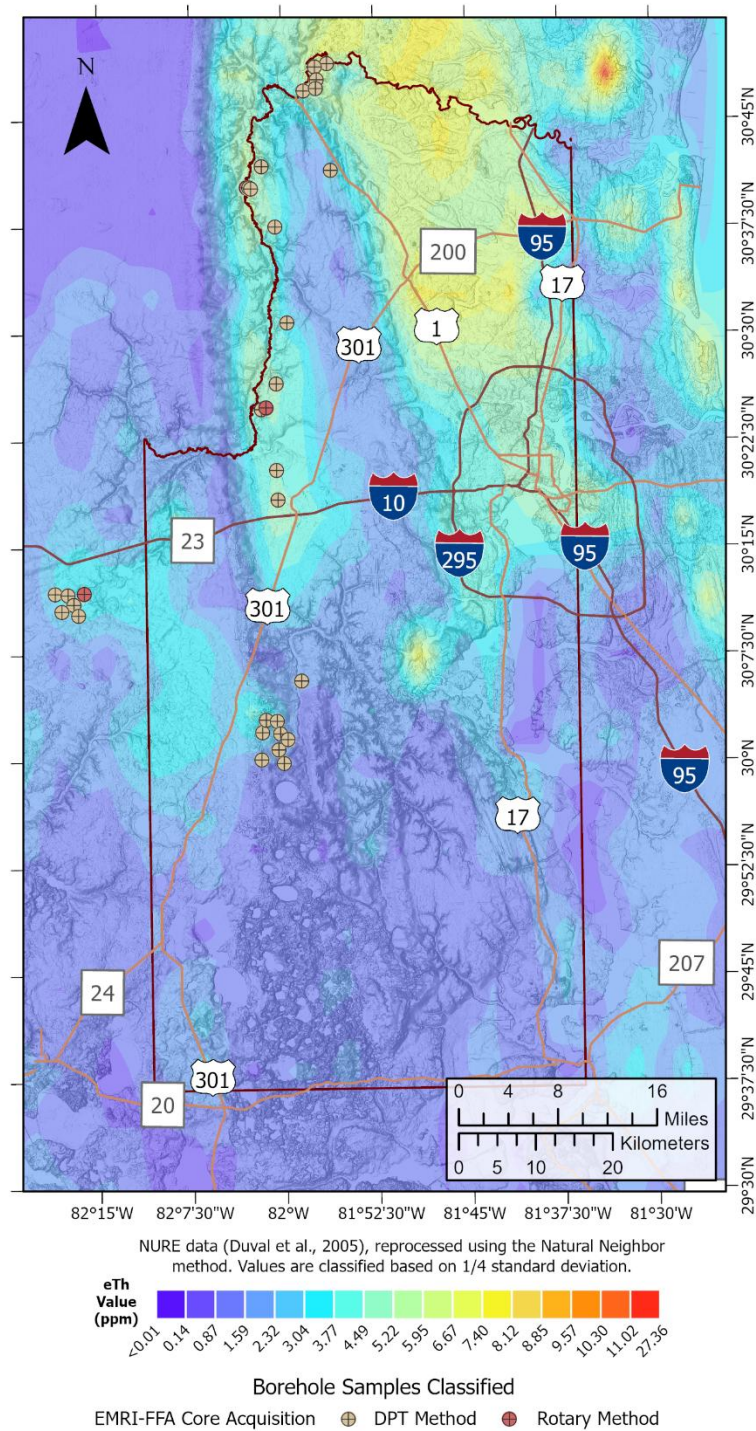


Figure 3. eTh NURE data and sites selected for drilling. The drill method is indicated by the colored point symbology.



Figure 4. FGS staff geologists running the DPT rig an AMS 9120 RAP Power Probe TM, in Ralph E. Simmons State Forest.

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Figure 5. Samples collected using direct push technology. These samples were collected using the equipment in Figure 4, a truck mounted rig capable of collecting 1.5-inch diameter samples in 4-foot runs.



Figure 6. FGS staff geologists and drilling specialists recover DPT rod at a site being converted to rotary methods. Surficial unconsolidated sand and clay beds, when saturated, proved difficult for DPT penetration. Swelling clays at this site locked the DPT outer rods downhole at depth. The Mobile Drill B31 was outfitted with a modified coupling to recover DPT rods and sample.

Secondary Sample Analyses

Continuous cores were selected for secondary sample analyses from newly collected and “historical” or “legacy” core samples. Historical or legacy cores refer to those already catalogued in the FGS SCF prior to the initiation of the EMRI-FFA study. Samples from boreholes proximal to anomalies in the NURE data, and where the surficial geomorphic expression suggested the presence of relict paleoshoreline/barrier island deposits (Figure 7 and Figure 8), were targeted for secondary sample analyses. A total of 21 subsamples were submitted for analyses from 15 cores (Appendix B, Table 6) located within the EMRI-FFA. Specific details pertaining to the number of subsamples and analyses performed are included in the results section of this report and in Appendix C and Appendix D.

Heavy minerals were variably abundant and observed in multiple horizons in cores throughout the study area. Where heavy mineral volume estimates exceeded three percent, multiple horizons were sampled in order to capture comparative data within discrete horizons. Heavy minerals have been commonly recognized along relict coastal features and along modern shoreline deposits. In the EMRI-FFA, heavy minerals occur within the Cypresshead Formation, Quaternary beach ridge and dune sediments, Quaternary undifferentiated sediments, and Holocene sediments with the highest quantities observed in the Cypresshead Formation. All secondary samples selected for quantitative mineralogy and geochemical analyses were collected from unit(s) interpreted here as the Cypresshead Formation, previously interpreted as the Tertiary-Quaternary Trail Ridge sediments.

Discussions of marine ‘terraces’ and ‘scarps’, and the inappropriate application of these terms throughout the literature (Shattuck, 1906, Stephenson, 1912, Cooke, 1925, Cooke, 1931, and others) regarding paleoshoreline deposits within the Atlantic Coastal Plain have, for decades, complicated regional correlations and interpretations. Similarly, much of the literature erroneously employs formation level designation as formal nomenclature for these geomorphic units. For the purposes of our discussion regarding depositional geomorphic features identified in Georgia that extend into Florida, we adopt the geomorphic interpretations and nomenclature of Hails and Hoyt (1969) and previous authors, without the historical formation level designations. Seven paleoshoreline deposits each comprised of a paired barrier island facies and a lagoonal facies extend from Georgia into Florida. These deposits include, from west to east, the 1) Wicomico, 2) Penholoway, 3) Talbot, 4) Pamlico, 5) Princess Anne, 6) Silver Bluff, and 7) Holocene. Using the most recent available lidar data (2022) and by tracing coastline parallel positive and negative linear topographic features along strike, we correlate our selection of subsample sites within the EMRI-FFA to three of the aforementioned (Wicomico, Penholoway, and Talbot) barrier island and lagoon facies and their associated features. These three paleoshoreline deposits characterize the surficial geomorphology of the Duval Upland within the study area and within the Cypresshead Formation, a formally recognized lithostratigraphic unit in Florida and Georgia. As a result, six samples were collected from Wicomico (Trail Ridge) deposits, and nine samples were collected from Penholoway deposits. The Talbot and Penholoway barrier island sequence and associated lagoonal facies coalesce with one another along strike traversing south from Georgia into Florida. This relationship offers additional complexity and some uncertainty when interpreting the boundary between some of these relict coastal features.

Sample subsets were sent to SGS Canada Inc. for heavy liquid separation and quantitative mineralogy. Because of the various grain size distributions observed in several subsets, samples

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were separated using separatory funnels. Methylene iodide was selected as a heavy medium with a specific gravity of 2.9 g/cm^3 . Subsamples from the splits were riffled to prepare them for the graphite-impregnated, polished, epoxy grain mounts. Grain mounts were then analyzed using a TIMA-X (Figure 9). Sample subset separates were then shipped to the USGS Denver lab and prepared for additional analyses.

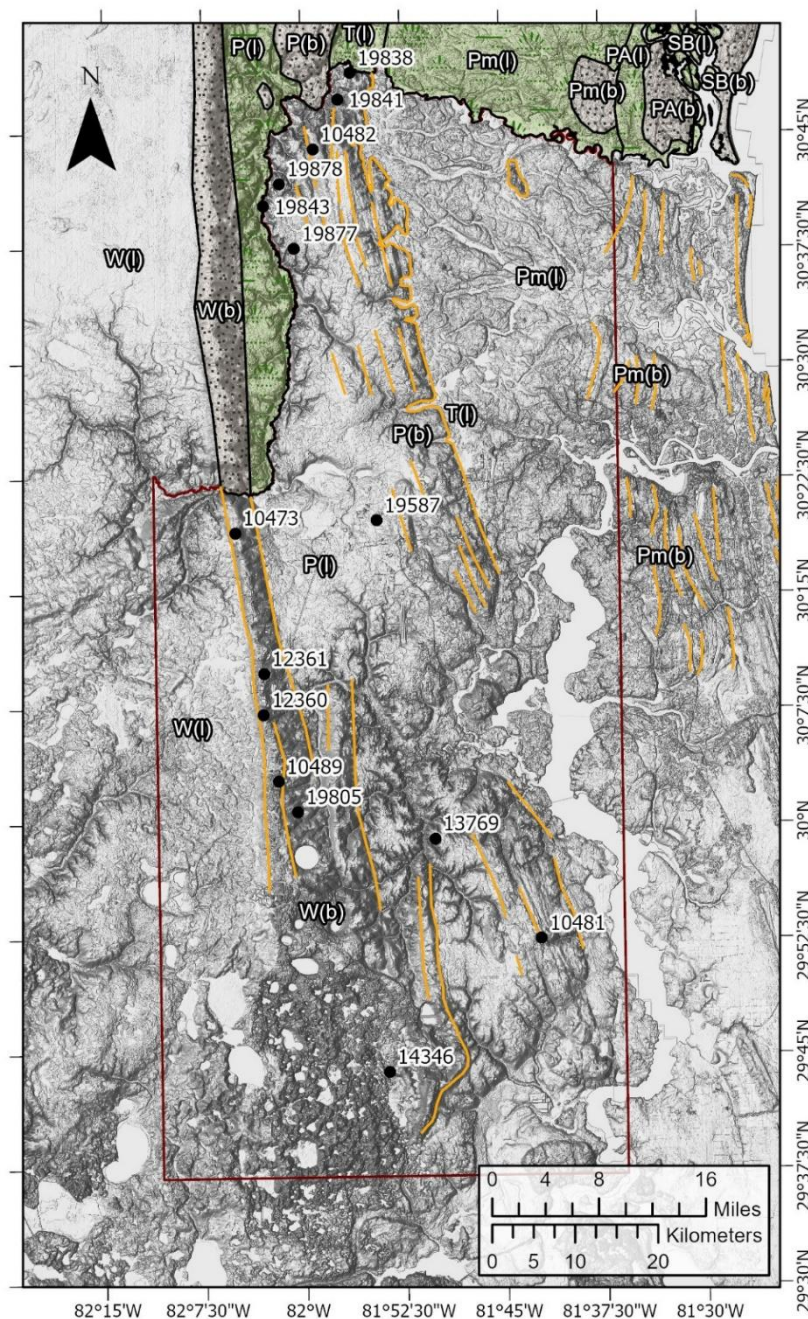


Figure 7. Multidirectional hillshade with a Z Factor scaled to 50, applied to the EMRI-FFA. The exaggerated data and annotated interpretations demonstrate the extension and traces of relict paleoshorelines identified by Hails and Hoyt (1969) and Pirkle et al. (2013). Orange lines represent ridge traces. Black dots represent the location of subsamples selected for geochemical analyses. These sites correspond to Table 6 (Appendix B) where depths and locations are reported. Paleoshoreline labels are as follows, (l) denotes the lagoonal facies and (b) denotes the barrier facies. W=Wicomico, P=Penholoway, T=Talbot, Pm=Pamlico, PA=Princess Anne, and SB=Silver Bluff.

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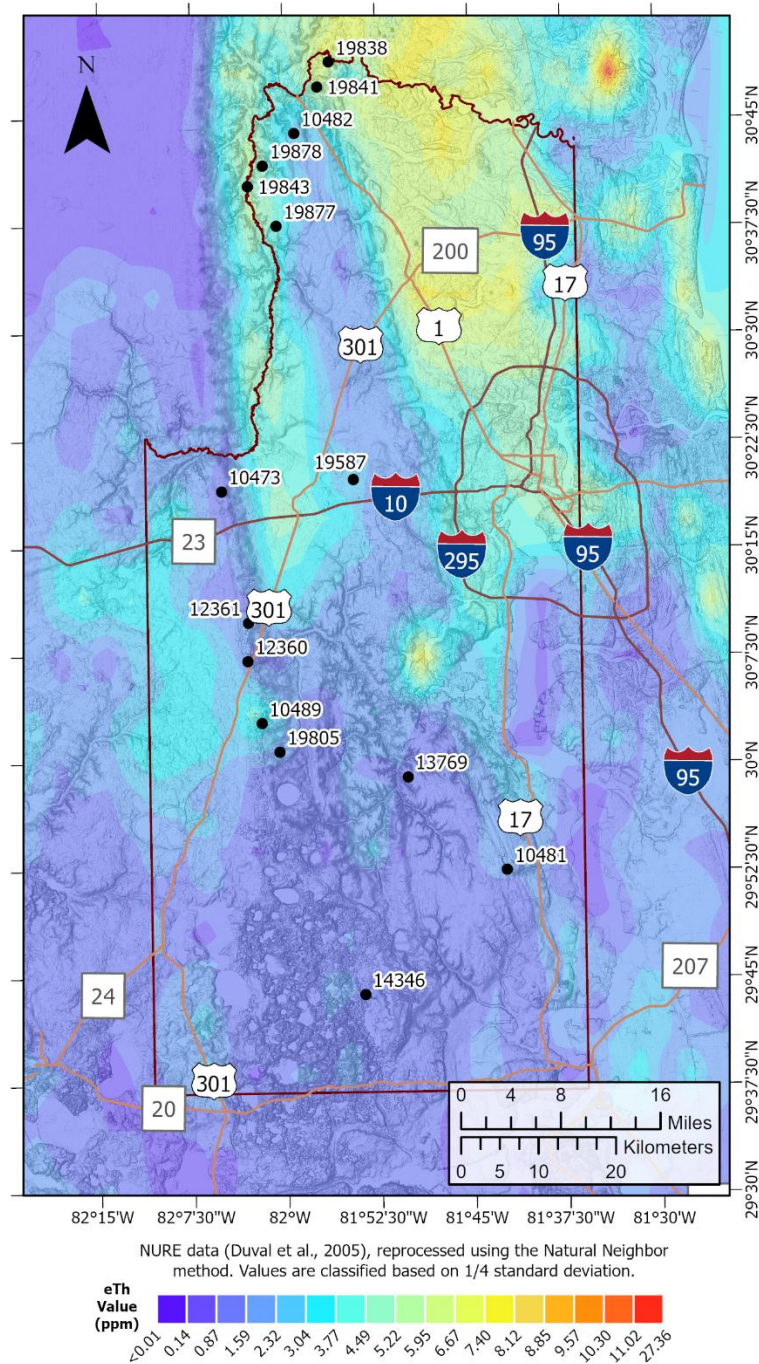


Figure 8. eTh NURE anomalies illustrated in the map above were used as additional guidance when determining sample and site selection for heavy mineral sand targets. Cores sampled are represented by a black dot and labeled with the FGS borehole number designation (W#). A hillshade generated from lidar data using an adjusted scale and a z-factor of 50 was added for an exaggerated topographic expression.

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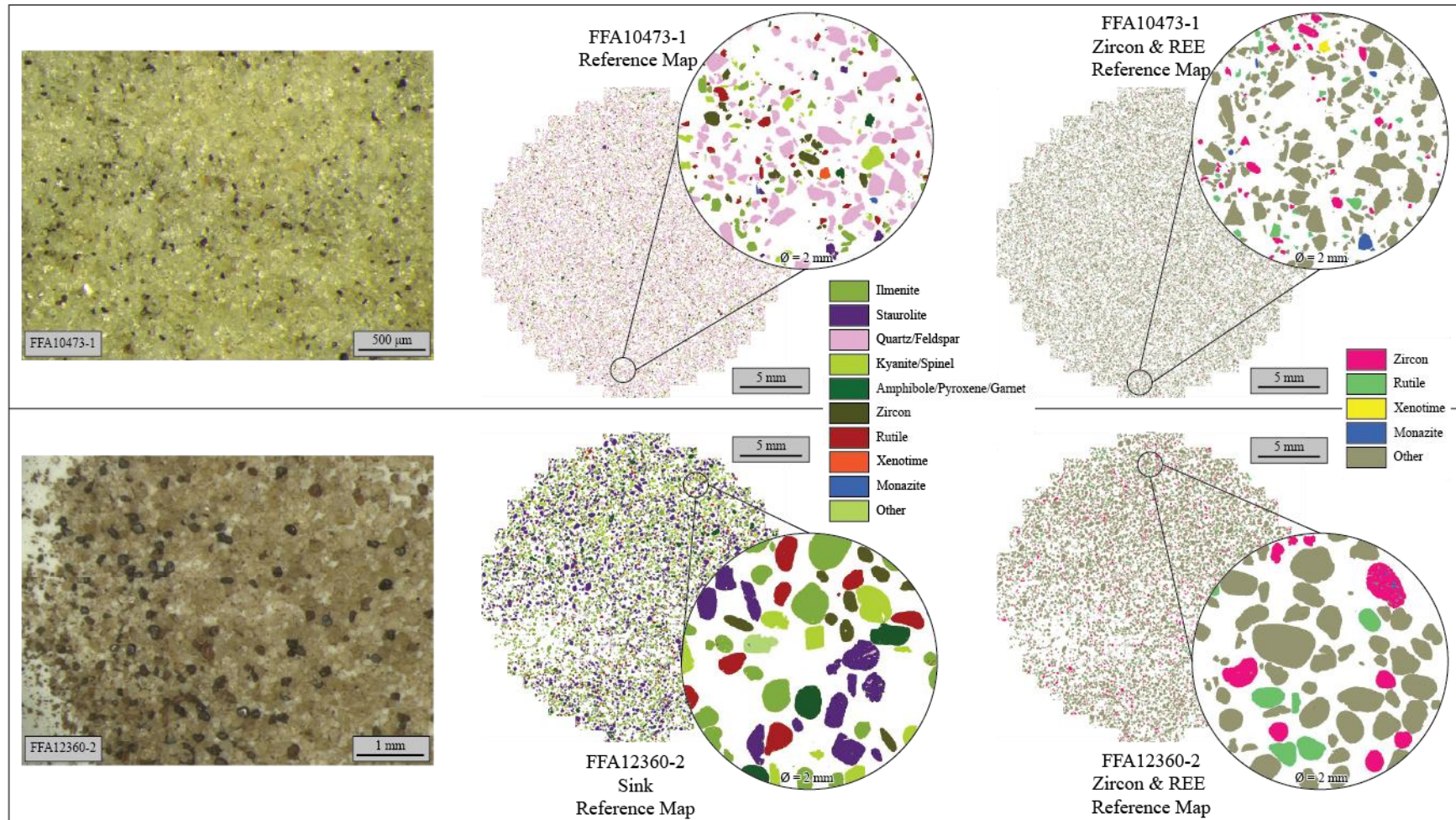


Figure 9. Samples correlate from left to right across the figure. Two samples were selected to demonstrate the mineral mapping results and techniques of the TIMA-X quantitative mineralogy. The software associated with the TIMA-X generates grain-reference maps and identifies individual or groups of minerals as determined by the user. The figures above demonstrate this where a subset of heavy minerals is visible vs. the heavy minerals associated with REE.

RESULTS OF MINERALOGIC AND GEOCHEMICAL ANALYSES

A total of 21 subsamples from 15 cores were prepared and submitted using the methods detailed above for quantitative mineralogy analyses. Twelve subsamples contained enough volume in the heavy mineral splits for ICP-OES-MS-61 trace elemental analysis. Five subsamples contained enough volume in the heavy mineral splits for ICP-OES-MS-16 major elemental analysis. The results of these analyses are discussed in detail below.

TIMA-X Quantitative Mineralogy and Grain Size Analyses

Quartz is the dominant mineral in each subsample and persists in varying quantities within each density fraction prepared with Methylene iodide for TIMA-X analyses. The average weight percent (wt. %) of the heavy (sink) fraction in all subsamples analyzed is 2.62%, with a minimum of 0.57% and a maximum of 7.78%. Subsamples from cores were targeted and selected based on an observed and estimated heavy mineral volume. Target volumes were estimated by examining samples with a binocular microscope under various magnifications. Intervals where the accessory heavy mineral fraction was estimated to be 3% or greater of the total subsample were selected for analyses. Subsamples were re-weighed prior to and following density separation via heavy liquids by SGS Canada Inc. The masses for all subsample splits (sinks and floats) are reported in Appendix C (Table 7). Following heavy liquid separation, it was concluded that about half of the selected subsamples contained at least a 2% heavy mineral fraction.

The dataset provided in Appendix C (Table 8) represents a complete view of the modal mineralogy (mass %) for each of the subsamples analyzed. Note the data for residual quartz, clay, mica, and feldspar fractions in total heavy mineral subsample separates. Minerals with a density $<2.9 \text{ g/cm}^3$, or where the minerals and/or composite grains can have a density range, are likely present due to some combination of coarseness, sorting, liquid density, the presence of composite or associated grains, and/or other factors pertaining to the separation techniques used. Similarly, much smaller fractions of heavy mineral species were identified in the float sample data. Some of the summary charts and data discussed in this section present an “adjusted” view of the data where the less dense mineral fraction and the associated minerals have been removed from the total heavy mineral separate volumes (Figure 10). Figure 11 presents a graphical view of the modal mineralogy constrained to the economic heavy minerals (EHM), and sub-economic and non-economic heavy minerals (SEHM) identified in samples. In the following subsection, we highlight this population of EHM as well as an abbreviated list of sub-economic and non-economic heavy minerals (SEHM) of importance. In each subsample, we evaluated the wt. % of each EHM with respect to the total heavy mineral (THM) population, and the sum of the EHM population with respect to the THM ($\Sigma\text{EHM wt. \% THM}$). We similarly evaluate the SEHM (Table 1 and Table 2, respectively). All re-processing steps are noted with the presentation of the various data summaries. A complete set of tabular data as it was reported from SGS Canada Inc. are provided in Appendix C.

Results from the 21 subsamples analyzed via TIMA-X provide insight into sample characterization, granulometrics, and the quantitative mineralogy and mineral association(s). Ilmenite is the most abundant heavy mineral in every sample analyzed. The heavy mineral fraction for each sample is generally comprised of *leucoxene (altered ilmenite), *rutile (rutile + ilmenorutile + pseudorutile) staurolite, zircon, kyanite, and amphibole/pyroxene, each on average greater than 5 wt. %. *Ilmenite (ilmenite + Ti-silicates), xenotime, apatite, and monazite also

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notably occur within the heavy mineral fraction in quantities less than 5 wt. % on average. Xenotime, apatite, and monazite are known host minerals for REE and therefore likely represent the bulk of the REE abundance (ppm) detected in each sample. Importantly, these REE host minerals consistently occur in quantities less than 2 wt. % of the total heavy mineral fraction. Furthermore, the occurrence of xenotime and apatite are negligible in almost all samples analyzed.

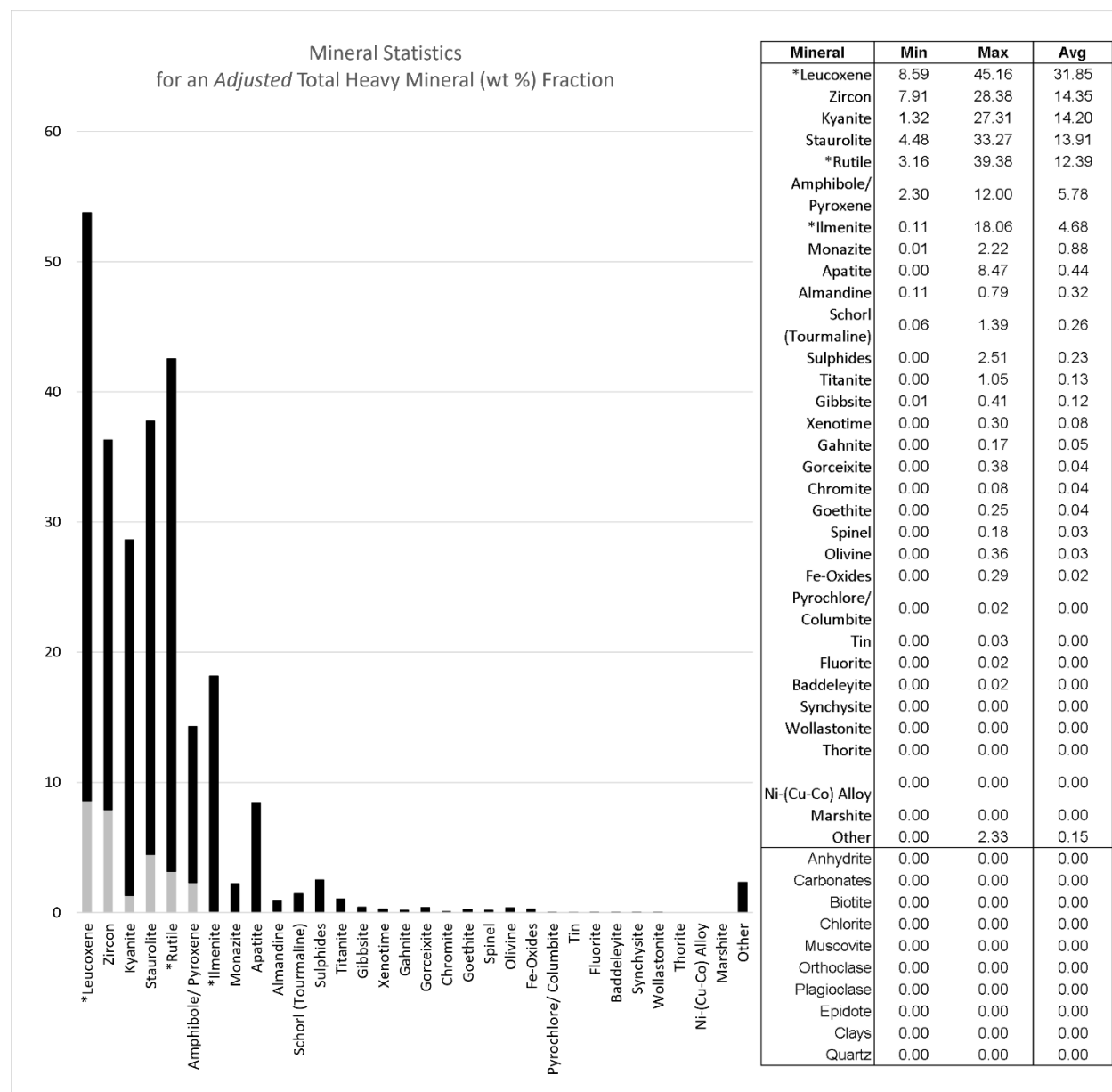


Figure 10. Data presented graphically indicate adjusted mineral statistics for all subsample sinks analyzed. Minerals listed at the bottom of the figure table with a value = 0.00 represent the minerals that have been adjusted. Gray bars represent the minimum values and black the maximum. Adjusted values correspond to the wt. % of the THM splits where carbonate(s), mica(s), feldspar(s), epidote, clay(s), and quartz have been removed. Note that: *Leucoxene = altered ilmenite, *rutile = rutile + ilmenorutile + pseudorutile, *ilmenite = ilmenite + Ti-silicates.

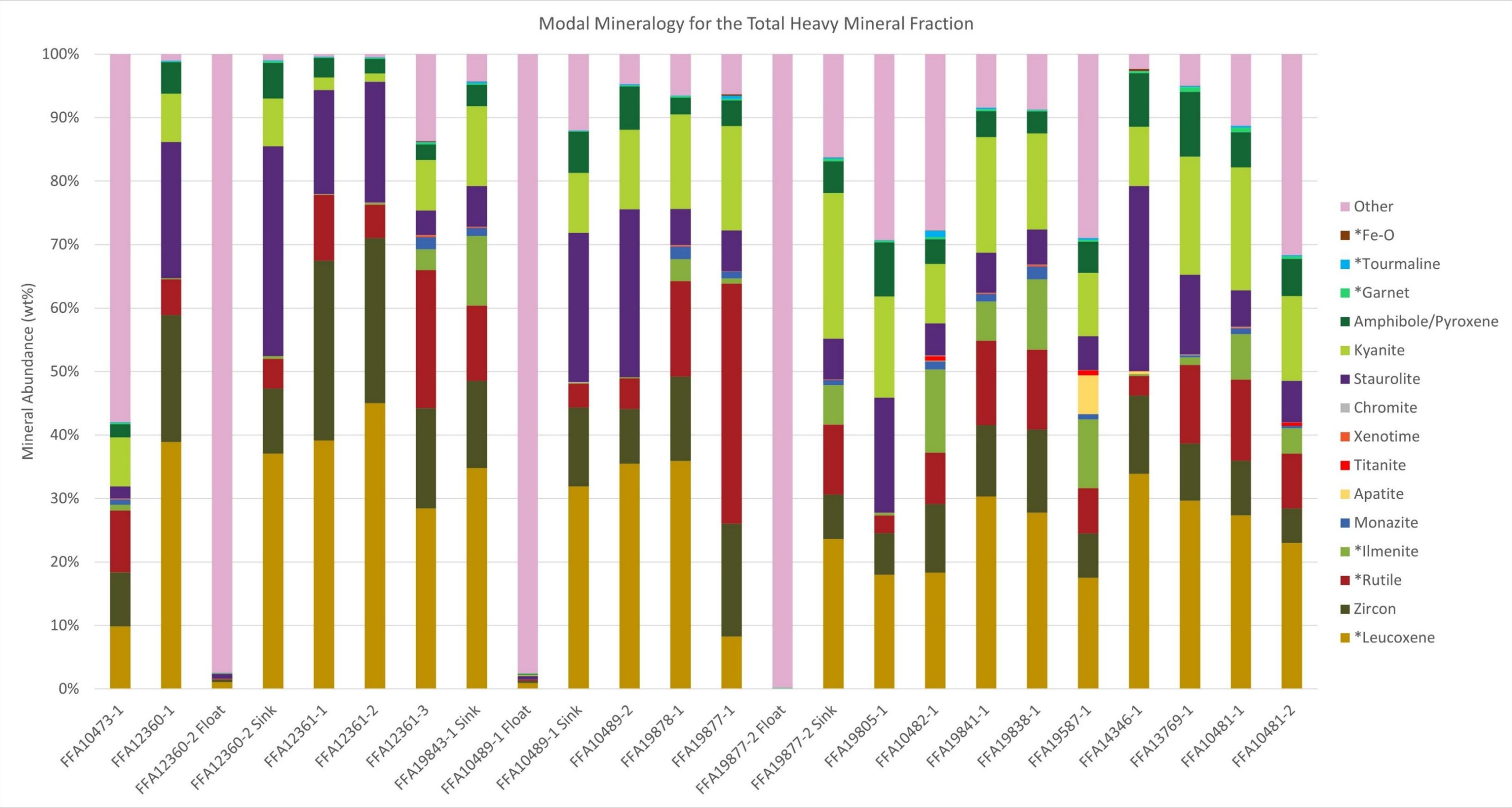


Figure 11. TIMA-X results for economic, sub-economic, and non-economic minerals of interest in subsamples analyzed for quantitative mineralogy. All subsamples represent the sink fraction unless otherwise indicated. The legend is organized based on stacking order. Subsamples are ordered along the x-axis based on geographic considerations, generally from west to east and north to south across the study area. Site IDs were established by adding an “FFA” prefix to the corresponding FGS (W#) borehole number designation. Borehole samples where multiple heavy mineral horizons were subsampled are denoted sequentially (i.e. -1,-2,-3). Associated data are provided in Appendix C.

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Table 1. Summary of TIMA-X data indicating the wt. % of economic heavy minerals (EHM) from subsamples. The total heavy mineral (THM) population represents the entire suite of minerals reported for sink data in Appendix C. Σ EHM (wt. %) represents the sum of all EHM (wt. %) values within the THM. The THM(T) (wt. %) is calculated from total sample mass reported for each subsample split. *Leucoxene = altered ilmenite, *rutile = rutile + ilmenorutile + pseudorutile, *ilmenite = ilmenite + Ti-silicates.

<i>Sample ID</i>	<i>*Leucoxene</i> wt. % <i>THM</i>	<i>Zircon</i> wt. % <i>THM</i>	<i>*Rutile</i> wt. % <i>THM</i>	<i>*Ilmenite</i> wt. % <i>THM</i>	<i>Monazite</i> wt. % <i>THM</i>	<i>Apatite</i> wt. % <i>THM</i>	<i>Titanite</i> wt. % <i>THM</i>	<i>Xenotime</i> wt. % <i>THM</i>	<i>Chromite</i> wt. % <i>THM</i>	Σ EHM wt. % <i>THM</i>	THM(T) wt. %
<i>FFAI0473-1</i>	9.86	8.52	9.74	0.89	0.85	0.00	0.00	0.09	0.03	29.99	2.76
<i>FFAI2360-1</i>	38.88	20.02	5.65	0.16	0.02	0.01	0.00	0.00	0.00	64.73	5.45
<i>FFAI2360-2</i>	37.09	10.25	4.69	0.40	0.01	0.01	0.00	0.00	0.01	52.45	3.89
<i>FFAI2361-1</i>	39.16	28.32	10.35	0.11	0.01	0.01	0.00	0.00	0.03	77.98	4.35
<i>FFAI2361-2</i>	45.03	26.03	5.22	0.22	0.04	0.01	0.00	0.00	0.04	76.61	4.55
<i>FFAI2361-3</i>	28.44	15.82	21.72	3.30	1.92	0.00	0.02	0.26	0.05	71.52	2.86
<i>FFAI9843-1</i>	34.79	13.75	11.87	10.97	1.27	0.00	0.01	0.13	0.05	72.84	1.57
<i>FFAI0489-1</i>	31.93	12.41	3.74	0.15	0.01	0.01	0.00	0.00	0.07	48.33	7.78
<i>FFAI0489-2</i>	35.49	8.63	4.80	0.20	0.01	0.01	0.00	0.00	0.00	49.14	5.45
<i>FFAI9878-1</i>	35.93	13.28	15.02	3.48	2.00	0.00	0.01	0.15	0.06	69.93	1.02
<i>FFAI9877-1</i>	8.25	17.81	37.82	0.80	1.09	0.00	0.01	0.05	0.01	65.84	0.86
<i>FFAI9877-2</i>	23.62	6.98	11.07	6.18	0.83	0.00	0.01	0.07	0.02	48.78	0.66
<i>FFAI9805-1</i>	18.00	6.52	2.80	0.40	0.02	0.01	0.01	0.01	0.00	27.77	1.98
<i>FFAI0482-1</i>	18.34	10.77	8.09	13.10	1.33	0.10	0.65	0.12	0.05	52.55	1.26
<i>FFAI9841-1</i>	30.31	11.25	13.30	6.17	1.22	0.00	0.01	0.12	0.06	62.43	0.95
<i>FFAI9838-1</i>	27.79	13.10	12.55	11.09	2.02	0.00	0.01	0.22	0.05	66.83	0.88

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Table 1. (Continued).

<i>Sample ID</i>	<i>*Leucoxene</i> wt. % <i>THM</i>	<i>Zircon</i> wt. % <i>THM</i>	<i>*Rutile</i> wt. % <i>THM</i>	<i>*Ilmenite</i> wt. % <i>THM</i>	<i>Monazite</i> wt. % <i>THM</i>	<i>Apatite</i> wt. % <i>THM</i>	<i>Titanite</i> wt. % <i>THM</i>	<i>Xenotime</i> wt. % <i>THM</i>	<i>Chromite</i> wt. % <i>THM</i>	Σ EHM wt. % <i>THM</i>	<i>THM(T)</i> wt. %
<i>FFAI9587-1</i>	17.52	6.97	7.12	10.86	0.82	6.13	0.76	0.04	0.03	50.24	1.82
<i>FFAI4346-1</i>	33.91	12.30	3.10	0.27	0.02	0.44	0.02	0.00	0.00	50.07	4.44
<i>FFAI3769-1</i>	29.67	8.99	12.37	1.22	0.34	0.08	0.00	0.00	0.02	52.69	0.57
<i>FFAI0481-1</i>	27.35	8.63	12.75	7.18	0.92	0.00	0.01	0.13	0.07	57.05	0.91
<i>FFAI0481-2</i>	22.99	5.44	8.63	3.99	0.39	0.00	0.50	0.03	0.00	41.99	0.98
<i>Mean</i>	28.30	12.66	10.59	3.86	0.72	0.32	0.10	0.07	0.03	56.65	2.62
<i>Standard Deviation</i>	9.76	6.11	7.79	4.41	0.71	1.33	0.23	0.08	0.03	13.93	2.04
<i>Median</i>	29.67	11.25	9.74	1.22	0.82	0.01	0.01	0.04	0.03	52.69	1.82
<i>Median Absolute Deviation</i>	6.26	2.62	3.56	1.11	0.78	0.00	0.01	0.04	0.02	10.70	0.96
<i>Max</i>	45.03	28.32	37.82	13.10	2.02	6.13	0.76	0.26	0.07	77.98	7.78
<i>Min</i>	8.25	5.44	2.80	0.11	0.01	0.00	0.00	0.00	0.00	27.77	0.57
<i>Count</i>	21	21	21	21	21	21	21	21	21	21	21

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Table 2. Summary of TIMA-X indicating the wt. % of select sub-economic and non-economic heavy minerals (SEHM) in the subsamples. The total heavy mineral (THM) population represents the entire suite of minerals reported for sink data in Appendix C. Σ EHM (wt. %) represents the sum of all EHM (wt. %) values within the THM. Σ SEHM (wt. %) represents the sum of all SEHM (wt. %) values within the THM. The THM(T) (wt. %) is calculated from total sample mass reported for each subsample split. Amp./py. = amphibole/pyroxene, *garnet = almandine, *tour. = schorl (tourmaline), *Fe-O = Fe-oxides + goethite, and *Other = Sum of all other accessory minerals identified in the THM population.

<i>Sample ID</i>	<i>Staurolite</i> wt. % <i>THM</i>	<i>Kyanite</i> wt. % <i>THM</i>	<i>Amp./Py.</i> wt. % <i>THM</i>	<i>*Garnet</i> wt. % <i>THM</i>	<i>*Tour.</i> wt. % <i>THM</i>	<i>*Fe-O</i> wt. % <i>THM</i>	<i>*Other</i> wt. % <i>THM</i>	Σ SEHM wt. % <i>THM</i>	Σ EHM wt. % <i>THM</i>	<i>THM(T)</i> wt. %
<i>FFA10473-1</i>	1.90	7.71	2.11	0.22	0.09	0.01	57.97	12.05	29.99	2.76
<i>FFA12360-1</i>	21.42	7.62	4.97	0.12	0.11	0.00	1.03	34.24	64.73	5.45
<i>FFA12360-2</i>	33.05	7.51	5.66	0.24	0.10	0.00	0.99	46.56	52.45	3.89
<i>FFA12361-1</i>	16.38	1.98	3.05	0.11	0.11	0.00	0.39	21.63	77.98	4.35
<i>FFA12361-2</i>	19.04	1.32	2.30	0.14	0.12	0.00	0.48	22.92	76.61	4.55
<i>FFA12361-3</i>	3.88	7.93	2.44	0.28	0.12	0.12	13.71	14.77	71.52	2.86
<i>FFA19843-1</i>	6.40	12.59	3.35	0.19	0.28	0.04	4.31	22.85	72.84	1.57
<i>FFA10489-1</i>	23.54	9.44	6.50	0.12	0.07	0.00	12.01	39.66	48.33	7.78
<i>FFA10489-2</i>	26.45	12.49	6.87	0.16	0.16	0.00	4.74	46.13	49.14	5.45
<i>FFA19878-1</i>	5.67	14.88	2.69	0.20	0.10	0.00	6.52	23.54	69.93	1.02
<i>FFA19877-1</i>	6.40	16.41	4.08	0.24	0.46	0.25	6.29	27.84	65.84	0.86
<i>FFA19877-2</i>	6.39	22.96	5.02	0.36	0.21	0.06	16.27	35.00	48.78	0.66
<i>FFA19805-1</i>	18.14	15.94	8.51	0.23	0.12	0.00	29.29	42.94	27.77	1.98
<i>FFA10482-1</i>	5.05	9.34	3.90	0.31	1.01	0.07	27.76	19.69	52.55	1.26
<i>FFA19841-1</i>	6.30	18.21	4.11	0.30	0.23	0.01	8.42	29.15	62.43	0.95

Table 2: (Continued).

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<i>Sample ID</i>	<i>Staurolite</i> wt. % <i>THM</i>	<i>Kyanite</i> wt. % <i>THM</i>	<i>Amp./Py.</i> wt. % <i>THM</i>	<i>*Garnet</i> wt. % <i>THM</i>	<i>*Tour.</i> wt. % <i>THM</i>	<i>*Fe-O</i> wt. % <i>THM</i>	<i>*Other</i> wt. % <i>THM</i>	Σ <i>SEHM</i> wt. % <i>THM</i>	Σ <i>EHM</i> wt. % <i>THM</i>	<i>THM(T)</i> wt. %
<i>FFA19838-1</i>	5.53	15.15	3.46	0.19	0.10	0.03	8.72	24.45	66.83	0.88
<i>FFA19587-1</i>	5.35	9.94	4.94	0.25	0.30	0.01	28.96	20.80	50.24	1.82
<i>FFA14346-1</i>	29.18	9.35	8.41	0.28	0.06	0.37	2.30	47.63	50.07	4.44
<i>FFA13769-1</i>	12.55	18.60	10.26	0.69	0.22	0.01	4.99	42.32	52.69	0.57
<i>FFA10481-1</i>	5.74	19.37	5.56	0.71	0.30	0.01	11.28	31.67	57.05	0.91
<i>FFA10481-2</i>	6.55	13.34	5.89	0.38	0.20	0.01	31.66	26.36	41.99	0.98
<i>Mean</i>	12.61	12.00	4.96	0.27	0.21	0.05	13.24	30.10	56.65	2.62
<i>Standard Deviation</i>	9.50	5.59	2.21	0.16	0.21	0.09	14.45	10.75	13.93	2.04
<i>Median</i>	6.40	12.49	4.94	0.24	0.12	0.01	8.42	27.84	52.69	1.82
<i>Median Absolute Deviation</i>	2.52	3.92	1.56	0.06	0.05	0.01	6.12	7.05	10.70	0.96
<i>Max</i>	33.05	22.96	10.26	0.71	1.01	0.37	57.97	47.63	77.98	7.78
<i>Min</i>	1.90	1.32	2.11	0.11	0.06	0.00	0.39	12.05	27.77	0.57
<i>Count</i>	21	21	21	21	21	21	21	21	21	21

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Table 3. Grain-size statistics and sample characterization. Data reported from SGS Canada Inc. and processed using GRADISTATv9.1.xls developed and maintained by Blott (2020). Sample separates are characterized following established methods and basic principles of statistical grain size analyses (Udden, 1914; Wentworth, 1922; Krumbein and Pettijohn, 1938; Folk, 1954; Folk and Ward, 1957). Sorting abbreviations: MS = moderately sorted, MWS = moderately-well sorted, WS = well sorted; Size abbreviations: VF = very fine, F = fine, M = medium, C = coarse, VC = very coarse.

<i>Wentworth</i>	<i>VC sand</i>	<i>C sand</i>	<i>M sand</i>	<i>F sand</i>	<i>VF sand</i>	<i>VC silt</i>	<i>C silt</i>	<i>M silt</i>	<i>F silt</i>	<i>Wentworth</i>
<i>Size Range</i>	1–2	0.5 –1	0.25–0.5	125–250	63–125	31–63	16–31	8 – 16	4 – 8	<i>Size Range</i>
<i>(metric)</i>	(mm)	(mm)	(mm)	(µm)	(µm)	(µm)	(µm)	(µm)	(µm)	<i>(metric)</i>
<i>φ scale</i>	φ 0 to -1	φ 1 to 0	φ 2 to 1	φ 3 to 2	φ 4 to 3	φ 5 to 4	φ 6 to 5	φ 7 to 6	φ 8 to 7	<i>φ scale</i>
<i>Sample ID</i>										<i>Description</i>
<i>FFA10473-1</i>	0.00%	0.00%	2.63%	40.81%	35.99%	17.01%	2.87%	0.57%	0.11%	<i>MS; VF Sand</i>
<i>FFA12360-1</i>	0.00%	2.69%	38.16%	50.57%	7.97%	0.42%	0.10%	0.05%	0.03%	<i>MWS; F Sand</i>
<i>FFA12360-2</i>	0.00%	2.94%	41.80%	48.34%	4.48%	0.43%	0.70%	0.65%	0.66%	<i>MWS; F Sand</i>
<i>FFA12361-1</i>	0.00%	0.40%	26.96%	61.39%	8.99%	0.67%	0.57%	0.49%	0.53%	<i>MWS; F Sand</i>
<i>FFA12361-2</i>	0.00%	0.98%	29.27%	61.06%	6.27%	0.46%	0.65%	0.61%	0.70%	<i>MWS; F Sand</i>
<i>FFA12361-3</i>	0.00%	0.02%	1.05%	10.78%	33.11%	41.86%	9.26%	2.43%	1.48%	<i>MS; VC Silt</i>
<i>FFA19843-1</i>	0.00%	0.03%	1.02%	39.81%	53.56%	4.26%	0.62%	0.44%	0.27%	<i>WS; VF Sand</i>
<i>FFA10489-1</i>	0.00%	6.13%	55.05%	35.75%	2.76%	0.19%	0.09%	0.03%	0.01%	<i>MWS; M Sand</i>
<i>FFA10489-2</i>	0.00%	3.34%	48.23%	43.78%	4.21%	0.29%	0.09%	0.04%	0.01%	<i>MWS; M Sand</i>
<i>FFA19878-1</i>	0.00%	0.00%	0.50%	24.19%	63.61%	9.03%	2.00%	0.56%	0.11%	<i>MWS; VF Sand</i>
<i>FFA19877-1</i>	0.32%	0.52%	3.05%	37.36%	50.19%	6.52%	1.39%	0.51%	0.14%	<i>MWS; VF Sand</i>
<i>FFA19877-2</i>	1.49%	2.31%	1.50%	32.97%	53.45%	5.66%	1.80%	0.65%	0.16%	<i>MWS; VF Sand</i>
<i>FFA19805-1</i>	0.14%	7.23%	48.23%	37.21%	5.87%	0.54%	0.30%	0.25%	0.22%	<i>MWS; M Sand</i>

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Table 3. (Continued).

<i>Wentworth</i>	<i>VC sand</i>	<i>C sand</i>	<i>M sand</i>	<i>F sand</i>	<i>VF sand</i>	<i>VC silt</i>	<i>C silt</i>	<i>M silt</i>	<i>F silt</i>	<i>Wentworth</i>
<i>Size Range</i>	1–2	0.5 –1	0.25–0.5	125–250	63–125	31–63	16–31	8 – 16	4 – 8	<i>Size Range</i>
<i>(metric)</i>	(mm)	(mm)	(mm)	(µm)	(µm)	(µm)	(µm)	(µm)	(µm)	<i>(metric)</i>
<i>φ scale</i>	φ 0 to -1	φ 1 to 0	φ 2 to 1	φ 3 to 2	φ 4 to 3	φ 5 to 4	φ 6 to 5	φ 7 to 6	φ 8 to 7	<i>φ scale</i>
<i>Sample ID</i>	---									<i>Description</i>
<i>FFA10482-1</i>	0.00%	0.32%	4.15%	31.52%	50.86%	11.22%	1.10%	0.57%	0.26%	<i>MWS; VF Sand</i>
<i>FFA19841-1</i>	0.00%	0.68%	1.07%	28.51%	61.91%	6.83%	0.54%	0.27%	0.20%	<i>MWS; VF Sand</i>
<i>FFA19838-1</i>	0.00%	0.00%	1.34%	19.14%	59.26%	17.90%	1.26%	0.67%	0.42%	<i>MWS; VF Sand</i>
<i>FFA19587-1</i>	0.00%	0.25%	3.60%	51.51%	40.49%	3.46%	0.38%	0.20%	0.11%	<i>MWS; F Sand</i>
<i>FFA14346-1</i>	0.00%	3.31%	55.67%	37.82%	2.76%	0.25%	0.06%	0.07%	0.06%	<i>MWS; M Sand</i>
<i>FFA13769-1</i>	0.00%	0.22%	10.93%	64.56%	22.61%	1.30%	0.19%	0.12%	0.07%	<i>MWS; F Sand</i>
<i>FFA10481-1</i>	0.00%	0.00%	0.95%	24.81%	61.81%	10.40%	1.08%	0.57%	0.38%	<i>MWS; VF Sand</i>
<i>FFA10481-2</i>	0.00%	0.00%	2.68%	54.64%	38.45%	3.59%	0.37%	0.18%	0.09%	<i>MWS; F Sand</i>

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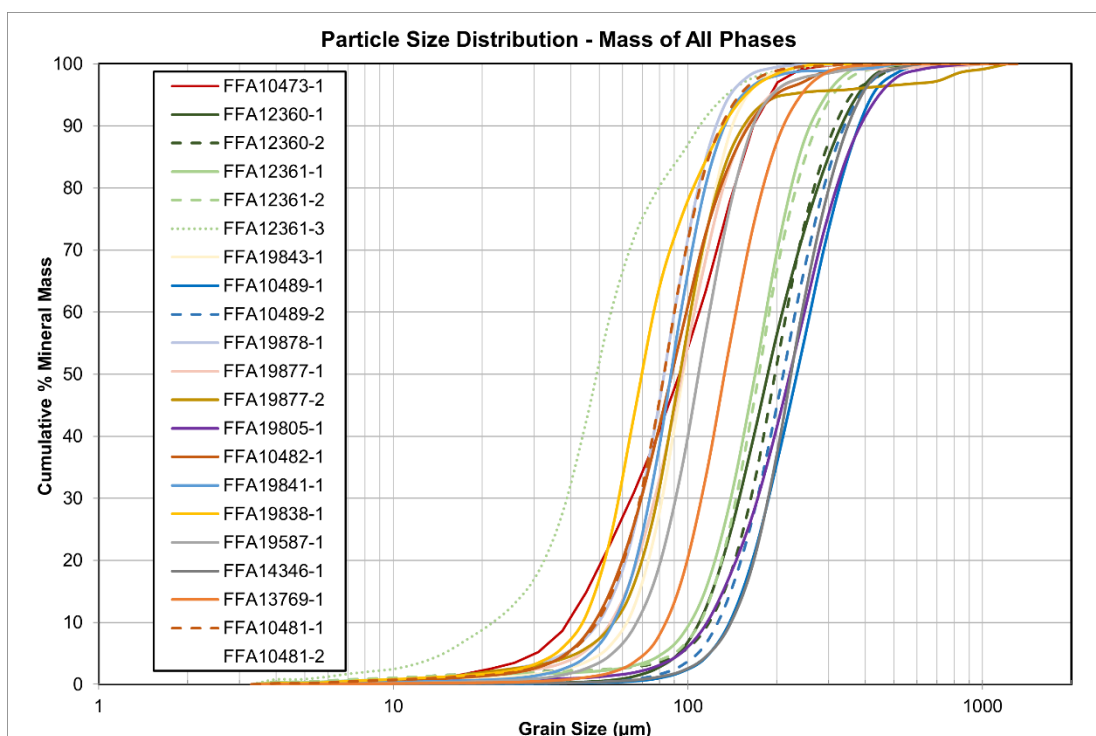


Figure 12. Particle size distribution for all phases analyzed via TIMA-X where grain size is illustrated relative to cumulative mineral mass.

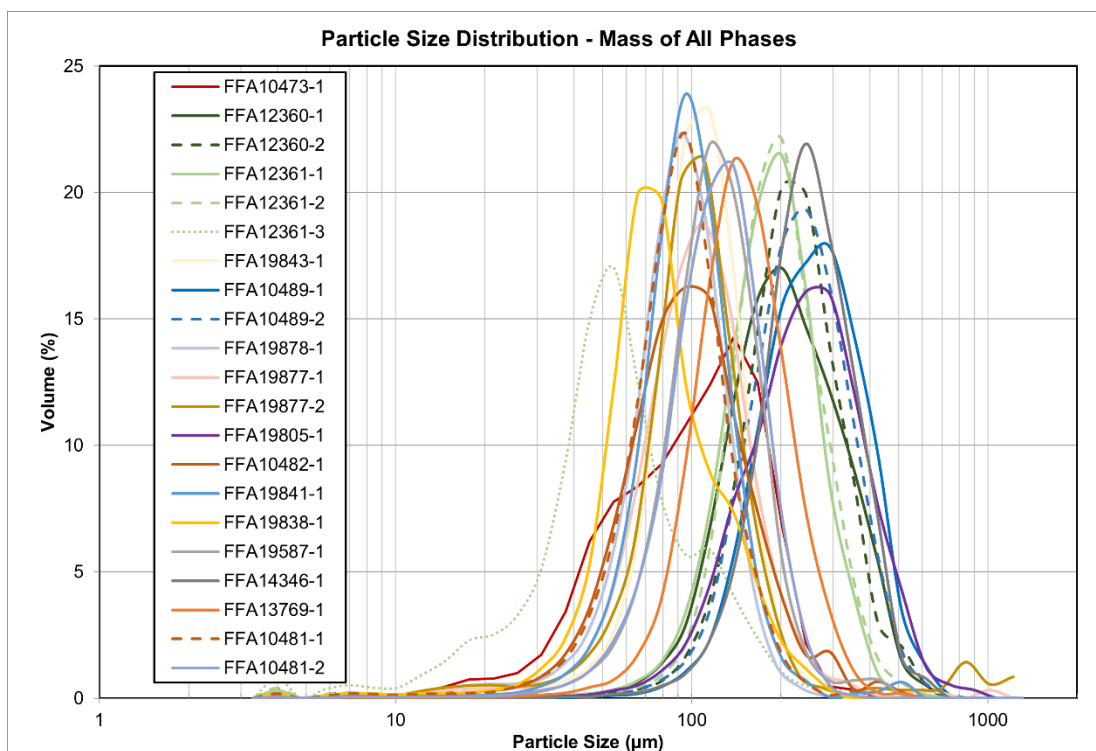


Figure 13. Particle size distribution for all phases analyzed via TIMA-X where grain size is indicated relative to percent volume.

Economic Mineral Potential

The mineralogical and geochemical data from heavy mineral concentrates collected from discrete and composite paleoshoreline sand samples is a valuable dataset that can assist in critical mineral exploration in other parts of the United States where the surficial geology is similar to that of the EMRI-FFA. A summary of the heavy mineral concentrates TIMA-X data is provided in Appendix C (Table 8) where the wt. % data for the THM population are shown. The Σ EHM represent the wt. % of economic/critical minerals and Σ SEHM represent the wt. % of sub-economic and non-economic minerals within the total population of minerals reported for the heavy mineral sinks (THM(T); Table 1 and Table 2). The average THM(T) for all samples analyzed is 2.62 wt. %. The average Σ EHM within the THM is 56.65 wt. %, and the average Σ SEHM within the THM is 30.10 wt. %. Subsamples have higher percentages of economic minerals such as *leucoxene, zircon, *rutile, and *ilmenite, which have been historically mined throughout the EMRI-FFA. Based on the Σ EHM for all subsamples analyzed, these four minerals account for an averaged 97.81% of the Σ EHM suite (56.65 wt. %): *leucoxene 28.30 wt. %, zircon 12.66 wt. %, *rutile 10.59 wt. %, and *ilmenite 3.86 wt. % (Table 1). The remaining 2.19% (1.24 wt. %) of the Σ EHM (56.65 wt. %) is comprised of Monazite, Apatite, Titanite, Xenotime, and Chromite. The wt. % data for the Σ SEHM are reported in Table 2. The data reveal there are notable concentrations of staurolite 2.61 wt. %, kyanite 12.00 wt. %, and amphibole/pyroxene 4.96 wt. %. Monazite is a common REE bearing mineral that is present in very low concentrations throughout the sample study area. The average monazite present is 0.72 wt. %, with sample FFA19838-1 having the highest amount of 2.02 wt. %.

The average of 56.65 wt. % of Σ EHM in the THM(T) fraction observed in concentrates could indicate conditions are favorable for extraction. However, there is variability from site to site. Furthermore, previously mined deposits that exhibit similar Σ EHM variability confirm that extraction operations have occurred at sites where Σ EHM values are less than 50% of the THM(T). Ultimately, evaluations should be conducted at the scale appropriate for site specific assessments to best characterize the geometry, continuity, and economic potential of heavy mineral placer deposits.

Grain Size Statistics

All subsamples analyzed were first described and classified by FGS project geologists using a binocular microscope. Accessory mineralogy, grain size, and sorting were characterized for each bulk sample selected for analysis. The grain size ranges were estimated and reported by project personnel and ranged from very fine to very coarse sand size sediments with accessory amounts of clay and silt; size mode estimates ranged from very fine to medium. With respect to the heavy mineral species specifically, multimodal grain size distributions were especially noticeable in samples where the darker, more conspicuous heavy mineral grains were present in relative abundance.

Additional grain and particle size statistics informed by the TIMA-X analyses were reported by SGS Canada Inc. and processed using GRADISTAT (v9.1) and methods referenced in Blott and Pye (2001) (Table 3). Sample statistics and grain size distributions from GRADISTAT (v9.1) are provided in Appendix D. This Excel® program was used to evaluate grain size, sorting, distribution, skewness, and kurtosis. The grain and particle size analyses for the mass of all phases reveal a typical grain size distribution for moderately- to moderately-well sorted sediments (Figure

12). Twenty of the 21 subsamples analyzed reveal a unimodal distribution and one a bimodal distribution (FFA12361-3), most are symmetrical and two are skewed (FFA10473-1: fine skewed, FFA19838-1: coarse skewed; Figure 13). Kurtosis values are variable with one sample classified as platykurtic (FFA10473-1); the rest are either mesokurtic or leptokurtic.

Grain size statistics were also reported for a subset of mineral species from the total heavy mineral (THM) analyses. The mineral specific data were variable when compared to the overall bulk sample separate statistics. These observable variations are likely a factor of their individual physical properties, source, transport method and time, and weathering index/alteration potential. Without additional chronologic constraints, the variations can only be noted, and no interpretations are provided. The following was observed with respect to a subset of the heavy minerals identified and analyzed. Each of the minerals discussed here is categorized as an economic heavy mineral.

Zircon occurs in each sample with a mean grain size that ranges from very coarse silt to fine sand. Zircon is observed in 75 % of the samples and is well sorted with a unimodal distribution. Some samples do appear to contain multimodal fractions of zircon. *Ilmenite (ilmenite + Ti-silicate) occurs in each sample with a mean grain size that ranges from very coarse silt to very fine sand. Its occurrence is multimodal in every sample but one; and in each sample, it is poorly sorted. Only rutile (not including pseudorutile or ilmenorutile) was reported with additional grain size data from the heavy mineral fraction. Rutile occurs with a mean grain size that ranges from very coarse silt to fine sand and exhibits a unimodal distribution where grains range from moderately- to moderately-well sorted. Monazite occurs in the heavy mineral fraction with a narrower grain size distribution that is less uniform than zircon but more uniform than the other minerals discussed here. The mean grain size of monazite ranges from coarse silt to very fine sand. In most of the samples it is well sorted and has a sample distribution that is unimodal. However, some of the samples do appear to contain multimodal fractions of monazite. Modality is discussed here to supplement the characterization of samples analyzed. Additional data are needed to establish significance.

Mineral Association and Liberation

The TIMA-X analyses also provided data on mineral associations for the four economic heavy minerals discussed above (zircon, ilmenite, rutile, and monazite). The minerals are each discussed as pure (where 100% of the particle volume is one mineral species), free (where >95% of the particle volume is one mineral species), liberated (where >80% of the particle volume is one mineral species), and associated (where <80% of the particle volume is one mineral species). Charts were prepared from the mineral association data (Figure 14 and Figure 15) to supplement the following discussion, tables containing the associated data are included in Appendix C.

Zircon, ilmenite, rutile, and monazite grains occur in each sample and largely occur as pure, free, and liberated grains (Figure 14). The data and discussion provided below provides additional insight and detail where these minerals occur in association with other identified mineral species and “complex” grains. Associated mineral species are referenced for each where they occur on average in excess of 1% of the normalized sample mass or where they occur in notable quantities. Notable quantities are defined herein where the average population in all samples is <1%, but many of the individual samples contain >1% (Figure 15).

Where zircon was specifically analyzed, only two of the samples analyzed exhibited less than 90% total liberation of zircon. Our data indicates an association between zircon and several

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mineral species identified. Zircon was observed in association with ilmenite on average in proportions greater than 1% of the normalized sample mass. Several individual samples also indicate notable associations with “complex” grains, staurolite, quartz/feldspars, “other” minerals, rutile, amphibole/pyroxene/garnet, and kyanite.

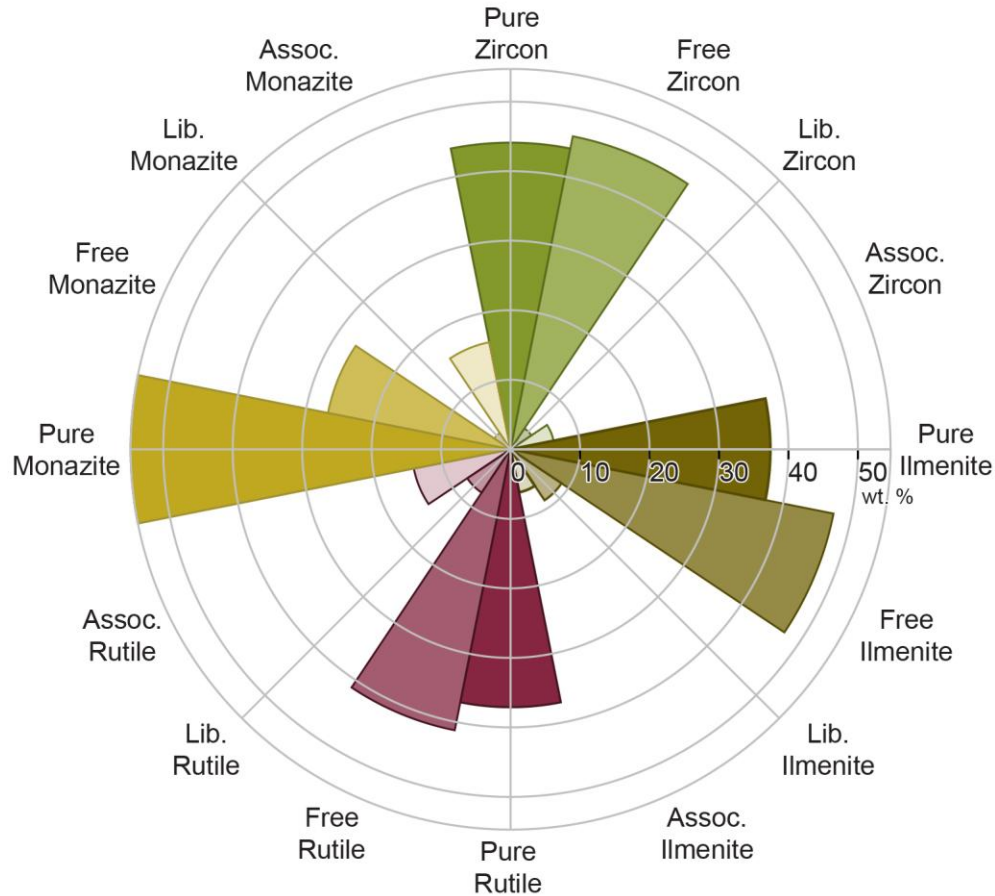


Figure 14. Rose diagram demonstrating distribution of pure, free, and liberated zircon, ilmenite, rutile, and monazite. Data for the individual samples were normalized to 100. The values above represent average wt. % for the total sample population analyzed.

Where ilmenite was specifically analyzed, only three of the samples exhibited less than 90% total liberation of ilmenite. Our samples indicate an association between ilmenite and several identified mineral species. Ilmenite is associated with rutile, “complex” grains, and zircon on average in proportions greater than 1% of the normalized sample mass. Several individual samples also indicate notable associations with “other” minerals, staurolite, and kyanite.

Where rutile was specifically analyzed, only five of the samples exhibited more than 90% total liberation of rutile. Our data indicates an association between rutile and several other mineral species identified. Rutile was observed in association with ilmenite, “complex” grains, and “other” minerals on average in proportions greater than 1% of the normalized sample mass. Several individual samples also indicate notable associations with staurolite, quartz/feldspars, zircon, amphibole/pyroxene/garnet, and kyanite.

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Where monazite was specifically analyzed, seven of the samples exhibited less than 90% total liberation of monazite. Of those seven samples, three exhibited less than 60% total liberation of monazite. Our data indicates an association between monazite and several identified mineral species. Monazite was reported in association with “complex” grains, ilmenite, kyanite, staurolite, and amphibole/pyroxene/garnet on average in amounts greater than 1% of the normalized sample mass. Several individual samples also indicate notable associations with zircon, quartz/feldspars, “other” minerals, and rutile. In some samples, monazite is observed in association with other mineral phases in proportions greater than its occurrence in a free or liberated state.

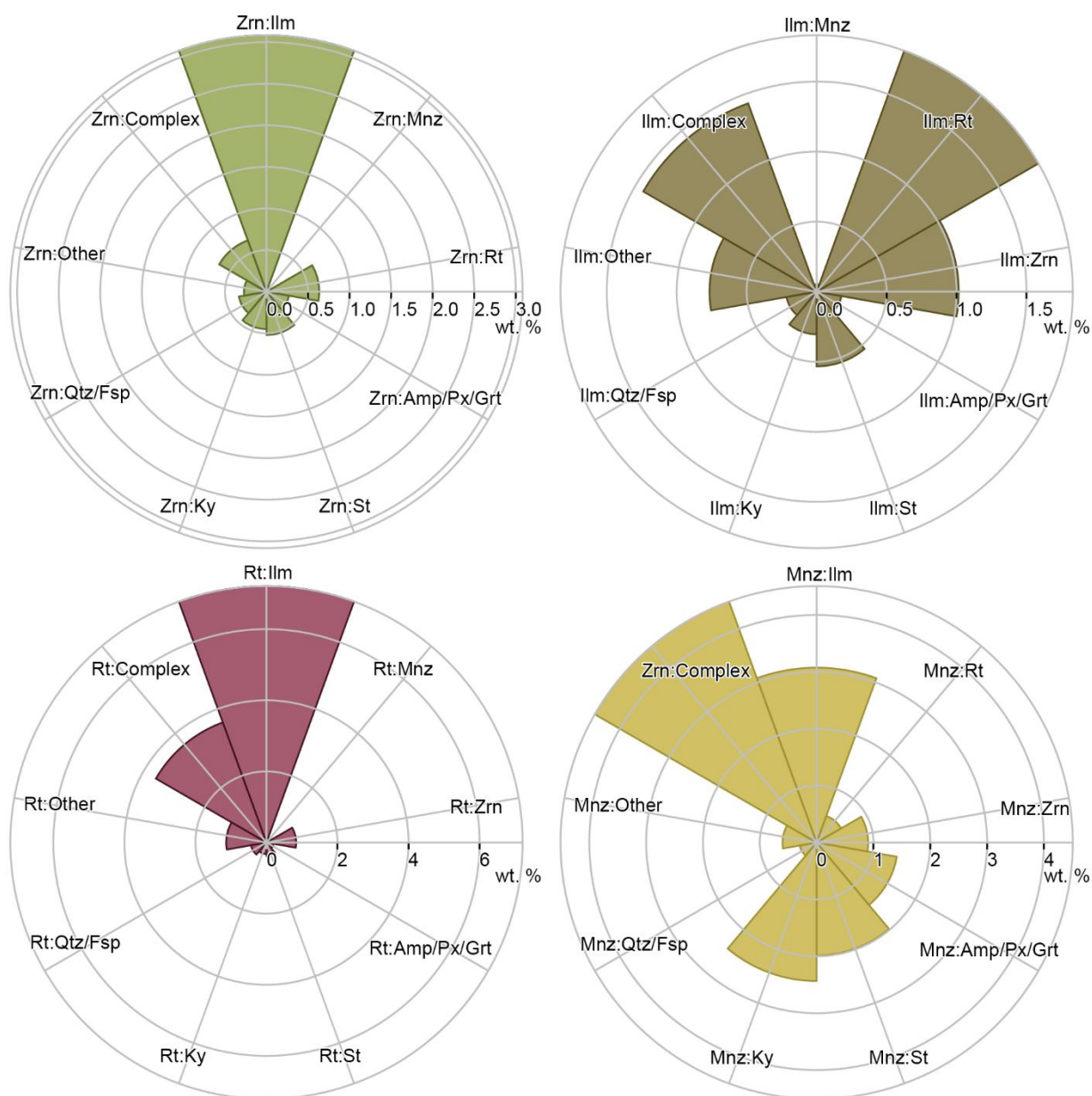


Figure 15. Mineral association diagrams for zircon (Zrn), ilmenite (Ilm), rutile (Rt), and monazite (Mnz). Data for the individual samples were normalized to 100. The values above represent average wt. % for the total sample population analyzed. Abbreviations include

amphibole/pyroxene/garnet (Amp/Px/Grt), staurolite (St), kyanite (Ky), quartz/feldspar (Qtz/Fsp), “other” mineral (Other), and “complex” grains (Complex).

ICP-OES-MS Elemental and Major Oxide Concentrations

One of the primary objectives of this study was to assess the economic potential of REE associated with heavy mineral sand concentrations within the EMRI-FFA. Of the 21 heavy mineral sand subsamples sent for geochemical analyses. Thirteen were analyzed for a suite of 61 elemental concentrations using ICP-OES-MS and five for the major element oxide data using ICP-OES. As previously discussed, subsample volumes were submitted based on estimated heavy mineral volumes. A number of the subsamples submitted, once processed into splits, were not large enough to conduct all three planned analyses. Heavy mineral separates analyzed consist of both composite and discrete samples. Sample and site-specific details are provided in Appendix B (Table 6). All subsample splits were sent to the USGS Denver Laboratory for geochemical analyses. Those results include concentrations of major element oxides in wt. %, and major and trace element data in ppm.

Major Element Oxide Concentrations

The major element oxide data obtained from ICP-OES-MS-16 are provided in Appendix E (Table 14). SiO₂ concentrations range from 18% - 35%, which is to be expected based on the nature of the samples and is much lower than that reported for average upper continental crust (UCC; Rudnick and Gao, 2003). Al₂O₃ and TiO₂ in samples analyzed were reported in much higher concentrations than values typical for average UCC (15.4% and 0.64% respectively; Rudnick and Gao, 2003). Al₂O₃ measured in samples ranged from 18% to 29% and TiO₂ from 21% to 26%. Fe₂O₃ concentrations in samples were also relatively high with respect to average UCC values. Sample values ranged from 13% to 17% whereas Rudnick and Gao (2003) report an average UCC of 5% for Fe₂O₃. K₂O and Na₂O were detected in low concentrations where K₂O ranged from 0.01% to 0.03%, and Na₂O ranged from 0.14% to 0.26%. We attribute the observed major element oxide concentrations to specific minerals present in the heavy mineral separates. For example, the TiO₂ concentrations are most likely associated with the concentrations of both *rutile (rutile + ilmenorutile + pseudoutile) and *ilmenite (ilmenite + Ti-silicates). Al₂O₃ concentrations are attributed to the minor amounts of kyanite, staurolite, almandine, and additional fractions of minerals present in the heavy mineral separates. Fe₂O₃ and MnO concentrations correspond to Fe-oxides, goethite, and garnet. SiO₂ concentrations are attributed to silicate bearing minerals, namely quartz, feldspars, and clays. Cr₂O₃ is associated with the minor amounts of chromite, spinel, and to a lesser extent is likely to appear as a trace element in other minerals present. V₂O₅ is known to occur in phosphate minerals such as apatite and some iron bearing minerals such as garnet. The presence of feldspar is inherently low in the placer deposits observed within the EMRI-FFA due to physical and chemical weathering associated with transport and depositional environment. Furthermore, any fully liberated feldspar present would have been removed with the float fraction during the separation process; K₂O, Na₂O, and P₂O₅ concentrations are likely associated with complex or composite grains and residual concentrations of the feldspars, clays, and any of their diagenetic derivatives; or additional fractions of minerals present in the heavy mineral separates.

Elemental Concentrations

Rare Earth Elements

Elemental data obtained from ICP-OES-MS are provided in Appendix E (Table 15). Figure 16 is a graphical representation of all 13 samples and their REE concentrations. The normalized sample data plot into two distinguishable groups herein referred to as Group 1 and Group 2. Samples will be discussed relative to these two groups and the total sample population. The total REE (Σ REE) concentrations in the heavy mineral sand separates range from 294.9 to 10,035.81 ppm, with an average of 2,549.05 ppm. Sc is the lightest REE but due to its ionic radius and its compatibility, does not behave like the other REE. Sc is not typically classified as a light rare earth element (LREE) or heavy rare earth (HREE) and has therefore not been included in the Σ REE data presented here. The geochemical data indicate that in some cases the concentrations of REE are approximately fifteen times greater than the values reported for average continental crust (Figure 17; Rudnick and Gao, 2003). However, for sample Group 2 this is not the case. Sample Group 1 exhibits the highest concentrations of REE and its data distribution parallels average UCC. Higher concentrations of U and Th were also observed in the Group 1 samples. Group 2, however, is marked by similarly trending, though lower value, LREE concentrations, and HREE concentrations that exhibit a positive slope. A negative Eu anomaly is observed in all samples.

For comparison, in a recent EMRI Fall Zone placer investigation conducted by the Virginia Department of Energy (Hawkins and Lassetter, 2022), where both bulk sediment and heavy mineral separates were analyzed, all samples exhibited parallel REE patterns to that of average UCC. The authors report concentrations of REE in bulk samples that are approximately the same or are slightly lower than the average abundances reported for average UCC. Hawkins and Lassetter (2022) also report enriched concentrations in heavy mineral separates that exceed five times those concentrations. A negative Eu anomaly is also present in the Virginia data, though in some samples is less pronounced. A subset of the Virginia samples also reveals HREE concentrations that exhibit a positive slope. A more in-depth study comparing data from additional Atlantic Coastal Plain states could reveal more meaningful trends throughout the region.

The relationship between LREE and HREE concentrations and distributions in samples analyzed for the EMRI-FFA are represented in Figures 18, 19, and 20. LREE are more abundant than HREE in the total sample population. This relationship persists in both Group 1 and Group 2. Sample ratios in the summed dataset range from 0.52 to 4.82 with a mean ratio of 2.31. The Σ LREE concentrations for samples in the total sample population range between 111.19 ppm to 7,972 ppm, with an average of 1,985.94 ppm; and the Σ HREE concentrations range from 138.55 ppm to 2,063.81 ppm, with an average of 563.10 ppm. As previously mentioned, samples can be split into two distinct groups where several notable relationships are apparent. Group 1 and Group 2 exhibit notable differences with their respective LREE and HREE concentrations and their associated LREE/HREE ratios. Samples assigned to Group 1 exhibit the highest Σ LREE and highest Σ HREE concentrations with the highest LREE/HREE ratios (mean ratio of 4.29). Samples assigned to Group 2 exhibit the lowest Σ LREE and lowest Σ HREE concentrations with the lowest LREE/HREE ratios (mean ratio of 1.07).

The THM(T) data and specifically the Σ EHM, Σ SEHM (sub-economic and non-economic) fractions represented in Tables 1 and 2 above also reveal some interesting correlations within sample Groups 1 and 2. Overall, the wt. % of many of these heavy mineral species within sample

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Groups 1 and 2 are variable. With respect to abundances, *ilmenite, monazite, and xenotime are noted for their relative abundance in Group 1 samples, and in Group 2 samples only staurolite is present in relative abundance (Figure 21).

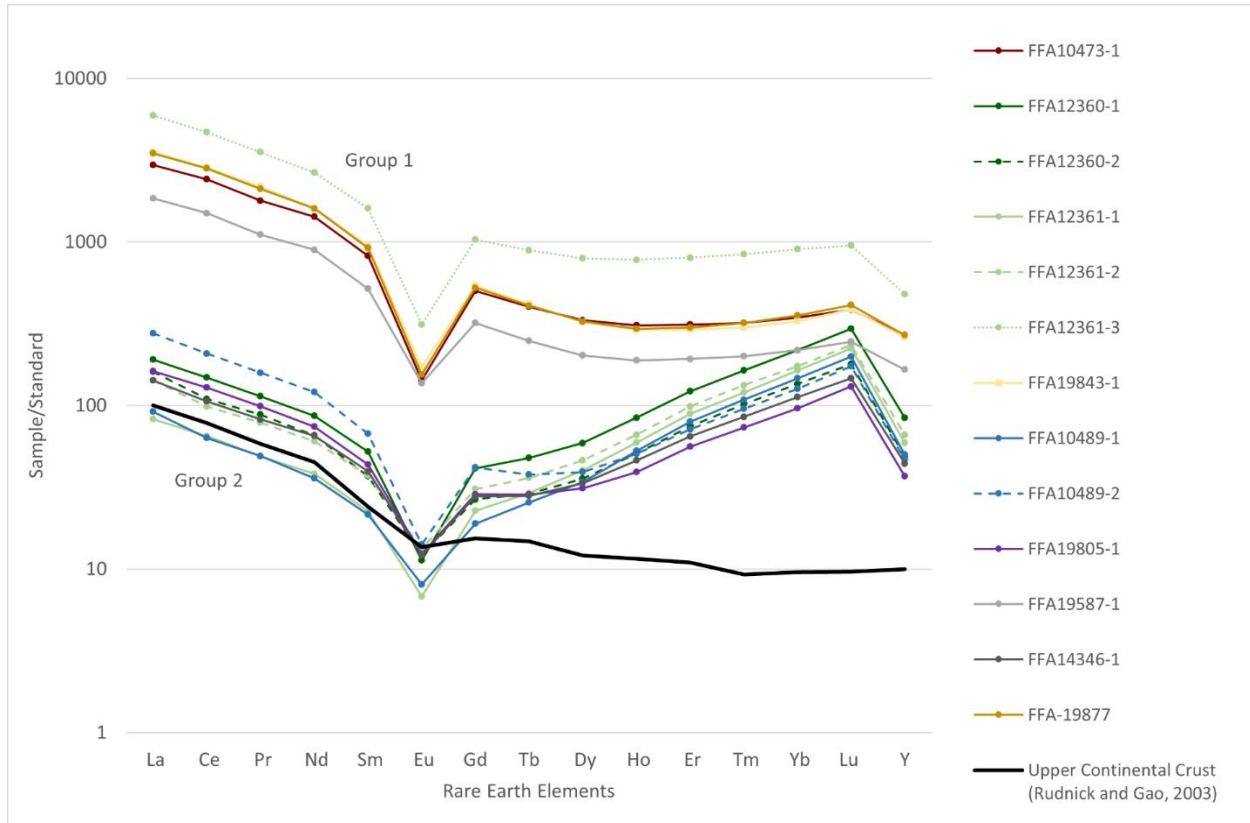


Figure 16. Chondrite normalized REE plot of all heavy mineral sand sample separates analyzed. The values for average upper continental crust from Rudnick and Gao (2003) are plotted in black. All samples are normalized to chondrite (Boynton, 1984). Group 1 and Group 2 referenced throughout this section are labeled.

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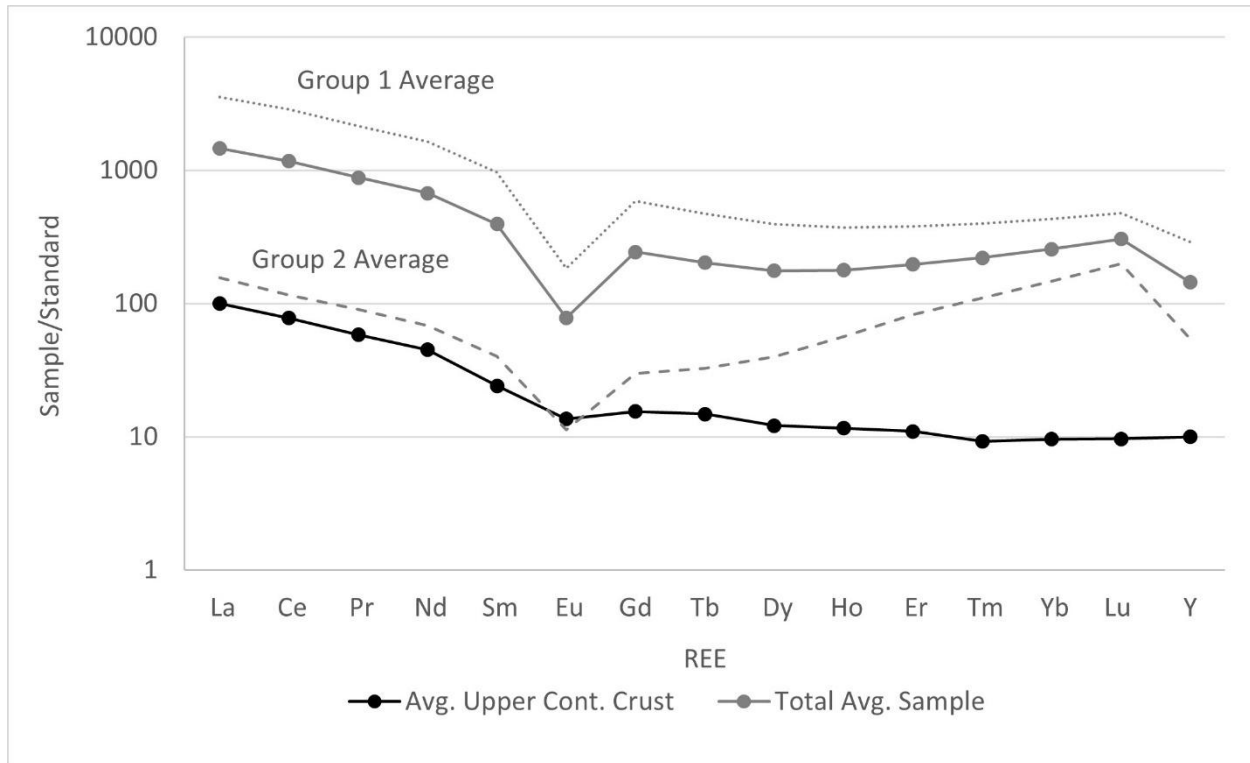


Figure 17. Spider diagram where: 1) average concentration values for upper continental crust from Rudnick and Gao (2003); 2) average concentration values for the total sample population (all 13 heavy mineral separates); 3) average concentration values for samples in Group 1; and 4) average concentration values for samples in Group 2 are indicated. All samples are normalized to chondrite (Boynton, 1984).

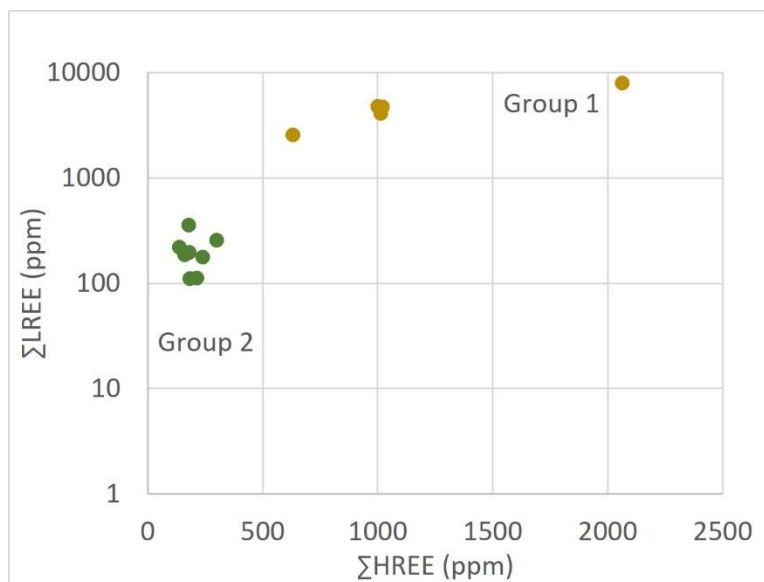


Figure 18. Scatter plot demonstrating the relationship between ΣLREE and ΣHREE concentrations for all samples. Sc is not included in the data. Group 1 (yellow) and Group 2 (Green) are indicated.

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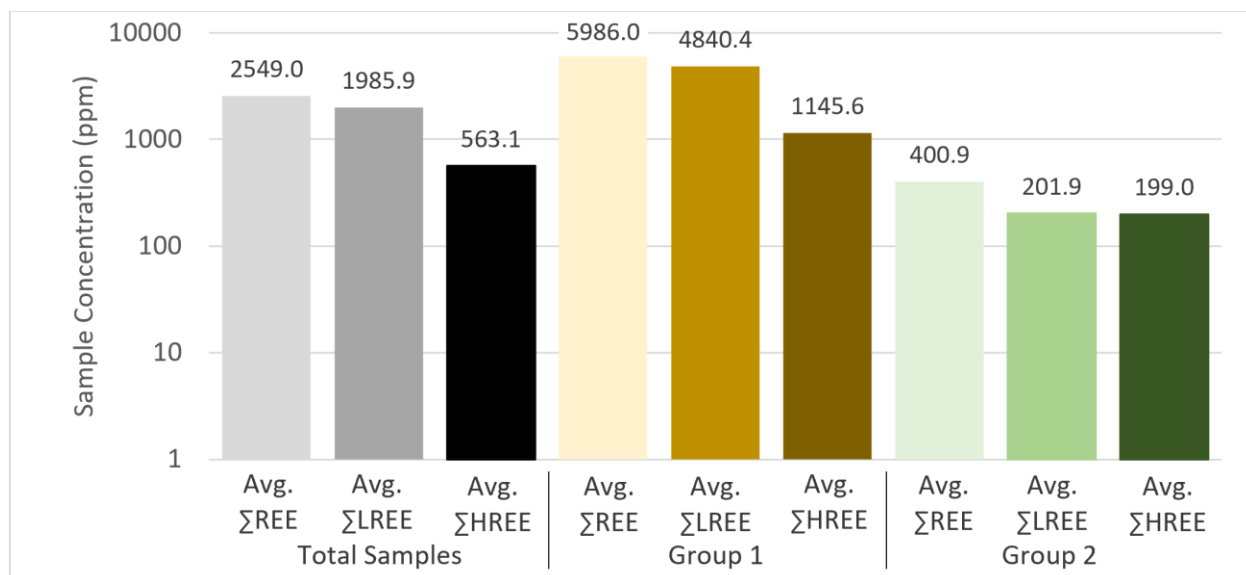


Figure 19. Average Σ REE concentrations for all samples (Total) and the sample groupings (Group 1 and Group 2).

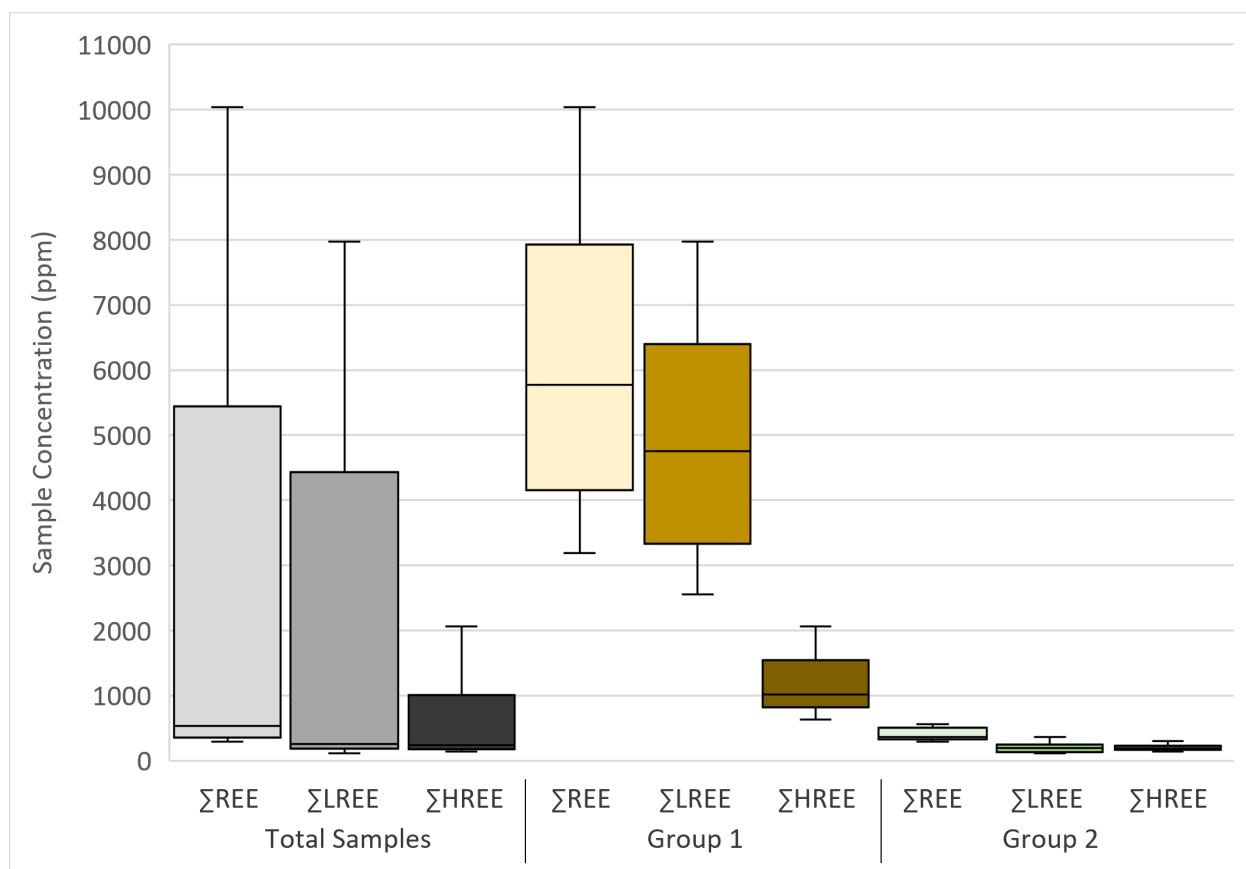


Figure 20. Σ REE concentrations for all samples (Total) and the sample groupings (Group 1 and Group 2). Minimum, maximum, median, and the interquartile range values are represented for each.

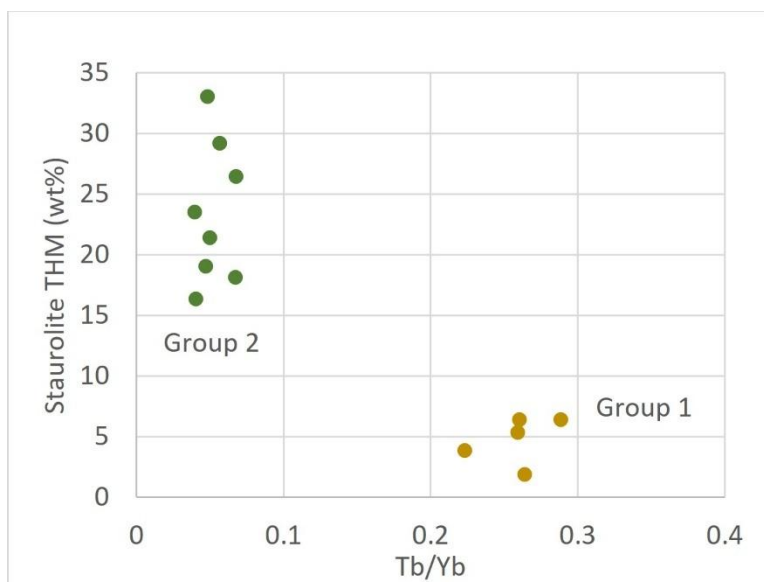


Figure 21. The wt. % of staurolite in the THM data plotted against Tb/Yb ratio highlights one of the notable distinguishing relationships between Group 1 and Group 2 samples.

Europium Anomaly

The REE spider diagrams (Figures 16 and 17) for the total sample population analyzed show a pronounced negative Eu anomaly. The Eu anomaly was calculated using the following equation where subscript N denotes a normalized element concentration value, $Eu/Eu^* = Eu_N/[Sm_N \cdot Gd_N]^{1/2}$ (Figure 22; Goldschmidt, 1954; Philpotts and Schnetzler, 1968; McLennan, 1989). Research has demonstrated an association between a negative Eu anomaly ($Eu/Eu^* < 1$) and post-Archaean shales, crustal rocks, and seawater (Taylor and McLennan, 1985; Das et al., 2006; Barros de Oliveira et al., 2007; White, 2013; Kritsanuwat et al., 2015; Lee et al., 2023). Negative Eu anomalies in sediment samples have been suggested as proxy for source characterization and an indicator of a sediment source from igneous differentiated rocks (Taylor and McLennan, 1985). Furthermore, Eu anomalies are commonly used as an indicator for the total amount of fractionation a given magma body has undergone (Weill and Drake, 1973; Fowler and Doig, 1983; Shearer and Papike, 1989). Although the majority of REE exist in the trivalent state, Eu has the capability to exist as the divalent Eu^{2+} ion and can substitute for calcium Ca^{2+} in plagioclase feldspar during igneous fractionation. Therefore, when calcium-rich plagioclase feldspar is crystallized, the cumulate becomes enriched in Eu relative to similar REE and depleted in the residual magma. While exploring our negative Eu anomaly, a couple of interesting relationships were observed. Figures 23 and 24 demonstrate some of these relationships. When comparing Eu/Eu^* values to Sr concentrations, a significant outlier was noted (Figure 23) and determined to be the result of the apatite content in that sample. The two distinct sample groupings persist in various cross plots, where Eu/Eu^* is plotted against various REE and REE ratios. Figure 22 demonstrates one of these relationships with the Eu/Eu^* and the Tb/Yb ratio.

The igneous and metamorphic rocks of the southern Appalachians are multigenerational and quite variable and are the major source for heavy mineral placer deposits in the southeastern U.S. Today, major rivers serve as the transport mechanism from the Blue Ridge and Piedmont to the Coastal Plain and modern shorelines. The proximity of known crystalline source material,

coupled with the observed heavy mineral suite in EMRI-FFA placers, and the negative Eu anomalies, suggest a significant granitic source for these placers. Data from U-Pb geochronology and related provenance studies will further facilitate our understanding of the heavy mineral suite present in the EMRI FFA.

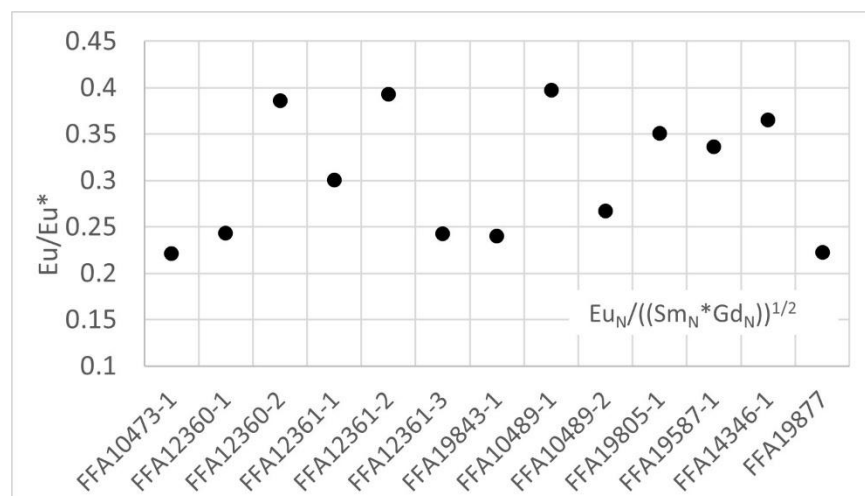


Figure 22. Cross plot of Eu/Eu* values calculated for each sample.

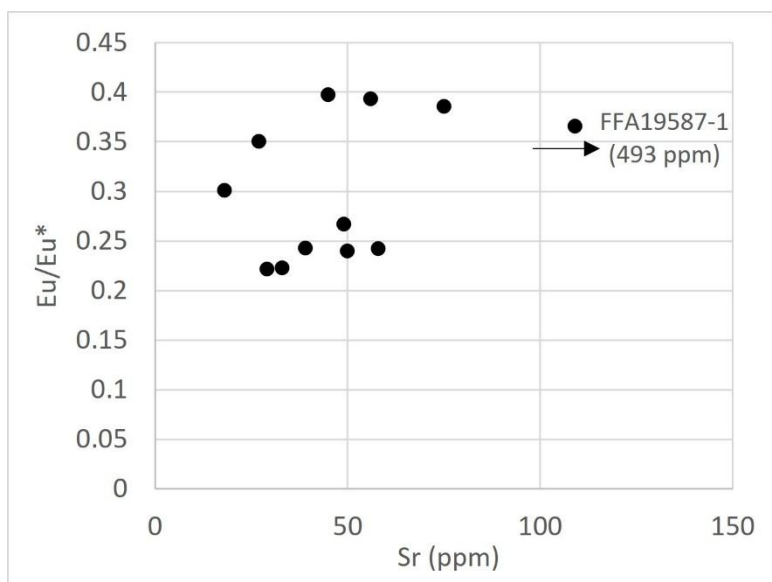


Figure 23. Relationship between the Eu/Eu* and Sr concentrations. FFA19597 is an extreme outlier with respect to Sr concentrations due to the presence of apatite, which is confirmed by both the TIMA-X data and the combined concentrations of Ca, Sr, and P in this sample.

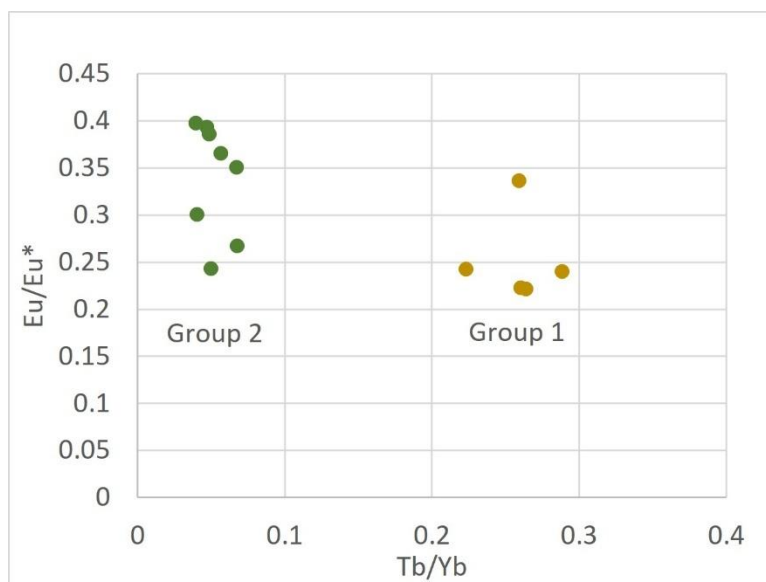


Figure 24. Cross plot of Eu/Eu^* values and the Tb/Yb ratio. Tb/Yb was selected because it encompasses the HREE series and a change of slope was observed in the data (see Figure 16).

Elemental Concentrations, Depletions, and Enrichments

The elemental concentrations reported were reviewed for any additional notable relationships that could facilitate enhanced characterization of the samples. Compared to concentration values for average UCC (Rudnick and Gao, 2003), the following statements hold true for all samples. Samples are generally depleted with respect to large-ion lithophile elements (LILE), enriched with respect to REE, and enriched with respect to high field strength elements (HFSE). Group 1 samples have highest concentration values for most elements in the LILE, REE, and HFSE groups. Group 1 and Group 2 samples exhibit concentrations that parallel average upper continental crust values for the LILE and LREE. As previously mentioned, a positive slope for Group 2 samples relative to average continental crust is observed in HREE concentrations. Group 1 samples contain the highest concentration of Th. All samples are notably enriched in Nb, Hf, Ta, Th, and U, which are likely associated with the zircon, monazite, apatite, and titanium mineral(s) suite in the individual samples (Figure 25; refer to Table 1 for THM wt. %).

Thorium and U concentrations (Figure 26) are relatively high in the heavy mineral sand separates, a relationship that was both anticipated and exploited. When making site selections for collecting subsurface samples we used the previously published airborne radiometric survey data collected by the NURE program (Duval et al., 2005). Equivalent Th (eTh) NURE data was most useful for site selection because of the mineralogy associated with the heavy mineral placer deposits. Equivalent Th (eTh) in ppm, has an energy range of 2.4 to 2.8 MeV and represents the processed and corrected data acquired by the airborne survey (Saltus et al., 1999).

The NURE data show high eTh values over Cretaceous and Tertiary Coastal Plain sediments from Cape Fear, North Carolina to eastern Alabama, with gradual decreases as distance from the Piedmont rocks increases. Additionally, Quaternary sediments along the modern Atlantic coastline are generally much lower in eTh than the Coastal Plain sediments, except where coast-parallel ridges interpreted as depositional systems (i.e. paleoshorelines) are located such as Wicomico (Trail Ridge), Penholoway, Talbot, Pamlico, and Princess Anne (Hails and Hoyt, 1969;

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Kellam et al., 1991; Shah et al., 2017). Thorium concentrations in the subsamples vary between 27.8 ppm and 749 ppm, with an average of 197.63 ppm. Uranium concentrations in the samples vary between 23.91 ppm and 239 ppm, with an average of 69.74 ppm. Our subsamples analyzed contain concentrations of Th that are 19 times higher than the value reported for average UCC (29 ppb) and concentrations of U that are 26 times the average UCC (7.4 ppb; Rudnick and Gao, 2003).

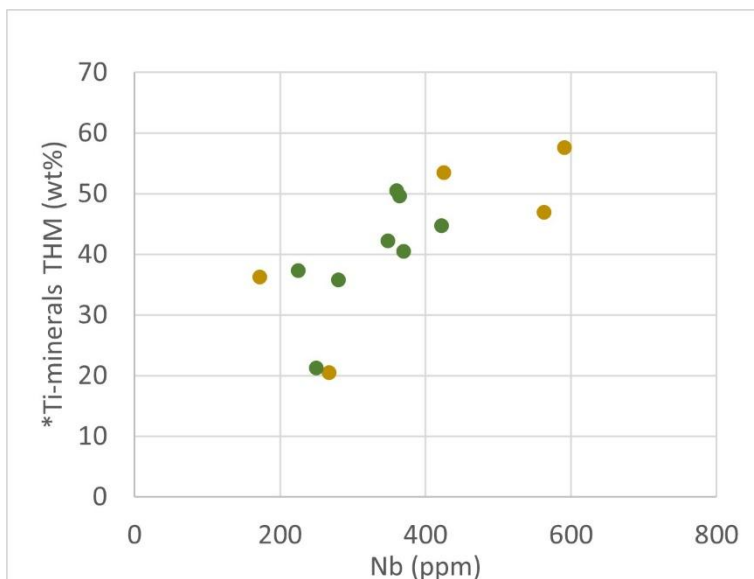


Figure 25. Cross plot of wt. % (*leucoxene, *rutile, *ilmenite, titanite) and niobium concentrations (ppm). A positive relationship exists between *Ti-minerals and Nb. Yellow markers represent Group 1, green Group 2.

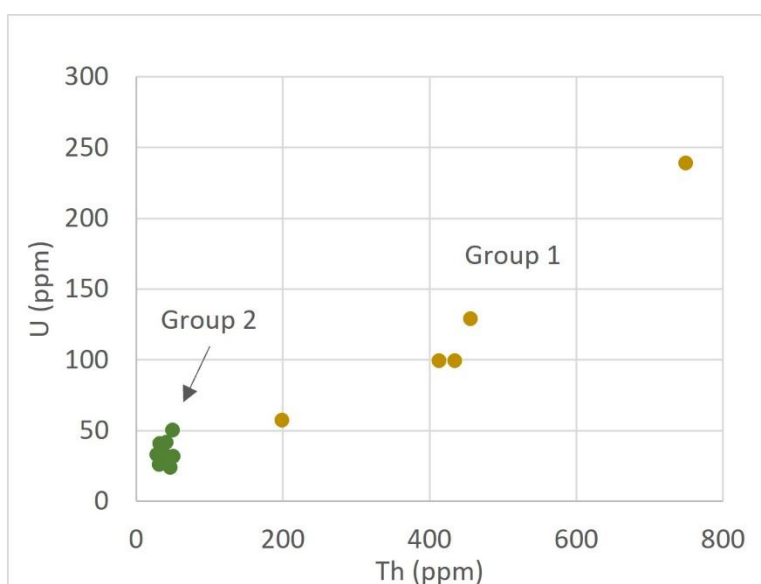


Figure 26. Cross plot of U and Th concentrations for the total sample population, Group 1 (yellow), and Group 2 (green).

GEOLOGIC SUMMARY AND DISCUSSION OF LITHOSTRATIGRAPHIC UNITS

The following geologic summary and discussion of subsurface structures, surface geomorphology, and lithostratigraphic units exceeds the scope of the heavy mineral investigations presented above but is intended to support and supplement the mapping deliverables. The heavy mineral analyses performed provide insight into the characterization of various surficial geologic units with an emphasis on the Cypresshead Formation discussed at length below.

Structure

Florida's subsurface structural geologic framework is not expressed at the land surface due to limited topographic relief combined with the thick packages of relatively young carbonate and siliciclastic cover. Most of the available geologic data for Florida's lithostratigraphic units is represented in borehole samples (i.e., cores and cuttings) and geophysical data. Features identified within or proximal to the study area that have influenced the stratigraphy observed within the EMRI-FFA (surficial and subsurface) are discussed briefly herein. Previous authors attribute the evolution of these features to various mechanisms (i.e., structure vs. erosion or nondeposition). The interpretations presented herein reflect the present consensus or best representation based on the current information at hand.

Figure 27 highlights several features in Florida's subsurface framework that relate to, or have influenced, the expression of pre-Pliocene units that occur within the study area. These features include those which comprise the Georgia Channel System (Apalachicola Embayment, Tallahassee Embayment, Chattahoochee Embayment, Gulf Trough, Suwannee Channel, and Southeast Georgia Embayment; Toulmin, 1955; Herrick and Vorhis, 1963; Huddlestun, 1993), the Peninsular Arch (Applin and Applin, 1944; Applin, 1951; Chen, 1965; Huddlestun, 1993; Renken, 1996), and the Jacksonville Basin (Goodell and Yon, 1960).

The Georgia Channel System encompasses several features or components thereof and covers a large swath of southern Georgia and northern Florida. Several features/components identified within the Georgia Channel System have been referenced by various authors and by different names throughout the literature. The interpretation presented here is that of Huddlestun (1993) where the system evolved over an extended period of geologic time ranging from the Late Cretaceous through the early Tertiary. The Suwannee Current occupied the Georgia Channel System periodically during the Late Cretaceous and into the early Tertiary (Huddlestun, 1993). The channel system flanks the northern extent of the Florida Platform and formed during a period of non- or limited sediment deposition under the axis of the Suwannee Current (Huddlestun, 1993). Spatial and temporal distinctions have been made within the channel where younger features are partially superimposed on components that are interpreted as older. The older channel, referred to as the Suwannee Channel, is a Late Cretaceous (Taylorian-Navarroan) through middle Eocene channel that connected the Tallahassee Embayment in the Florida Panhandle to the Southeast Georgia Embayment on the Atlantic-side of the northern peninsula (Huddlestun, 1993). The second, and younger channel/component of the Georgia Channel System, is the Gulf Trough (middle Eocene to middle Miocene), which interacts with another negative topographic feature referred to as the Chattahoochee Embayment (Huddlestun, 1993). Both southwestward-flaring negative topographic features combined represent the Apalachicola Embayment (Huddlestun, 1993).

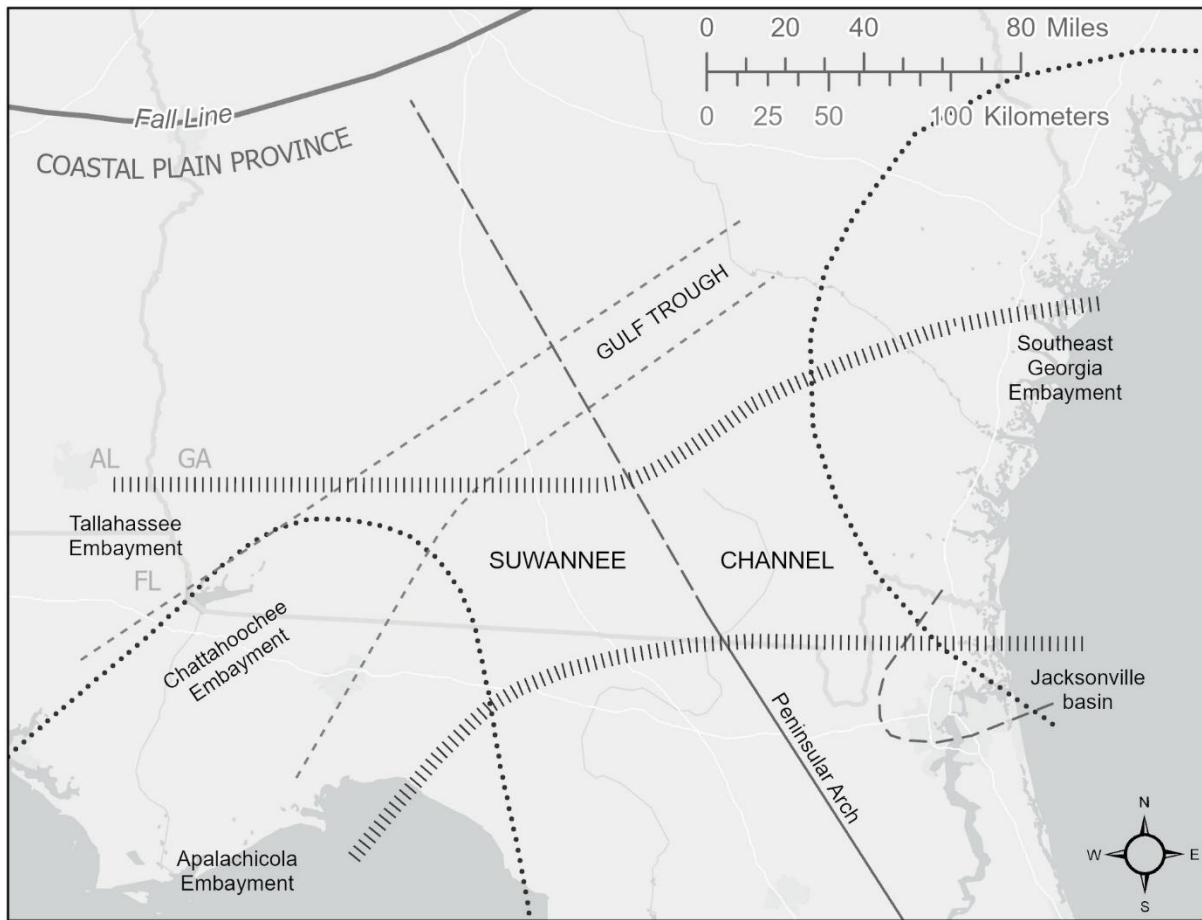


Figure 27. Prominent subsurface features that relate to or have influenced the expression of pre-Pliocene units encountered within this study area. Geometries of features are modified from sources referenced and based on observations in this study (Chen, 1965; Huddleston, 1993; Renken, 1996).

The Peninsular Arch has historically been interpreted as a positive structural feature and/or a positive paleotopographic feature. The extension of its axis north and into Georgia is critical to our understanding and characterization of the feature. In Georgia, the Peninsular Arch influences the thickness of overlying units as young as middle Eocene (Claibornian). It is described as a subtle feature by Huddleston (1993) that has been overprinted by the Georgia Channel System. However, it is not observed structurally influencing any post-Cretaceous units along strike and to the south in Florida (Applin and Applin, 1967; Maher, 1965; Maher and Applin, 1971; Huddleston, 1993). Regardless of its evolution, the Peninsular Arch does appear to affect Oligocene and subsequent deposition. Furthermore, it represents a stratigraphic high with respect to Florida units and their observed structural surfaces below land surface and represents a pseudo hinge line between the Gulf of America (formerly referred to as the Gulf of Mexico) and Atlantic Ocean and their associated basin(s).

The Jacksonville basin represents a deepening and thickening of Miocene strata in the vicinity of Jacksonville, Florida. This basin is apparent from the structural surface of the Ocala

Limestone. The overlying Oligocene section is notably absent from the stratigraphy. It has been suggested that the Jacksonville basin is structurally controlled by faults and downwarping (Goodell and Yon, 1960). However, no direct evidence of faulting has been documented. The thick packages of Miocene sediments in the deepest part of the basin appear to thin and their structural surfaces gradually approach the land surface near the margin(s) of the basin. Therefore, the Jacksonville basin likely represents a negative topographic feature that provided ample accommodation space for this well-developed basin and the associated fill/deposition.

Geomorphology

The EMRI-FFA study area encompasses an area characterized by three geomorphic districts: 1) the Barrier Island Sequence District; 2) the Okefenokee Basin District; and 3) the Lakes District (Figure 28). The surficial geology of these districts is composed primarily of Tertiary-Quaternary quartz sand and clay deposits. The western extent of the EMRI-FFA study area approaches the Ocala Karst District, a fourth geomorphic district whose surficial geology is distinctly different than the other three, where Eocene to Miocene carbonates are present at or near the surface. The three districts listed above will be discussed briefly herein. For an in-depth discussion of Florida geomorphology, please see Williams et al. (2022).

Samples collected for both mineralogic and geochemical analyses were selected in part based on the geomorphic expression of the Cypresshead Formation in and along relict ridges within the Barrier Island Sequence District. Several of these relict ridges align with, or are on trend with, the paleoshorelines defined by Hails and Hoyt (1969) and Pirkle et al. (2013).

The Barrier Island Sequence District (Clark and Zisa, 1976) continues from Florida into Georgia and based on regional lidar likely continues northward into Virginia, where similar coastal geomorphology extends up the Atlantic coastline. The Barrier Island Sequence District encompasses roughly 1,920 square miles of the EMRI-FFA. This district is characterized by north-south trending Pliocene to Holocene beach ridge systems, barrier island complexes, lagoons, embayments, and shallow water terraces (Williams et al., 2022). The modern topographic surface has been shaped by previous sea-level stands from the Pliocene to modern day, and the subsequent development and evolution of strand plains, tidal marshes, barrier islands, and the trellis drainage that result. Major rivers throughout the region have affected surface landforms, helping to guide erosion, transport, and deposition. These rivers facilitate the source to sink connection for the non-native mineralogic framework observed in Florida's heavy mineral placer deposits. The Barrier Island Sequence District is composed of 11 distinct provinces (Plate 3), six of which occur in the FFA. These include the: 1) Duval Upland Province; 2) Sea Islands Province; 3) Trail Ridge Province; 4) Atlantic Coastal Complex Province; 5) Lower St. Johns River Valley Province; and 6) St. Marys Plain Province.

The Okefenokee Basin District, which includes the Okefenokee Swamp, occurs in north-central peninsular Florida and extends into Georgia. The Okefenokee Basin District encompasses roughly 252 square miles of the EMRI-FFA. This district is characterized by Miocene to Pleistocene(?) strata. Prominent geomorphic features include low lying wetlands in the northern part of the district near the Okefenokee Swamp and in swales between coastal features with higher relief (i.e., Lake City Ridge and Raiford Ridges; Williams et al., 2022). The topographic surface and modern-day drainage reflect these relict features. The wetlands and ridges drain via the St. Marys, Suwannee, Alapaha, and Santa Fe rivers. The Okefenokee Basin District is composed of

three provinces, all of which occur within the FFA. These include the: 1) Ocean Pond Plain Province; 2) Lake City Ridge Province; and 3) Raiford Ridges Province.

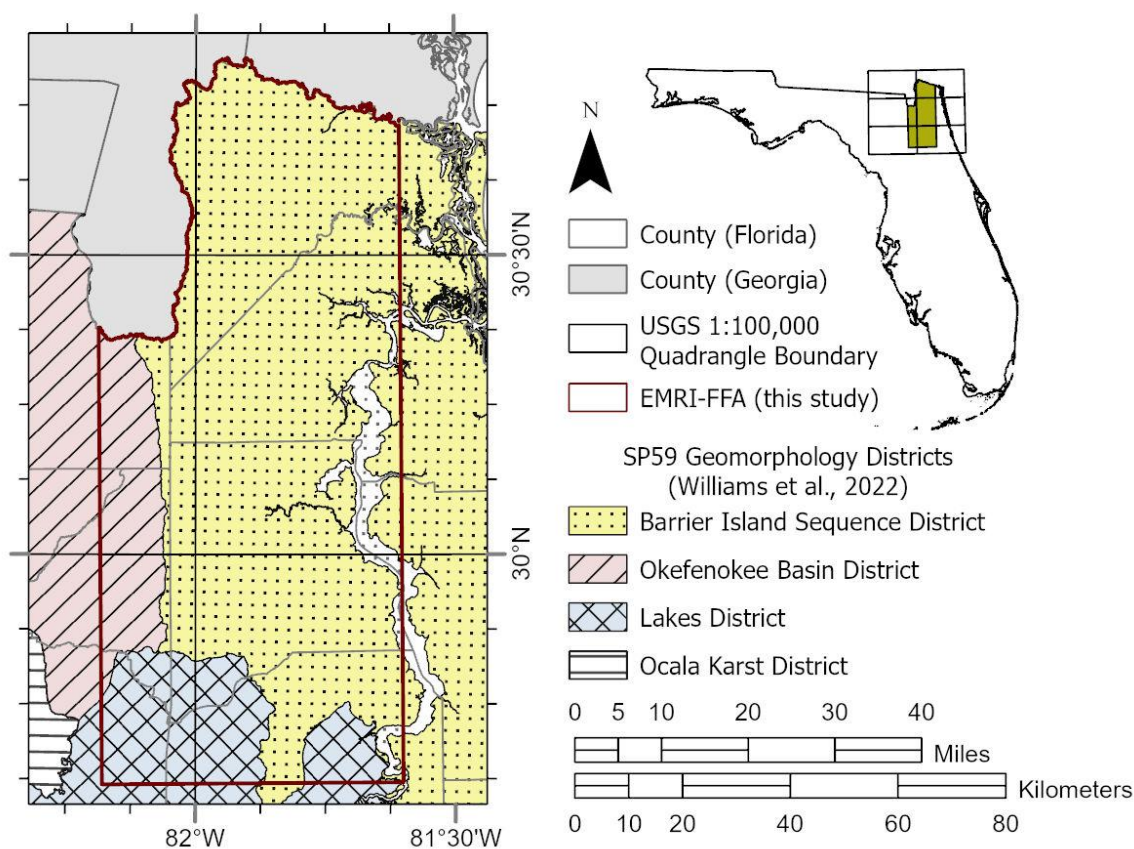


Figure 28. Geomorphic districts within the EMRI-FFA study area (after Williams et al., 2022). See Plate 3 for districts and provinces.

The Lakes District occurs in central peninsular Florida and extends from the southern portions of the EMRI-FFA to the southern tip of the Lake Wales Ridge Complex Province. The Lakes District encompasses 333 square miles of the EMRI-FFA. This district is characterized by Miocene to Holocene strata and prominent geomorphic features include north-south trending ridges, large lakes, and segments of the St. Johns River valley (Williams et al., 2022). In the EMRI-FFA, the northern portion of the Lakes District is marked by extensive karstification of carbonates in the subsurface. Here the dissolution is pervasive enough where several large sinkholes are expressed at the surface and have developed through the overlying Cypresshead Formation sediments. Trail Ridge at its southern extent approaches its highest elevations. This coincides with a thinning of the siliciclastic deposits. Authors have suggested karstification as a method of rejuvenation and later stages of uplift (Adams et al., 2010; Creveling et al., 2019). The Lakes District is composed of 13 provinces, three of which occur within the FFA. These include the: 1) Hawthorne Lakes Province; 2) Palatka Hill Province; and 3) St. Johns River Offset Province.

FLORIDA GEOLOGICAL SURVEY

Lithostratigraphic Units

All lithostratigraphic units discussed in this report appear on the accompanying plates (Plate 1 and Plate 2) and in Figure 27. The plates include a surficial geologic map (Plate 1), associated cross sections (Plate 2), and the surficial geomorphology (Plate 3) of the EMRI-FFA. In addition to defining their characteristics within the EMRI-FFA, each lithostratigraphic unit includes a discussion of historical interpretations and references.

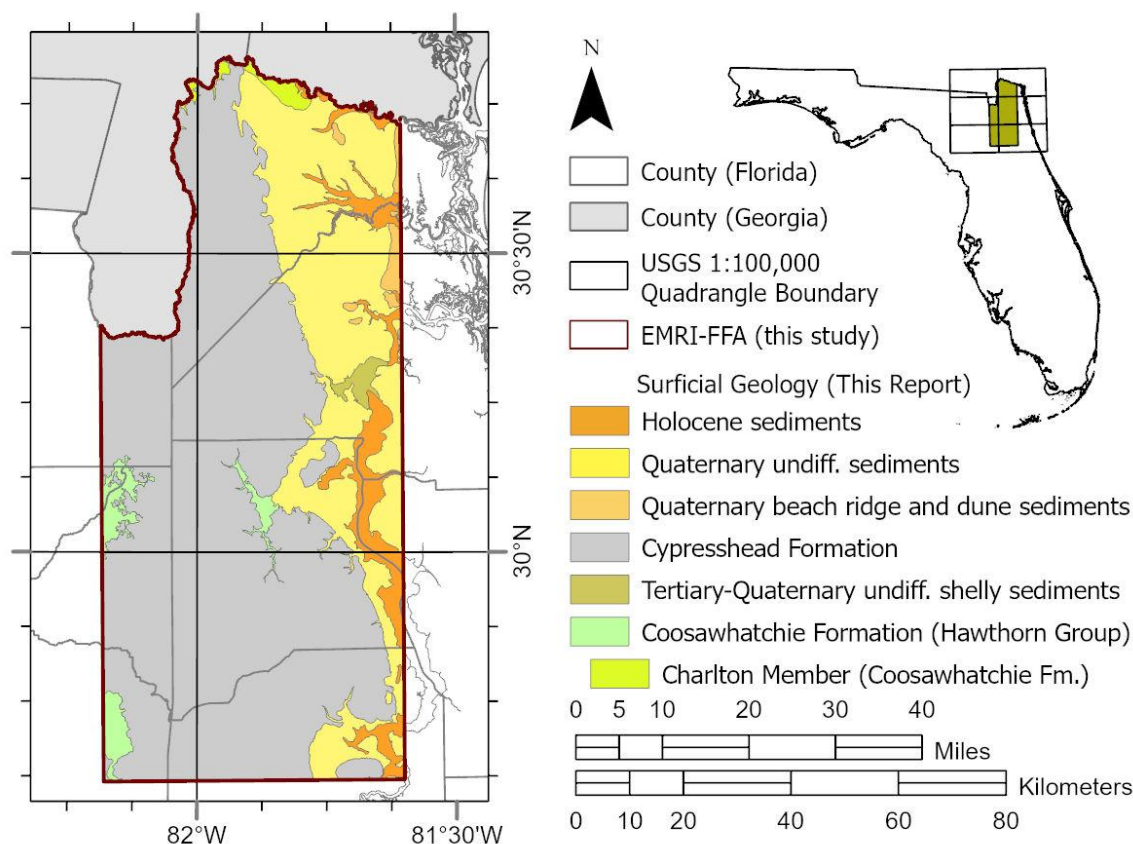


Figure 29. Simplified surficial geologic map of the EMRI-FFA. See corresponding Plates 1 and 2 for more detailed information.

Tertiary System

Eocene Series

Avon Park Formation

The middle Eocene Avon Park Formation (Tap) was first described by Applin and Applin (1944) and is a subsurface unit that is encountered in various boreholes within the study area. The Avon Park Formation consists of two predominant lithologies: limestone and dolostone. However, this unit is often described as a dolomitized limestone. Following the Dunham classification system (Dunham, 1962), the limestones consist of cream to light brown to tan, poorly- to well-indurated, variably fossiliferous grainstone, packstone, and wackestone, with rare occurrences of

mudstone. They are often interbedded with tan to brown, very poorly- to well-indurated, very fine- to medium-crystalline, fossiliferous (molds and casts), vuggy dolostones. Minor clay beds and organic-rich laminations occur throughout the unit. Accessory minerals include chert, pyrite, celestine, gypsum and quartz (exhibiting various crystal habits, typically ranging from euhedral to subhedral in vugs). Evaporitic rock material, such as gypsum and anhydrite, are more abundant at depth. Fossils present in the Avon Park Formation include mollusks, foraminifera (*Spirolina sp.*, *Lituonella floridana*, *Bolivina spp.*, *Cushmania americana*, *Cribratulina cushmani*, *Fabiana cubensis*) echinoids (*Neolaganum dalli*), algae, and carbonized plant remains. Porosity in the Avon Park Formation is generally considered intergranular or intercrystalline. Fractured porosity is common in more densely recrystallized, sucrosic, dolostones. Where the Avon Park Formation is heavily dolomitized, sucrosic textures are common and intercrystalline porosity dominates.

The Avon Park Formation unconformably overlies the lower Eocene Oldsmar Formation and is unconformably overlain by the upper Eocene Ocala Limestone. The Avon Park Formation was deposited within a broad, distally steepened carbonate platform setting (Budd, 2002). Highly cyclical deposits of carbonate sediments that accumulated in supratidal to shallow subtidal environments are represented in the Avon Park Formation and reflect repeated short-term changes in relative sea level throughout the middle Eocene (Randazzo et al., 1990; Budd, 2002; Arthur et al., 2008).

Ocala Limestone

The upper Eocene Ocala Limestone (To), first described by Dall and Harris (1892), is a biogenic marine fossiliferous limestone comprised largely of benthic foraminifera, mollusks, echinoids, and bryozoans and occurs as a subsurface unit in the study area. The Ocala Limestone is foraminifera-rich and often easily identifiable in core and cuttings. Based on the distinctive lithology, the Ocala Limestone has been informally subdivided into upper and lower facies (Scott, 1991). The upper facies is typically a white to cream, fine- to coarse-grained, poorly- to well-indurated, poorly- to well-sorted, very fossiliferous limestone (predominantly wackestone, packstone, and grainstone). Fossils commonly include large benthic foraminifera (*Lepidocyclina ocalana*, *Nummulites vanderstoki*, *Nummulites ocalana* and abundant miliolids), bryozoans, mollusks, and a rich diversity of echinoids. The lower facies is typically a white to cream, fine- to medium-grained, poorly- to moderately-indurated, moderately- to well-sorted limestone (grainstone to packstone). Fossils include large benthic foraminifera (*Amphistegina pinarensis* and abundant miliolids), bryozoans, algae, mollusks, echinoids, and crustaceans. The Ocala Limestone was deposited on a distally steepened, carbonate ramp in a shallow, subtidal to intertidal, somewhat high energy, open marine environment (Randazzo et al., 1990; Cander, 1994; Loizeaux, 1995; Arthur et al., 2008). This formation represents a more constant and stable depositional environment than the underlying Avon Park Formation (Randazzo et al., 1990).

The Ocala Limestone does not crop out within the EMRI-FFA but occurs at depth in core and cuttings samples and is a useful marker bed and boundary that illustrates the basin geometry and accommodation space prior to the onset of Miocene sedimentation. The Ocala Limestone unconformably overlies the Avon Park Formation, and it is unconformably overlain by the lower Oligocene Suwannee Limestone in areas where it has not been eroded away. In areas where the Suwannee Limestone is missing, as is the case for the EMRI-FFA, Oligocene-Miocene Hawthorn Group unit(s) unconformably overlie the Ocala Limestone.

FLORIDA GEOLOGICAL SURVEY

Oligocene-Miocene Series

Hawthorn Group

In northeast Florida, the Oligocene-Miocene Hawthorn Group is subdivided into three formations. In the EMRI-FFA, all three north Florida Hawthorn Group formations occur primarily in the subsurface. Only the Coosawhatchie Formation and its subunits crop out within the study area. The northern peninsular Florida Hawthorn Group formations include the Penney Farms Formation (Thpf), the Marks Head Formation (Thmh), and the Coosawhatchie Formation (The) (Scott, 1988; Green et al., 2016a; Green et al., 2016b). These formations are highly variable lithologically and can be difficult to identify as they are rarely exposed at the surface within the EMRI-FFA. Formation picks can be particularly difficult when looking at drill cuttings and “disturbed samples” where sample intervals are large and/or gaps occur intermittently. As previously indicated, the Hawthorn Group unconformably overlies the Ocala Limestone within the EMRI-FFA, and therefore the contact between these lithostratigraphic units is primarily observed in core. At other localities, outside the study area (Georgia and Florida), these contacts are exposed in outcrop. The nature of this contact is apparent based on an irregular erosional surface both observed and inferred from detailed lithologic descriptions. In the western portions of the EMRI-FFA, the Hawthorn Group is unconformably overlain by younger, dominantly siliciclastic units including the Pliocene-Pleistocene Cypresshead Formation (TQc), the Tertiary-Quaternary undifferentiated shelly sediments (TQsu), and the Quaternary undifferentiated sediments (Qu).

The deposition of the Hawthorn Group signifies a marked change in sedimentation and depositional environment across Florida, when an influx of siliciclastic material sourced from the southern Appalachians was transported onto the Florida Platform at the beginning of the Neogene. Interpreting the geologic history and depositional environment(s) for Hawthorn Group units is further complicated by fluctuations in sea level. Marine transgressions and regressions are recorded by the dominant sediment type and associated accessory minerals. Beds where carbonates dominate are interpreted to represent periods of relatively higher sea level stands, or transgression, while beds dominated by siliciclastics represent periods of lower sea level stands or regression. These complex depositional environments developed throughout the Miocene and ranged from prodeltaic to open, shallow marine, carbonate bank. The lower section of the Hawthorn Group (Penney Farms and Marks Head Formations) is interpreted to represent a shallow marine environment based on its mineralogic framework and fossil occurrence (Scott, 1988). The Coosawhatchie Formation is also thought to have been deposited in a subtidal, shallow marine environment (Scott, 1988), but notably contains more siliciclastics and fewer carbonate beds compared to the underlying Hawthorn Group units. Hawthorn Group undifferentiated is invoked in areas where internal formalized units are indistinguishable.

Penney Farms Formation

The type core for the lower Miocene Penney Farms Formation (W13769) is located near Penney Farms, Florida in Clay County. The Penney Farms Formation (Thpf) represents the basal unit of the Hawthorn Group in northern and central peninsular Florida and consists of carbonates interbedded with quartz sand, phosphatic sand, and clay in varying proportions. The top of the Penney Farms Formation is recognized by the occurrence of a dark gray to olive gray clay or a dark gray-green, highly recrystallized dolostone bed. The carbonate beds in this formation are moderately- to well-indurated, medium gray to olive gray dolostone, occasionally containing

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mollusk molds. The dolostone is typically highly recrystallized with accessory quartz sand, phosphatic sand, and clay. The quartz sand ranges from very fine to medium grained, is moderately sorted, and is subangular to subrounded. Phosphatic sand is common in this formation, and is generally present as an accessory of 5-10 percent, but is observed in excess of 20 percent at some localities.

The Penney Farms Formation does not crop out within the EMRI-FFA. This unit unconformably overlies the Ocala Limestone and is unconformably overlain by the Marks Head Formation. Scott (1988) recognized two informal, unnamed members within the Penney Farms Formation. The contact between these two members is marked by a gradual change in sedimentation and a transition from dominantly siliciclastic material in the upper member into dominantly carbonate material in the lower member (Scott, 1988).

Marks Head Formation

The type core for the lower Miocene Marks Head Formation (W14219) is the Jennings # 1 Core from Clay County, Florida. The Marks Head Formation (Thmh) is the most lithologically variable formation in Hawthorn Group within the EMRI-FFA. It consists of interbedded sands, clays, and carbonates. Dolostone is the dominant form of carbonate represented in the Marks Head Formation. Limestone beds occur, but are less common. The carbonate beds in the Marks Head Formation are typically more indurated than those in the overlying Coosawhatchie Formation. Mollusk molds are commonly present. The quartz sand is fine- to coarse-grained, poorly- to moderately-sorted, and subangular to subrounded. Phosphate content varies but is generally between 5 and 20 percent, with grain sizes ranging from sand to gravel. Additionally, phosphatized fossil shark teeth are common in this formation.

The Marks Head Formation unconformably overlies the Penney Farms Formation. The contact between these units is marked by a transition from lighter- to darker-colored sediments (Scott, 1988). The Marks Head Formation is unconformably overlain by the Coosawhatchie Formation, with the top of the unit typically being placed at the first hard, carbonate bed (Scott, 1988).

Coosawhatchie Formation

The middle Miocene Coosawhatchie Formation (The) is the uppermost formation in the Hawthorn Group and one of the only Hawthorn Group formations to crop out within the EMRI-FFA. The Coosawhatchie Formation was originally proposed as a formalized unit in Georgia by Huddlestun (1988). Three members are recognized: 1) an informal lower unit; 2) an informal upper unit; and where present, 3) the Charlton Member (discussed below). The Coosawhatchie Formation is composed of interbedded sands, clays, and dolostones. The dolostone is typically sandy, silty, and poorly indurated. The quartz sand is fine to medium grained, poorly to moderately sorted, and subangular to subrounded. Phosphatic sand content varies but typically ranges from 2 to 10 percent.

The Coosawhatchie Formation unconformably overlies the Marks Head Formation. The contact is typically marked by a hard carbonate bed. Additionally, the Coosawhatchie Formation is stratigraphically overlain by younger siliciclastic units. This contact is interpreted as unconformable and is easily identified by the contrast in clay, carbonate, and phosphate content present in the upper part of the Coosawhatchie Formation or Charlton Member (where present).

Charlton Member

The middle Miocene Charlton Member (Thcc) of the Coosawhatchie Formation (Hawthorn Group) is the only formally recognized member of the Coosawhatchie Formation. It can be observed in outcrop within the EMRI-FFA, specifically along the St. Marys River (Plate 1). Where present, the Charlton Member is the stratigraphic top of the Hawthorn Group within the EMRI-FFA. This unit is composed of interbedded carbonate and clay and contains significantly less quartz sand and phosphatic sand than other Hawthorn Group units (Scott, 1988). The carbonate beds in this unit range from dolostones to limestones, which often contain abundant mollusk molds, and are typically yellowish gray to light gray. The clays in this member are typically dolomitic to calcareous and range from light gray to yellowish gray, with a more blue/greenish-gray color in the far northwest portion of the mapping area. The Charlton Member overlies all other interbedded sands, clays, and dolostones of the Coosawhatchie Formation and is unconformably overlain by younger siliciclastic units.

Tertiary-Quaternary Systems, Pliocene-Pleistocene Series

A preliminary discussion of the Pliocene/Pleistocene-Holocene series is provided to lend reference and insight to the historical evolution of interpretations and the ones provided here. The interpretation of map units within the study area has evolved since the early 1900s with the advance of ideas, our understanding of the geological sciences, data collection, improved field and laboratory techniques, and the development and adherence to the North American Stratigraphic Code. With respect specifically to the study area and paleoshorelines, the early interpretations and nomenclature were extended into Florida from the northern extents of the Atlantic Coastal Plain where ‘terrace’ deposits and ‘escarpments’ stack and trace along the margin’s edge. The northern features seemingly trace southward into the paleoshoreline deposits that are the focus of this report. William J. McGee of USGS, whose focus was surficial deposits, provides several discussions of these geomorphic features, their characterization, and correlation(s). McGee describes “a practically continuous series of terraces and beach marks...a series of shorelines...generally more profoundly modified by erosion” (Shattuck, 1901). Where initially defined, these features and the terms applied seem to closely agree. The northern geomorphic features, interpreted as ‘terrace’ and ‘scarp’ deposits, often represent prominent topographic features marking the landscape that formed through a series of depositional and erosional processes. They are defined as consisting of paleoshoreline deposits and associated marine escarpments formed by an oscillating though dominantly retreating ocean following Pleistocene glaciations. These geomorphic features are coastline parallel, represent subsequent fluctuating sea-level(s); a consequence of glacial retreat, isostatic rebound, and associated sedimentation (Shattuck, 1901; Veatch and Stephenson, 1911; Cooke, 1945; MacNeil, 1950; Scott et al., 1986; Huddlestun, 1988). Many of these features have been characterized based on their elevations, though the range in regional response to sea-level changes, geometry of the margin/coastline, and isostasy resulted in greater topographic expressions in northern exposures.

In Georgia and Florida, similar discussions called for ‘terrace’ correlation, and others arguing for an environment unlike many of the northern counterpart erosional features. However, ‘terrace’ designations and their associated nomenclature dominated the literature (USGS, Georgia Geological Survey, and FGS) up through the 1970s and 1980s. Much of the work during this time commonly applied stratigraphic unit and formation level designations to these geomorphic features. The relationships were so intertwined that to reference the work, warranted a discussion

of geomorphology versus lithology. Huddlestun (1988) offered revisions of the stratigraphy in the Southeastern Coastal Plain and included a comprehensive background of the issues addressed, units, features, and the associated nomenclature. For the most part, in the 1980s, much of the geologic work and mapping shifted in favor of unit designations based on lithology, age, and correlation. As a result, formation level designations as applied to geomorphic units was largely abandoned and much of the stratigraphic nomenclature of the surficial geology in the area took shape and is still used to this day.

The Florida Geological Survey has in part included informal lithostratigraphic units and geomorphic units on the statewide surficial geologic map (Scott et al., 2001) of Florida in order to facilitate a better understanding of Florida's more recent geologic history. The nature of these deposits often presents a challenge when elevating a lithostratigraphic unit to a formalized rank. While a more detailed and informative map product is achieved, unit correlations remain challenging, and interstate stratigraphic correlations remain in part ununified. Moving from the era of using the 'terrace' deposits nomenclature and into one of using formal and informal lithostratigraphic nomenclature, stratigraphic interpretations in northeast Florida and within the EMRI-FFA have varied since county scale mapping began around 1992.

On the Geologic Map of Baker County (Scott, 1993), the area west of Trail Ridge is interpreted to be Tertiary-Quaternary undifferentiated (TQu) sediments, an informal lithostratigraphic unit. However, Scott indicates that there may potentially be Cypresshead Formation within the mapped area. The authors here presently agree with this interpretation and, as discussed below, believe the sediments currently mapped as Tertiary-Quaternary undifferentiated sediments should be investigated and reevaluated.

The Surficial Geologic Map of Florida (Scott et al., 2001) depicts several informal lithostratigraphic and geomorphic units within the study area. For example, Trail Ridge, a geomorphic province, is mapped as Trail Ridge sands. Tertiary-Quaternary undifferentiated sediments are mapped west of the Trail Ridge sands, and east of Trail Ridge the Cypresshead Formation is mapped. The Cypresshead Formation encompasses the entirety of the Duval Upland within the study area. The Duval Upland and Trail Ridge are both geomorphic provinces located within the larger Barrier Island Sequence District which notably includes the geomorphic features associated with the Wicomico, Penholoway, and Talbot paleoshoreline deposits. Huddlestun (1988) provides a discussion, with respect to the age of the Cypresshead Formation and the three Pleistocene shoreline deposits mentioned, regarding younger 'terrace' development atop the Cypresshead Formation. We presently find a stronger argument for their inclusion within the Cypresshead Formation rather than invoking a new informal lithostratigraphic unit.

Green et al. (2016a; 2016b) provide alternative surficial geologic unit interpretations within the study area to those presented in this study. East of the Trail Ridge Province (shown on the map as Trail Ridge sands; Green et al. 2016a), in the area formerly mapped as the Cypresshead Formation, they assign the area to another informal lithostratigraphic unit referred to as Quaternary undifferentiated sediments. Based on our lithologic and stratigraphic investigations and interpretations, we extend the Cypresshead Formation to once again encompass the area that comprises the Duval Upland Province and contains the geomorphic features correlated to the Wicomico, Penholoway, and Talbot systems.

FLORIDA GEOLOGICAL SURVEY

Tertiary-Quaternary undifferentiated sediments

Tertiary-Quaternary undifferentiated sediments (TQu) are an informally recognized lithostratigraphic unit that consist of siliciclastics and are differentiated from the Quaternary undifferentiated sediments (Qu) solely on the basis of elevation (Scott, 2001). Pleistocene sea level reached a maximum of approximately 100 feet above mean sea level (MSL; Colquhoun et al., 1991). The sediments which occur above 100 feet MSL are interpreted as older than Pleistocene but may have been reworked through subsequent surficial geomorphic processes.

Tertiary-Quaternary undifferentiated sediments are comprised of poorly consolidated to unconsolidated coarse- to fine-grained quartz sand that range in color from white to gray, tan to orange. Accessory minerals include clay, heavy minerals, mica, and variable amounts of organic matter. Thicknesses of the TQu can vary throughout the mapping area. Although the current authors do not interpret or map this unit within the EMRI-FFA, it is mentioned here because of previous investigations where this unit has been defined and recognized west of Trail Ridge as occurring stratigraphically above the Hawthorn Group units. Traditionally, this unit represents the stratigraphic top of the section west of Trail Ridge within the EMRI-FFA (Scott et al., 2001; Green et al., 2005). However, based on occurrence and mineralogy, the authors suggest a correlation between the Tertiary-Quaternary undifferentiated sediments, Trail Ridge sands, and the Cypresshead Formation; therefore, the area formerly mapped as TQu (Scott et al., 2001) within the EMRI-FFA is mapped as the Cypresshead Formation on the surficial geologic map (Figure 29 and Plate 1). Tertiary-Quaternary undifferentiated sediments were mapped following the convention of Scott et al. (2001) to facilitate a better understanding of Florida's geology.

Tertiary-Quaternary undifferentiated shelly sediments

The Tertiary-Quaternary undifferentiated shelly sediments (TQsu) is an informal lithostratigraphic unit that consists of fine-to-medium quartz sand with variable amounts of calcilutite, fossil mollusk shells, and clay. The shells, which are mostly marine, are often bleached and weathered, and typically vary from whole body to highly fragmented. In some borings, the shells are the dominant lithology. Other accessory minerals may include calcite, aragonite, clay, muscovite mica, heavy minerals, and phosphate. Colors can range from light gray, to orangish-gray, to light olive gray. The thickness and spatial distribution of these shelly sediments varies throughout the EMRI-FFA. This unit occurs unconformably above Hawthorn Group units and below the Cypresshead Formation. Based on the stratigraphic position, and its occurrence in the subsurface, these Tertiary-Quaternary shelly sediments are either older than the Cypresshead Formation or were deposited concurrently with the Cypresshead Formation in laterally adjacent environments. Like many of the informal lithostratigraphic units referenced in this report, the Tertiary-Quaternary undifferentiated shelly sediments were mapped to facilitate a better understanding of Florida's geology and following an earlier convention established by Scott et al. (2001).

Cypresshead Formation

The Pliocene-Pleistocene Cypresshead Formation (TQc) was named by Huddlestun (1988) in the Coastal Plain of Georgia and was extended into Florida by Scott (1988). At the type section in Wayne County, Georgia, it is comprised of mottled reddish-brown to reddish orange to white, unconsolidated to poorly consolidated, fine to very coarse grained, variably clayey to clean quartz

sand. The unit is characterized by its sand and clay composition, as well as the presence of heavy minerals and muscovite mica. Cross-bedding is common within this formation (Scott et al., 2001; Green et al., 2016a; Green et al., 2016b) and the trace fossil, *Ophiomorpha nodosa*, can be observed at some outcrops. Discoid quartzite pebbles of varying size, heavy minerals, muscovite mica, and clay minerals are often present throughout the formation. The Cypresshead Formation is a nearshore, shallow marine deposit that correlates with the fluvio-deltaic sediments of Citronelle Formation and the Miccosukee Formation prodeltaic sediments in the Florida Panhandle (Scott, 2001).

The Cypresshead Formation unconformably overlies both the siliciclastic-dominant Coosawhatchie Formation and Statenville Formation of the Hawthorn Group. Where it is not exposed at the surface, this unit is unconformably overlain by Quaternary undifferentiated sediments (Qu). Based on both field observations and detailed core descriptions, the authors here propose the Cypresshead Formation should be expanded to include deposits mapped as Trail Ridge sediments (Qtr) and adjacent areas currently mapped as Tertiary-Quaternary undifferentiated sediments (TQu). Importantly, the Cypresshead Formation, deposits mapped as Tertiary-Quaternary undifferentiated sediments, and Trail Ridge share several defining characteristics which notably include stratigraphic position and accessory heavy mineral suite (ilmenite, staurolite, zircon, kyanite, rutile, amphibole, pyroxene, Ti-silicates, garnet, tourmaline, monazite, and xenotime). Humate beds are common throughout and vary in color from dark brown to black. With respect to paleoshorelines and heavy mineral placers, this interpretation of the Cypresshead Formation and its geographic extent would include remnant depositional systems of the Talbot, Penholoway, and Wicomico barrier island and lagoonal facies defined to the north in Georgia (Hails and Hoyt, 1969; Pirkle et al., 2013). However, this interpretation and the results presented in this report will need more work to confirm.

Pleistocene-Holocene Series

Quaternary undifferentiated sediments

Quaternary undifferentiated sediments (Qu) is an informal lithostratigraphic siliciclastic-dominant unit that is found at or near the land surface in areas within the EMRI-FFA at lower elevations and east of Trail Ridge. This unit is characterized by its gray to brown, unconsolidated-to poorly- consolidated, fine- to coarse- grained, variably clayey, unfossiliferous quartz sand, sandy clay, and clay. Organic debris, plant and root remains, and disseminated organics are present. The thickness of these undifferentiated sediments varies throughout the study area. This unit is mapped throughout large swaths of the EMRI-FFA and northeast Florida and represents deposition within a transitional to coastal environment with riverine, estuarine, tidal, and shallow marine influences. These Quaternary undifferentiated sediments in some areas unconformably overlie the Cypresshead Formation and have been deposited at an elevation above the stratigraphic base of the Cypresshead Formation. This stratigraphic relationship stems from the complex erosional and depositional history in northeast Florida where Qu, TQc, and Quaternary beach ridge and dune sediments (Qbd) are observed in part as adjacent units and exist, to some degree, at the same stratigraphic position. With respect to relict paleoshorelines and heavy mineral placers, the Quaternary undifferentiated sediments occur south of and along trend of a similar geomorphic feature(s) mapped north into Georgia referred to as the Pamlico lagoon facies (Hails and Hoyt,

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1969; Pirkle et al., 2013). Quaternary undifferentiated sediments were mapped following the convention of Scott et al. (2001) to facilitate a better understanding of Florida's geology.

Quaternary beach ridge and dune sediments

Quaternary beach ridge and dune sediments (Qbd) is an informal lithostratigraphic unit and a subdivision of the Quaternary undifferentiated sediments that are mapped based on surficial expression of relict beach ridges and dunes, and as such this unit more appropriately defines a geomorphic unit. Quaternary beach ridge and dune sediments were mapped following the convention of Scott et al. (2001) to facilitate a better understanding of Florida's geology. Beach ridge and dune sediments are dominantly unconsolidated to poorly consolidated quartz sand. Organics typically occur as disseminated organic matrix, roots and plant remains, and as carbonized remains or charcoal. Accessory to trace amounts of heavy minerals and mica have also been observed. These sediments are mapped along the eastern edge of the EMRI-FFA closest to the Atlantic coastline to facilitate a better understanding of Florida's geology and include several of the paired barrier island and lagoonal facies coastal deposits interpreted from Hails and Hoyt (1969) and Pirkle et al. (2013). These paleoshoreline features include, from west to east, the Pamlico, Princess Anne, and Silver Bluff deposits.

Holocene sediments

Holocene sediments (Qh) are an informally recognized siliciclastic-dominant unit that is found at or near the land surface in tidally influenced river valleys, and along the shoreline as modern beach dunes, ridges, and lagoons. This unit typically occurs as gray, tan to buff, brown to black, unconsolidated to poorly consolidated, clean to clayey, silty, nonfossiliferous, variably organic-rich quartz sand. Fresh water mollusks occur in more clayey sections. Holocene sediments occur within the EMRI-FFA primarily as floodplain deposits in the vicinity of the St. Johns River. Thicknesses of these undifferentiated Holocene sediments can vary throughout the mapping area. Following the lead of Scott et al. (2001) and Green et al. (2016a; 2016b), Holocene sediments were mapped here to facilitate a better understanding of Florida's geology.

DISTURBED GEOLOGY: SPOIL, MINED, AND RECLAIMED AREAS

The EMRI-FFA was mapped based on naturally occurring, undisturbed surficial geology. Spoil piles, mined, and reclaimed areas are common (Figure 28). Locations of mining operations and their spatial extent were approximated using the following sources of information. The Mining and Mitigation Program, Division of Water Resource Management (Florida Department of Environmental Protection) database, historical aerial imagery, and the USGS mine resources database (Horton and San Juan, 2021). Heavy mineral sand mining operations along Trail Ridge, near Boulogne, and Green Cove Springs, in Florida are extensive. Spoil not associated with mining operations is common along large hydrologic features maintained by dredging.

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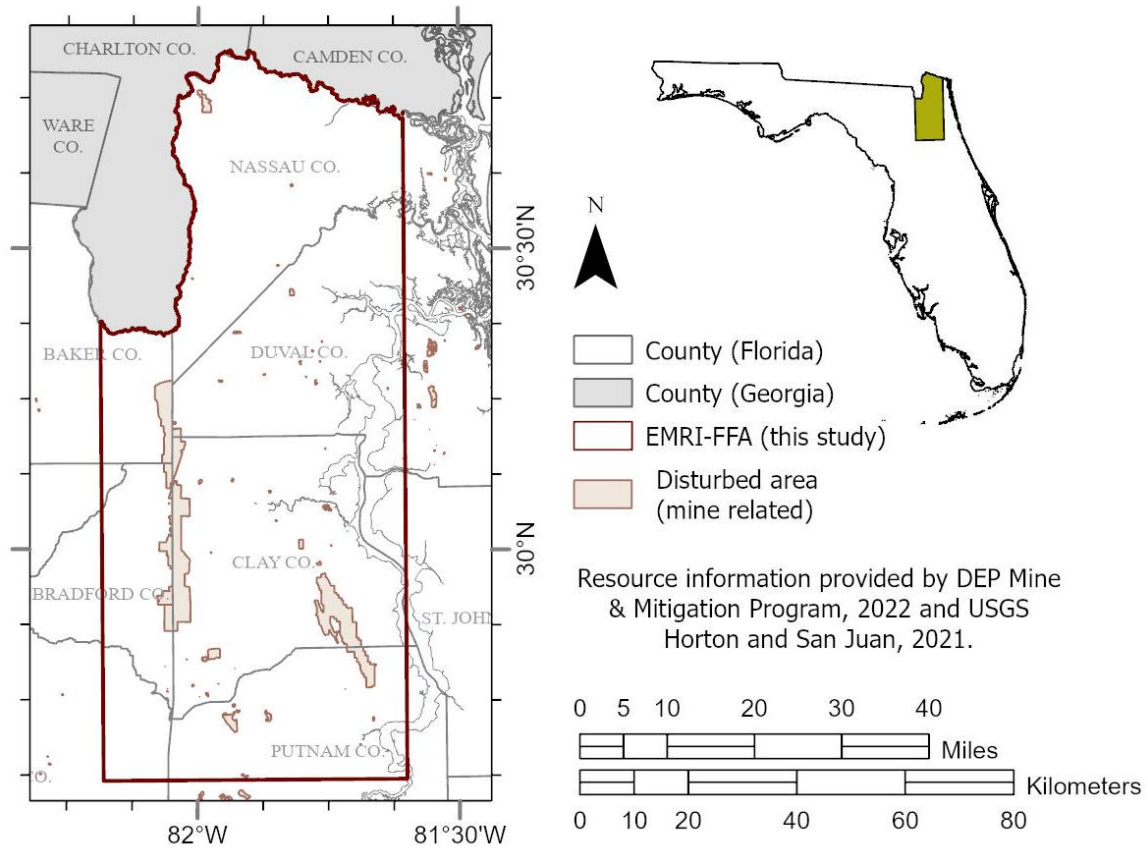


Figure 30. Mining operations and reclaimed areas in northeast Florida. Most of the area mined within the EMRI-FFA was processed specifically for heavy mineral sand resources.

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APPENDIX A: BOREHOLES USED FOR SURFICIAL GEOLOGIC MAPPING

Table 4. Records for all boreholes used for surficial and subsurface characterization of geologic units within the EMRI-FFA study area. Location data are reported here in WGS 84 decimal degrees. Data is organized by FGS W Number. Location methods defined: Address Matching/Precision Matching (ADDM), Digital Map Interpolation (DMAP), Digital Aerial Photography (DPHO), Manual Map Interpolation (MMAP), Unknown (UNKN), Code Phase GPS with Wide-Area Augmentation Service Correction (WGPS). Location accuracy defined: based on Corrected GPS (CGPS), based on Standard GPS (GPS), based on GPS-Selective Availability (GPS-SA), within a First Quarter Area (160 acres; QTR1), within a Second Quarter Area (40 acres; QTR2), within a Third Quarter Area (10 acres; QTR3), within a parcel (<5 acres; PARCEL), within the Section (SECT), within the Township-Range (TWN RNG). Sample type defined: Cuttings (CUT), Continuous Core (CCR), Standard Penetration Test Samples (SPT), Core Chips (CHIP), Core Segments (CSEG).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
78	30.1658	-81.702	DMAP	PARCEL	Qu	CUT	20.87	370	JACKSONVILLE	ORANGE PARK
116	30.33072	-81.7881	DMAP	PARCEL	TQc	CUT	58.73	1060	JACKSONVILLE	MARIETTA
145	29.99344	-81.5473	DMAP	QTR1	Qu	CUT	17.49	436	SAINT AUGUSTINE	PICOLATA
336	30.74844	-81.9491	DMAP	QTR2	TQc	CUT & CHIP	93.37	4824	FERNANDINA BEACH	HILLIARD
523	30.33118	-81.6034	DMAP	SECT	Qu	CUT	24.51	748	JACKSONVILLE	ARLINGTON
524	30.04806	-82.1906	MMAP	SECT	TQu	CUT	131.43	440	LAKE CITY	RAIFORD
531	29.86278	-82.1383	DMAP	GPS-SA	TQu	CUT	143.67	235	GAINESVILLE	WALDO
537	29.93971	-81.9797	DMAP	SECT	TQc	CUT	195.41	581	SAINT AUGUSTINE	KINGSLEY
544	30.41884	-81.647	DMAP	GPS-SA	Qu	CUT	18.96	1019	JACKSONVILLE	TROUT RIVER
581	30.22802	-81.8859	DMAP	PARCEL	TQc	CUT	77.33	980	JACKSONVILLE	FIFTONE
597	30.28203	-82.1206	DPHO	PARCEL	TQu	CUT	132.09	455	LAKE CITY	MACCLENNEY EAST
635	29.83715	-82.0453	UNKN	QTR2	TQc	CUT	174.90	535	GAINESVILLE	KEYSTONE HEIGHTS

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
659	30.29052	-81.979	DMAP	PARCEL	TQc	CUT	86.84	750	JACKSONVILLE	BALDWIN
731	30.24885	-81.8984	DMAP	PARCEL	TQc	CUT	79.49	780	JACKSONVILLE	FIFTONE
741	30.3288	-81.5582	DMAP	QTR1	Qu	CUT	50.20	1050	JACKSONVILLE	ARLINGTON
910	30.282	-82.121	DPHO	PARCEL	TQu	CUT	133.20	595	LAKE CITY	MACCLENNEY EAST
1043	30.41547	-81.6936	DMAP	SECTION	Qu	CUT	14.40	46	JACKSONVILLE	TROUT RIVER
1045	30.41932	-81.8017	DMAP	QTR1	Qu	CUT	19.29	75	JACKSONVILLE	DINSMORE
1046	30.40393	-81.891	MMAP	QTR1	TQc	CUT	78.81	106	JACKSONVILLE	BRYCEVILLE
1047	30.35833	-82.0825	DMAP	GPS-SA	TQc	CUT	63.68	94	LAKE CITY	MACCLENNEY EAST
1048	30.35737	-82.1824	DMAP	QTR2	TQu	CUT	65.32	123	LAKE CITY	MACCLENNEY WEST
1071	30.03685	-81.8847	DMAP	QTR1	Th	CUT	17.91	136	JACKSONVILLE	MIDDLEBUR G SW
1072	30.0158	-82.0031	DMAP	QTR1	TQc	CUT	169.16	117	LAKE CITY	LAWTEY
1073	30.02275	-82.0954	DMAP	QTR1	TQu	CUT	146.16	116	LAKE CITY	LAWTEY
1077	30.03724	-81.8851	DMAP	QTR1	Th	CUT	17.03	60	JACKSONVILLE	MIDDLEBUR G SW
1078	30.06632	-81.979	DMAP	PARCEL	TQc	CUT	79.53	80	JACKSONVILLE	MIDDLEBUR G SW
1079	30.06713	-82.0707	DMAP	QTR1	TQu	CUT	151.97	195	LAKE CITY	LAWTEY
1080	30.02511	-82.0954	MMAP	QTR1	TQu	CUT	147.57	42	LAKE CITY	LAWTEY
1081	30.05174	-82.1616	DMAP	QTR1	TQu	CUT	133.79	170	LAKE CITY	RAIFORD
1082	30.03472	-82.2197	DMAP	QTR3	Thc	CUT	119.00	70	LAKE CITY	RAIFORD
1514	29.70298	-81.8441	MMAP	QTR3	TQc	CUT	201.94	3328	SAINT AUGUSTINE	BAYWOOD
1724	29.91295	-82.0356	UNKN	QTR1	TQc	CUT	219.26	294	GAINESVILLE	STARKE
1808	30.19373	-82.0244	DMAP	SECT	TQc	CUT	91.99	40	LAKE CITY	MAXVILLE

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
1971	29.72111	-82.1278	UNKN	QTR3	TQc	CUT	165.78	150	GAINESVILLE	ORANGE HEIGHTS
2276	30.24444	-81.7232	MMAP	QTR3	Qu	CUT	17.95	775	JACKSONVILLE	ORANGE PARK
2280	30.28219	-81.7234	DMAP	GPS-SA	TQsu	CUT	11.29	1250	JACKSONVILLE	JACKSON- VILLE
2443	30.28691	-81.5687	DMAP	QTR1	Qu	CUT	4.76	750	JACKSONVILLE	ARLINGTON
2558	30.39591	-81.6359	MMAP	QTR1	Qu	CUT	14.93	1015	JACKSONVILLE	TROUT RIVER
2960	30.22941	-81.8859	DMAP	PARCEL	TQc	CUT	76.57	950	JACKSONVILLE	FIFTONE
2964	30.60905	-81.5997	DMAP	QTR1	Qu	CUT	32.38	905	FERNANDINA BEACH	HEDGES
3013	30.23444	-81.6953	MMAP	TWNRN G	Qu	CUT	13.06	460	JACKSONVILLE	ORANGE PARK
3120	30.42167	-81.6008	DMAP	SECT	Qu	CUT	13.09	1006	JACKSONVILLE	EASTPORT
3279	30.05008	-82.0555	DMAP	QTR2	TQc	CUT	175.07	725	LAKE CITY	LAWTEY
3282	30.28451	-81.5919	DMAP	SECT	Qu	CUT	22.44	1006	JACKSONVILLE	ARLINGTON
3416	30.2961	-81.5905	DMAP	SECT	Qu	CUT	9.22	1000	JACKSONVILLE	ARLINGTON
3435	30.24686	-81.6083	ADDM	PARCEL	Qu	CUT	18.11	1150	JACKSONVILLE	BAYARD
3464	30.16608	-81.6276	DMAP	PARCEL	Qu	CUT	17.91	940	JACKSONVILLE	ORANGE PARK
3478	29.97552	-81.6506	DMAP	PARCEL	Qu	CUT	13.88	600	SAINT AUGUSTINE	GREEN COVE SPRINGS
3492	30.40389	-81.6956	ADDM	PARCEL	Qu	CUT	11.35	84	JACKSONVILLE	TROUT RIVER
3509	30.29691	-81.6426	ADDM	PARCEL	Qu	CUT	22.74	1500	JACKSONVILLE	JACKSON- VILLE
3567	30.42389	-81.6486	ADDM	PARCEL	Qu	CUT	23.79	740	JACKSONVILLE	TROUT RIVER
3591	30.16137	-81.6008	ADDM	PARCEL	Qu	CUT	21.78	528	JACKSONVILLE	BAYARD
3788	30.42785	-81.6028	DMAP	QTR3	Qu	CUT	10.89	1012	JACKSONVILLE	EASTPORT
3813	30.07168	-82.2139	DMAP	QTR2	TQu	CUT	127.99	612	LAKE CITY	RAIFORD

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
3856	29.71286	-81.7044	DMAP	QTR2	Qu	CUT	3.97	600	SAINT AUGUSTINE	PALATKA
3961	30.03774	-81.8967	DMAP	QTR3	TQc	CUT	78.44	359	JACKSONVILLE	MIDDLEBUR G SW
3981	30.01778	-82.2014	DMAP	QTR3	TQu	CUT	141.44	257	LAKE CITY	RAIFORD
3990	30.23552	-81.8987	DMAP	PARCEL	TQc	CUT	75.00	964	JACKSONVILLE	FIFTONE
4012	30.40107	-81.6448	DMAP	PARCEL	Qu	CUT	7.84	1009	JACKSONVILLE	TROUT RIVER
4197	30.2675	-81.9073	MMAP	QTR2	TQc	CUT	82.91	1300	JACKSONVILLE	BALDWIN
4202	30.30083	-81.9727	DMAP	QTR2	TQc	CUT	84.71	715	JACKSONVILLE	BALDWIN
4532	30.23896	-82.051	DMAP	QTR2	TQc	CUT	131.17	272	LAKE CITY	MAXVILLE
4596	30.23475	-82.1345	DMAP	QTR2	TQu	CUT	133.50	610	LAKE CITY	MANNING
4599	30.22989	-82.1388	DMAP	QTR2	TQu	CUT	124.31	610	LAKE CITY	MANNING
4695	30.205	-81.6939	DMAP	GPS-SA	Qu	CHIP	26.21	522	JACKSONVILLE	ORANGE PARK
4696	30.53802	-81.7257	DMAP	GPS-SA	Qu	CUT	15.09	1115	FERNANDINA BEACH	ITALIA
4711	30.06167	-82.1858	DMAP	GPS-SA	Th	CUT	127.33	707	LAKE CITY	RAIFORD
4712	30.06011	-82.188	DMAP	GPS-SA	Th	CUT	124.18	700	LAKE CITY	RAIFORD
4834	30.17797	-81.7384	DMAP	PARCEL	TQc	CUT	57.45	1030	JACKSONVILLE	ORANGE PARK
4883	30.4094	-81.7224	DMAP	GPS-SA	Qu	CUT	13.12	1225	JACKSONVILLE	TROUT RIVER
4913	30.37504	-81.5861	ADDM	PARCEL	Qu	CUT	18.80	1045	JACKSONVILLE	ARLINGTON
4953	30.05508	-82.0483	DMAP	QTR2	TQc	CUT	200.59	883	LAKE CITY	LAWTEY
5028	29.65861	-81.5743	DMAP	QTR2	Qu	CUT	18.14	547	SAINT AUGUSTINE	HASTINGS
5161	30.00562	-82.1717	DMAP	QTR2	TQu	CUT	138.52	30	LAKE CITY	RAIFORD
5170	29.98418	-82.017	UNKN	QTR2	TQc	CUT	229.59	21	GAINESVILLE	STARKE
5173	29.97797	-81.8632	DMAP	QTR2	TQc	CUT	88.75	24	SAINT AUGUSTINE	PENNEY FARMS

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
5322	30.33218	-81.5604	DMAP	PARCEL	Qu	CUT	24.67	1012	JACKSONVILLE	ARLINGTON
5354	29.77602	-82.041	UNKN	QTR2	TQc	CUT	151.64	492	GAINESVILLE	KEYSTONE HEIGHTS
5459	30.33552	-81.5962	ADDM	PARCEL	Qu	CUT	44.46	1411	JACKSONVILLE	ARLINGTON
5460	30.35192	-81.569	DMAP	QTR3	Qu	CUT	42.88	1301	JACKSONVILLE	ARLINGTON
6254	30.37441	-81.7304	DMAP	GPS-SA	Qu	CUT	10.53	1326	JACKSONVILLE	JACKSON- VILLE
6341	29.6327	-81.6417	DMAP	QTR2	Qu	CUT	36.19	610	SAINT AUGUSTINE	PALATKA
6465	30.3936	-81.5585	ADDM	PARCEL	Qu	CUT	16.17	801	JACKSONVILLE	EASTPORT
6502	30.26182	-82.2669	DMAP	QTR2	TQu	CUT	150.03	825	LAKE CITY	SANDERSON NORTH
6532	30.68884	-81.9186	DMAP	PARCEL	TQc	CUT	66.50	803	FERNANDINA BEACH	HILLIARD
7104	30.35494	-81.6045	DMAP	CGPS	Qu	CUT	45.21	1300	JACKSONVILLE	ARLINGTON
7507	30.07371	-81.8854	DMAP	QTR1	Thc	CUT	28.48	108	JACKSONVILLE	MIDDLE- BURG SW
7508	30.03782	-81.8761	DMAP	QTR1	Th	CUT	5.58	107	JACKSONVILLE	MIDDLE- BURG SW
8207	30.16421	-81.7418	ADDM	PARCEL	TQc	CUT	64.70	125	JACKSONVILLE	ORANGE PARK
8400	29.71351	-81.8445	MMAP	QTR2	TQc	CCR	211.25	302	SAINT AUGUSTINE	BAYWOOD
8736	30.40468	-81.8737	DMAP	PARCEL	TQc	CUT	84.28	708	JACKSONVILLE	DINSMORE
9577	30.1953	-82.1559	DMAP	SECT	TQu	CUT	136.98	460	LAKE CITY	MANNING
10473	30.31722	-82.0854	DMAP	QTR2	TQc	CCR	166.70	288	LAKE CITY	MACCLENNY EAST
10481	29.87533	-81.7055	MMAP	SECT	TQc	CCR	87.01	108	SAINT AUGUSTINE	GREEN COVE SPRINGS
10482	30.73361	-81.9843	DMAP	SECT	TQc	CCR	95.21	98	FERNANDINA BEACH	HILLIARD
10488	29.92777	-82.0333	UNKN	QTR3	TQc	CCR	234.02	332	GAINESVILLE	STARKE
10489	30.04703	-82.0328	DMAP	PARCEL	TQc	CCR	214.30	146	LAKE CITY	LAWTEY

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
10588	29.68692	-81.6542	ADDM	PARCEL	Qu	CUT	8.96	347	SAINT AUGUSTINE	PALATKA
10632	30.5044	-81.5757	DMAP	QTR3	Qu	CUT	15.29	706	FERNANDINA BEACH	HEDGES
10634	30.48846	-81.6337	DMAP	SECT	Qu	CUT	28.67	815	JACKSONVILLE	TROUT RIVER
10635	30.36608	-81.5804	DMAP	QTR3	Qu	CUT	16.31	1104	JACKSONVILLE	ARLINGTON
10636	30.48632	-81.7043	DMAP	QTR2	Qu	CUT	25.69	1105	JACKSONVILLE	TROUT RIVER
10715	30.63417	-81.6367	DMAP	GPS-SA	Qu	CUT & CHIP	24.31	5440	FERNANDINA BEACH	GROSS
10797	29.98225	-81.7123	ADDM	PARCEL	TQc	CUT	56.96	640	SAINT AUGUSTINE	GREEN COVE SPRINGS
10798	30.13016	-82.0962	DMAP	QTR2	TQu	CUT	141.80	3150	LAKE CITY	MAXVILLE
10919	30.21417	-81.6167	ADDM	PARCEL	Qu	CUT	5.84	740	JACKSONVILLE	BAYARD
10920	30.45885	-81.6382	DMAP	PARCEL	Qu	CUT	28.31	1330	JACKSONVILLE	TROUT RIVER
11281	30.11583	-81.6028	ADDM	PARCEL	Qu	CUT	14.70	600	JACKSONVILLE	ORANGE- DALE
11548	30.42449	-81.6604	DMAP	GPS	Qu	CUT	21.42	1296	JACKSONVILLE	TROUT RIVER
11582	30.20793	-81.7368	DMAP	GPS-SA	Qu	CUT	11.71	950	JACKSONVILLE	ORANGE PARK
11585	30.04841	-81.8279	DMAP	PARCEL	TQc	CUT	79.36	616	JACKSONVILLE	MIDDLE- BURG
12056	30.1779	-81.7387	DMAP	PARCEL	TQc	CUT	57.48	1014	JACKSONVILLE	ORANGE PARK
12223	30.28638	-81.8042	ADDM	PARCEL	TQc	CUT	76.61	762	JACKSONVILLE	MARIETTA
12224	30.28638	-81.8042	ADDM	PARCEL	TQc	CUT	76.61	761	JACKSONVILLE	MARIETTA
12225	30.25724	-82.1159	DMAP	SECT	TQu	CUT	125.46	796	LAKE CITY	MACCLENNY EAST
12279	30.2861	-82.1275	DMAP	GPS	TQu	CUT	128.94	815	LAKE CITY	MACCLENNY WEST

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
12360	30.11957	-82.0509	DMAP	QTR2	TQc	CCR	200.07	493	LAKE CITY	LAWTEY
12361	30.16433	-82.0502	DMAP	QTR2	TQc	CCR	188.65	127	LAKE CITY	MAXVILLE
12383	30.3808	-81.6081	DMAP	CGPS	Qu	CUT	11.94	1009	JACKSONVILLE	EASTPORT
12782	30.30552	-81.6498	DMAP	GPS-SA	Qu	CUT	13.35	1296	JACKSONVILLE	JACKSON- VILLE
12847	30.33515	-81.592	DMAP	PARCEL	Qu	CUT	45.83	1360	JACKSONVILLE	ARLINGTON
12859	30.28496	-81.9734	DMAP	PARCEL	TQc	CUT	81.82	905	JACKSONVILLE	BALDWIN
13074	30.64209	-81.6089	DMAP	PARCEL	Qu	CUT	43.57	580	FERNANDINA BEACH	ST. MARYS (GA)
13189	30.17758	-81.7384	DMAP	PARCEL	TQc	CUT	56.59	1002	JACKSONVILLE	ORANGE PARK
13314	30.01137	-82.1536	DMAP	QTR3	TQu	CUT	139.37	42	LAKE CITY	RAIFORD
13316	30.0043	-82.1407	DMAP	SECT	TQu	CUT	141.86	60	LAKE CITY	RAIFORD
13343	30.41473	-81.6101	DMAP	GPS-SA	Qu	CUT	17.13	660	JACKSONVILLE	EASTPORT
13474	30.06703	-82.1111	DMAP	PARCEL	TQu	CUT	145.44	84	LAKE CITY	LAWTEY
13492	30.45361	-81.6183	ADDM	PARCEL	Qu	CUT	11.35	1280	JACKSONVILLE	EASTPORT
13562	30.14256	-81.7462	DMAP	PARCEL	TQc	CUT	28.77	861	JACKSONVILLE	ORANGE PARK
13563	30.62438	-81.6311	DMAP	SECT	Qu	CUT	19.46	624	FERNANDINA BEACH	ITALIA
13591	30.0454	-82.0723	DMAP	GPS	TQu	CUT	159.42	527	LAKE CITY	LAWTEY
13769	29.98429	-81.8375	DMAP	QTR2	TQc	CCR	94.26	319	SAINT AUGUSTINE	PENNEY FARMS
13814	30.03833	-82.1758	DMAP	QTR2	TQu	CCR	126.41	272	LAKE CITY	RAIFORD
13815	30.63611	-81.9347	DMAP	SECT	TQc	CCR	81.46	490	FERNANDINA BEACH	HILLIARD
13983	29.74468	-81.6383	MMAP	SECT	TQc	CUT	40.75	440	SAINT AUGUSTINE	PALATKA
13984	29.74468	-81.6383	MMAP	SECT	TQc	CUT	40.75	440	SAINT AUGUSTINE	PALATKA
14179	30.14916	-82.0063	DMAP	QTR3	TQc	CCR	86.71	320	LAKE CITY	MAXVILLE

FLORIDA GEOLOGICAL SURVEY

Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
14219	30.11528	-81.8825	DMAP	PARCEL	TQc	CCR	88.91	492	JACKSONVILLE	MIDDLE- BURG SW
14230	30.06236	-82.1858	DMAP	GPS-SA	TQu	CUT	124.28	525	LAKE CITY	RAIFORD
14280	29.91666	-82.2033	UNKN	QTR2	TQu	CCR	140.06	175	GAINESVILLE	SAMPSON
14301	29.86722	-81.9203	DMAP	GPS-SA	TQc	CCR	163.52	255	SAINT AUGUSTINE	GOLD HEAD BRANCH
14346	29.73134	-81.8968	DMAP	QTR2	TQc	CCR	89.40	182	SAINT AUGUSTINE	PUTNAM HALL
14476	29.98283	-81.7233	DMAP	QTR3	TQc	CCR	62.70	425	SAINT AUGUSTINE	GREEN COVE SPRINGS
14521	29.84106	-81.6625	DMAP	QTR2	TQc	CCR	80.51	385	SAINT AUGUSTINE	BOSTWICK
14566	29.65831	-81.881	MMAP	QTR2	TQc	CCR	97.28	227	SAINT AUGUSTINE	PUTNAM HALL
14594	29.71644	-82.033	UNKN	QTR2	TQc	CCR	166.44	231	GAINESVILLE	MELROSE
15183	29.72542	-81.9546	DMAP	SECT	TQc	CUT	133.83	350	SAINT AUGUSTINE	PUTNAM HALL
15662	30.7375	-81.9936	DMAP	QTR2	TQc	CUT	62.89	916	FERNANDINA BEACH	HILLIARD
15857	30.10818	-82.0498	DPHO	QTR3	TQc	CCR	208.27	440	LAKE CITY	LAWTEY
15885	30.07028	-82.2186	MMAP	GPS	TQu	CCR	130.64	251	LAKE CITY	RAIFORD
16128	30.71861	-81.9081	DMAP	PARCEL	TQc	CUT	45.64	580	FERNANDINA BEACH	HILLIARD
16129	30.71667	-81.5989	MMAP	TWNRN G	Qu	CUT	4.33	660	FERNANDINA BEACH	ST. MARYS (GA)
16145	29.91632	-82.1293	UNKN	SECT	TQu	CCR	153.08	208	GAINESVILLE	SAMPSON
16169	30.28294	-81.9846	ADDM	PARCEL	TQc	CUT	84.81	100	JACKSONVILLE	BALDWIN
16207	29.73367	-82.2219	UNKN	SECT	TQu	CCR	151.28	191	GAINESVILLE	ORANGE HEIGHTS
16208	30.76972	-81.9728	DMAP	GPS	TQc	CUT	50.92	610	FERNANDINA BEACH	BOULOGNE (GA)
16209	30.00896	-81.6998	MMAP	SECT	Qu	CUT	16.14	1000	JACKSONVILLE	FLEMING ISLAND

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
16245	30.30472	-82.132	DPHO	QTR3	TQu	CUT	129.17	140	LAKE CITY	MACCLENNY WEST
16250	30.095	-81.6143	ADDM	QTR3	Qu	CUT	11.38	500	JACKSONVILLE	ORANGE-DALE
16292	30.25361	-81.5822	ADDM	PARCEL	Qu	CUT	22.15	600	JACKSONVILLE	ARLINGTON
16330	30.69882	-81.7425	DMAP	GPS	Qu	SPT & CCR	9.58	201	FERNANDINA BEACH	GROSS
16331	30.60516	-81.9964	DMAP	GPS	TQc	SPT & CCR	69.46	146	FERNANDINA BEACH	HILLIARD SW
16332	30.74388	-81.957	DMAP	GPS	TQc	SPT	98.88	197	FERNANDINA BEACH	HILLIARD
16334	30.66096	-81.8826	DMAP	GPS	TQc	SPT	42.29	201	FERNANDINA BEACH	HILLIARD
16337	30.77901	-81.8466	DMAP	GPS	Thcc	SPT	8.60	82	FERNANDINA BEACH	KINGS FERRY (GA)
16338	30.74891	-81.8255	DMAP	GPS	Thcc	SPT	9.32	87	FERNANDINA BEACH	HILLIARD NE
16339	30.7671	-81.8177	DMAP	GPS	Thcc	SPT	20.93	87	FERNANDINA BEACH	KINGS FERRY (GA)
16340	30.74911	-81.7914	DMAP	GPS	Thcc	SPT	13.71	96	FERNANDINA BEACH	HILLIARD NE
16341	30.72768	-81.7683	DMAP	GPS	Qu	SPT & CCR	14.53	96	FERNANDINA BEACH	HILLIARD NE
16343	30.69882	-81.7177	DMAP	GPS	Qu	SPT	26.90	107	FERNANDINA BEACH	GROSS
16345	30.61746	-81.714	DMAP	GPS	Qu	SPT & CCR	16.86	121	FERNANDINA BEACH	ITALIA
16351	30.51053	-81.8898	DMAP	GPS	TQc	SPT & CCR	86.94	100	FERNANDINA BEACH	HILLIARD SW
16352	30.58	-81.978	DMAP	GPS	TQc	SPT & CCR	77.30	121	FERNANDINA BEACH	HILLIARD SW

FLORIDA GEOLOGICAL SURVEY

Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
16353	30.61951	-81.9522	DMAP	GPS	TQc	SPT & CCR	86.98	140	FERNANDINA BEACH	HILLIARD SW
16354	30.63654	-81.9546	DMAP	GPS	TQc	SPT & CCR	94.16	120	FERNANDINA BEACH	HILLIARD
16355	30.65303	-81.9911	DMAP	GPS	TQc	SPT & CCR	88.52	152	FERNANDINA BEACH	HILLIARD
16357	30.75576	-81.9852	MMAP	GPS	TQc	SPT	81.63	120	FERNANDINA BEACH	BOULOGNE (GA)
16358	30.75992	-81.9249	DMAP	GPS	TQc	SPT	36.29	140	FERNANDINA BEACH	BOULOGNE (GA)
16359	30.77102	-81.9102	DMAP	GPS	Qu	SPT	13.25	77	FERNANDINA BEACH	BOULOGNE (GA)
16360	30.67424	-81.7375	DMAP	GPS	Qu	SPT & CCR	15.58	97	FERNANDINA BEACH	GROSS
16361	30.65268	-81.7337	DMAP	GPS	Qu	SPT & CCR	17.88	120	FERNANDINA BEACH	GROSS
16362	30.52692	-81.9241	DMAP	GPS	TQc	SPT	68.57	116	FERNANDINA BEACH	HILLIARD SW
16363	30.53753	-81.9766	DMAP	GPS	TQc	SPT	72.64	116	FERNANDINA BEACH	HILLIARD SW
16364	30.56029	-81.9668	DMAP	GPS	TQc	SPT & CCR	71.23	122	FERNANDINA BEACH	HILLIARD SW
16365	30.68168	-81.9835	DMAP	GPS	TQc	SPT	78.71	126	FERNANDINA BEACH	HILLIARD
16366	30.61111	-81.6758	DMAP	GPS	Qu	SPT	15.78	70	FERNANDINA BEACH	ITALIA
16367	30.61508	-81.6698	DMAP	GPS	Qu	SPT	1.94	72	FERNANDINA BEACH	ITALIA
16381	30.09524	-81.7653	DMAP	PARCEL	Qu	CUT	12.96	651	JACKSONVILLE	MIDDLEBUR G
16393	30.27117	-81.9681	ADDM	PARCEL	TQc	CCR	85.89	353	JACKSONVILLE	BALDWIN

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
16551	30.46829	-81.5712	DMAP	PARCEL	Qu	CUT	24.64	798	JACKSONVILLE	EASTPORT
16559	30.2275	-81.5844	DMAP	SECT	Qu	CUT	20.87	860	JACKSONVILLE	BAYARD
16679	30.4573	-81.9091	MMAP	SECT	TQc	CUT	70.41	90	JACKSONVILLE	BRYCEVILLE
16806	30.54181	-81.7211	ADDM	PARCEL	Qu	CUT	18.14	480	FERNANDINA BEACH	ITALIA
16825	30.04253	-81.8953	DMAP	PARCEL	TQc	CUT	75.92	441	JACKSONVILLE	MIDDLEBUR G SW
16847	30.68715	-81.9271	ADDM	PARCEL	TQc	CUT	81.20	500	FERNANDINA BEACH	HILLIARD
16888	30.06753	-82.239	DMAP	QTR2	TQu	CUT	136.15	20	LAKE CITY	RAIFORD
16980	29.96047	-82.0233	MMAP	SECT	TQc	CUT	231.79	300	GAINESVILLE	STARKE
17143	30.78316	-81.953	DPHO	GPS	TQc	CUT	89.07	825	FERNANDINA BEACH	BOULOGNE (GA)
17155	30.59479	-81.8301	DMAP	PARCEL	Qu	CUT	18.83	1075	FERNANDINA BEACH	CALLAHAN
17285	30.78314	-81.953	DPHO	GPS	TQc	CUT	88.81	380	FERNANDINA BEACH	BOULOGNE (GA)
17329	30.01472	-82.0958	DMAP	GPS-SA	TQu	CCR	153.77	87	LAKE CITY	LAWTEY
17330	30.00722	-82.1775	DMAP	GPS-SA	TQu	CCR	133.92	54	LAKE CITY	RAIFORD
17331	30.05861	-82.1358	DMAP	GPS-SA	Th	CUT	129.40	68	LAKE CITY	RAIFORD
17498	29.73295	-82.1721	UNKN	SECT	TQc	CCR	103.28	175	GAINESVILLE	ORANGE HEIGHTS
17544	30.4025	-81.9211	DMAP	PARCEL	TQc	CUT	77.56	500	JACKSONVILLE	BRYCEVILLE
17545	30.4025	-81.9211	DMAP	PARCEL	TQc	CUT	77.56	500	JACKSONVILLE	BRYCEVILLE
17546	30.78194	-81.9186	DMAP	GPS-SA	Qu	CUT	23.69	23	FERNANDINA BEACH	BOULOGNE (GA)
17548	30.4025	-81.9211	DMAP	PARCEL	TQc	CUT	77.56	42	JACKSONVILLE	BRYCEVILLE
17772	30.4025	-81.9211	DMAP	PARCEL	TQc	CUT & CCR	77.56	120	JACKSONVILLE	BRYCEVILLE

FLORIDA GEOLOGICAL SURVEY

Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
17774	30.15721	-81.9377	DMAP	PARCEL	TQc	CUT	82.64	82	JACKSONVILLE	FIFTONE
17778	30.1575	-81.5753	DMAP	QTR3	Qu	CUT	25.66	420	JACKSONVILLE	BAYARD
17849	30.13639	-81.8842	DMAP	PARCEL	TQc	CUT	78.81	26	JACKSONVILLE	FIFTONE
18015	30.15722	-81.9378	DMAP	QTR1	TQc	CUT	82.48	540	JACKSONVILLE	FIFTONE
18133	30.59479	-81.8301	DMAP	PARCEL	Qu	CUT	18.83	2114	FERNANDINA BEACH	CALLAHAN
18159	30.78323	-81.953	DMAP	GPS	TQc	CUT	88.98	1912	FERNANDINA BEACH	BOULOGNE (GA)
18178	30.055	-82.0317	DMAP	PARCEL	TQc	SPT	217.36	132	LAKE CITY	LAWTEY
18213	30.22917	-81.7044	DMAP	GPS-SA	Qu	CUT	5.12	2020	JACKSONVILLE	ORANGE PARK
18254	29.87278	-81.6597	DMAP	GPS-SA	TQc	CUT	63.25	390	SAINT AUGUSTINE	BOSTWICK
18280	29.56864	-81.6521	DMAP	GPS-SA	TQc	CUT & CCR	59.78	500	SAINT AUGUSTINE	SATSUMA
18283	29.94028	-81.6858	DMAP	QTR2	TQc	CUT	45.77	440	SAINT AUGUSTINE	GREEN COVE SPRINGS
18292	29.98306	-82.0108	DMAP	PARCEL	TQc	CUT	226.61	480	GAINESVILLE	STARKE
18366	30.12722	-81.5442	DMAP	SECT	Qu	CUT	20.47	200	JACKSONVILLE	BAYARD
18424	30.735	-81.5514	DMAP	GPS-SA	NOSM	CUT & CSEG	6.86	2126	FERNANDINA BEACH	ST. MARYS (GA)
18469	30.78322	-81.953	DPHO	GPS	TQc	CUT & CCR	88.88	389	FERNANDINA BEACH	BOULOGNE (GA)
18529	30.08389	-81.7231	DMAP	PARCEL	Qu	CUT, CCR, CHIP	10.10	290	JACKSONVILLE	FLEMING ISLAND
18532	29.58997	-81.5759	DMAP	GPS	Qu	CUT	20.54	260	SAINT AUGUSTINE	SAN MATEO
18618	30.11829	-81.8485	DMAP	PARCEL	TQc	CUT	65.03	90	JACKSONVILLE	MIDDLE- BURG

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
18809	30.0969	-81.9662	DMAP	PARCEL	TQc	CUT	116.44	470	JACKSONVILLE	MIDDLE- BURG SW
18818	30.48106	-81.8243	DMAP	PARCEL	Qu	CUT & CCR	14.24	195	JACKSONVILLE	DINSMORE
18819	29.9783	-81.8629	DMAP	PARCEL	TQc	CUT	88.91	420	SAINT AUGUSTINE	PENNEY FARMS
19218	30.22917	-81.7044	DMAP	PARCEL	Qu	CCR	5.12	124	JACKSONVILLE	ORANGE PARK
19405	30.53613	-81.7056	DMAP	GPS	Qu	SPT & CCR	17.36	252	FERNANDINA BEACH	ITALIA
19406	30.53611	-81.5841	DMAP	SECT	Qu	SPT	10.14	620	FERNANDINA BEACH	HEDGES
19407	30.53611	-81.7056	DMAP	PARCEL	Qu	CCR	17.42	540	FERNANDINA BEACH	ITALIA
19429	30.66772	-81.6382	DMAP	PARCEL	Qu	CCR	21.10	490	FERNANDINA BEACH	GROSS
19430	30.6675	-81.6383	DMAP	PARCEL	Qu	CCR	19.69	770	FERNANDINA BEACH	GROSS
19440	30.60972	-81.7175	DMAP	GPS	Qu	SPT	6.36	251	FERNANDINA BEACH	ITALIA
19461	30.55001	-81.6453	DMAP	PARCEL	Qu	CCR	7.45	175	FERNANDINA BEACH	ITALIA
19496	29.71411	-81.9415	DMAP	GPS-SA	TQc	SPT & CCR	91.83	1400	SAINT AUGUSTINE	PUTNAM HALL
19500	29.87992	-82.0399	DMAP	GPS-SA	TQc	SPT	203.67	252	GAINESVILLE	STARKE
19501	29.87106	-82.0161	DMAP	GPS-SA	TQc	SPT & CCR	184.97	150	GAINESVILLE	KEYSTONE HEIGHTS
19502	29.8655	-82.0386	DMAP	GPS-SA	TQc	SPT & CCR	204.56	170	GAINESVILLE	KEYSTONE HEIGHTS
19520	29.71861	-81.9431	DMAP	GPS-SA	TQc	SPT & CCR	111.06	508	SAINT AUGUSTINE	PUTNAM HALL

FLORIDA GEOLOGICAL SURVEY

Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
19525	29.81822	-82.0189	DMAP	GPS-SA	TQc	SPT & CCR	143.11	350	GAINESVILLE	KEYSTONE HEIGHTS
19528	29.81712	-82.022	DMAP	GPS-SA	TQc	SPT	132.97	40	GAINESVILLE	KEYSTONE HEIGHTS
19537	29.83779	-81.726	DMAP	GPS-SA	TQc	CUT	110.40	1050	SAINT AUGUSTINE	BOSTWICK
19561	30.167	-81.8826	DMAP	CGPS	TQc	CCR	86.38	325	JACKSONVILLE	FIFTONE
19587	30.33033	-81.9079	WGPS	GPS	TQc	CCR	84.91	340	JACKSONVILLE	BALDWIN
19626	29.76972	-82.0133	DMAP	GPS-SA	TQc	SPT & CCR	97.93	150	GAINESVILLE	KEYSTONE HEIGHTS
19666	29.79194	-82.0183	DMAP	GPS-SA	TQc	SPT & CCR	158.63	220	GAINESVILLE	KEYSTONE HEIGHTS
19667	29.80222	-82.0356	DMAP	GPS-SA	TQc	SPT & CCR	142.55	220	GAINESVILLE	KEYSTONE HEIGHTS
19738	29.58819	-82.067	DMAP	GPS-SA	TQu	SPT	101.74	250	GAINESVILLE	HAWTHORNE
19739	29.5925	-82.0665	DMAP	GPS-SA	TQu	SPT & CCR	102.13	500	GAINESVILLE	HAWTHORNE
19742	30.60986	-81.6314	DMAP	GPS	Qu	CUT	15.35	1190	FERNANDINA BEACH	ITALIA
19801	29.99822	-82.0015	MMAP	GPS	TQc	CCR	180.81	16	GAINESVILLE	STARKE
19802	30.00269	-82.0318	MMAP	GPS	TQc	CCR	235.27	20	LAKE CITY	LAWTEY
19803	30.03452	-82.0305	MMAP	GPS	TQc	CCR	214.01	16	LAKE CITY	LAWTEY
19804	30.04895	-82.0256	MMAP	GPS	TQc	CCR	205.48	24	LAKE CITY	LAWTEY
19805	30.01407	-82.0088	MMAP	GPS	TQc	CCR	184.71	44	LAKE CITY	LAWTEY
19806	30.04766	-82.0106	MMAP	GPS	TQc	CCR	177.92	20	LAKE CITY	LAWTEY
19807	30.03305	-82.0064	MMAP	GPS	TQc	CCR	174.15	32	LAKE CITY	LAWTEY
19808	30.02608	-81.9963	DMAP	GPS	TQc	CCR	148.52	28	JACKSONVILLE	MIDDLE- BURG SW

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Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
19820	30.09444	-81.9775	DMAP	QTR2	TQc	SPT	88.98	185	JACKSONVILLE	MIDDLE- BURG SW
19821	30.6914	-81.9331	MMAP	PARCEL	TQc	SPT	84.74	302	FERNANDINA BEACH	HILLIARD
19837	30.78451	-81.9696	DMAP	GPS	Thcc	CCR	23.33	20	FERNANDINA BEACH	BOULOGNE (GA)
19838	30.81632	-81.9372	DMAP	GPS	TQc	CCR	68.08	44	FERNANDINA BEACH	BOULOGNE (GA)
19839	30.81269	-81.9537	DMAP	GPS	Thcc	CCR	27.26	28	FERNANDINA BEACH	BOULOGNE (GA)
19840	30.79763	-81.9513	DMAP	GPS	TQc	CCR	58.63	34	FERNANDINA BEACH	BOULOGNE (GA)
19841	30.78733	-81.9528	DMAP	GPS	TQc	CCR	74.21	32	FERNANDINA BEACH	BOULOGNE (GA)
19843	30.67176	-82.0473	WGPS	GPS	TQc	CCR	67.52	210	OKEFENOKEE SWAMP	TOLEDO (GA)
19851	30.67162	-82.0442	DMAP	GPS	TQc	CCR	65.94	43	OKEFENOKEE SWAMP	TOLEDO (GA)
19852	30.67028	-82.0417	MMAP	GPS	TQc	CCR	66.73	36	OKEFENOKEE SWAMP	TOLEDO (GA)
19873	30.34104	-82.0092	MMAP	GPS	TQc	CCR	79.72	44	LAKE CITY	MACCLENLY EAST
19874	30.41197	-82.0291	MMAP	GPS	TQc	CCR	79.33	28	LAKE CITY	MACCLENLY NE (GA)
19875	30.44203	-82.0089	MMAP	GPS	TQc	CCR	75.85	40	LAKE CITY	MACCLENLY NE (GA)
19876	30.51338	-81.9938	MMAP	GPS	TQc	CCR	77.07	24	FERNANDINA BEACH	HILLIARD SW
19877	30.62574	-82.009	MMAP	GPS	TQc	CCR	72.28	43	OKEFENOKEE SWAMP	TOLEDO (GA)

FLORIDA GEOLOGICAL SURVEY

Table 4. (Continued).

<i>FGSW No.</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Location Method</i>	<i>Location Accuracy</i>	<i>Surface Unit Observed</i>	<i>Sample Type</i>	<i>Elevation (ft)</i>	<i>Borehole Total Depth (ft)</i>	<i>USGS 100K QUAD</i>	<i>USGS 24K QUAD</i>
19878	30.69617	-82.027	MMAP	GPS	TQc	CCR	73.56	43	OKEFENOKEE SWAMP	TOLEDO (GA)
19879	30.30645	-82.0073	MMAP	GPS	TQc	CCR	74.15	48	LAKE CITY	MACCLENNY EAST
19919	30.41415	-82.023	WGPS	GPS	TQc	CCR	80.68	16	LAKE CITY	MACCLENNY NE (GA)
19920	30.41415	-82.023	WGPS	GPS	TQc	CCR	80.68	321	LAKE CITY	MACCLENNY NE (GA)
20048	30.19744	-82.2699	DPHO	GPS	TQc	CCR	129.82	616	LAKE CITY	SANDERSON SOUTH
20049	30.19583	-82.2919	DPHO	GPS	TQc	CCR	128.74	36	LAKE CITY	SANDERSON SOUTH
20050	30.19711	-82.309	DPHO	GPS	TQc	CCR	130.31	44	LAKE CITY	SANDERSON SOUTH
20051	30.18465	-82.284	DPHO	GPS	TQc	CCR	125.00	36	LAKE CITY	SANDERSON SOUTH
20052	30.17641	-82.3002	DPHO	GPS	TQc	CCR	130.25	36	LAKE CITY	SANDERSON SOUTH
20053	30.17194	-82.2778	DPHO	GPS	TQc	CCR	136.52	20	LAKE CITY	SANDERSON SOUTH

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APPENDIX B: EMRI-FFA SAMPLE ACQUISITION

Table 5. Records of all boreholes drilled for the completion of the EMRI-FFA study.

<i>FGS W No.</i>	<i>Site Name</i>	<i>Total Depth (ft)</i>	<i>Total Depth (m)</i>	<i>County</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Drill Date</i>
19801	EMRI-CB001	16	4.88	Clay	29.99822	-82.0015	5/10/2021
19802	EMRI-CB002	20	6.10	Clay	30.00269	-82.0318	5/10/2021
19803	EMRI-CB003	16	4.88	Clay	30.03452	-82.0305	5/11/2021
19804	EMRI-CB004	24	7.32	Clay	30.04895	-82.0256	5/11/2021
19805	EMRI-CB005	44	13.41	Clay	30.01407	-82.0088	5/25/2021
19806	EMRI-CB006	20	6.10	Clay	30.04766	-82.0106	5/26/2021
19807	EMRI-CB007	32	9.75	Clay	30.03305	-82.0064	5/26/2021
19808	EMRI-CB008	28	8.53	Clay	30.02608	-81.9963	5/26/2021
19843	EMRI-FYRCS001	210	64.01	Nassau	30.67176	-82.0473	5/9/2022
19851	EMRI-FYRCS002	43	13.11	Nassau	30.67162	-82.0442	11/3/2021
19852	EMRI-FYRCS003	36	10.97	Nassau	30.67028	-82.0417	11/4/2021
20048	EMRI-M&M Dairy No. 1	616	187.76	Baker	30.19744	-82.2699	6/30/2023
20049	EMRI-M&M Dairy No. 2	36	10.97	Baker	30.19583	-82.2919	4/18/2023
20050	EMRI-M&M Dairy No. 3	44	13.41	Baker	30.19711	-82.309	4/19/2023
20051	EMRI-M&M Dairy No. 4	36	10.97	Baker	30.18465	-82.284	4/20/2023
20052	EMRI-M&M Dairy No. 5	36	10.97	Baker	30.17641	-82.3002	4/24/2023
20053	EMRI-M&M Dairy No. 6	20	6.10	Baker	30.17194	-82.2778	5/12/2023
19919	EMRI-MSTOKES-001	16	4.88	Nassau	30.41415	-82.023	5/17/2022

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Table 5. (Continued).

<i>FGS W No.</i>	<i>Site Name</i>	<i>Total Depth (ft)</i>	<i>Total Depth (m)</i>	<i>County</i>	<i>Latitude Decimal</i>	<i>Longitude Decimal</i>	<i>Drill Date</i>
19920	EMRI-MSTOKES-001A	321	97.84	Nassau	30.41415	-82.023	12/13/2022
19873	EMRI-NC121-001	44	13.41	Nassau	30.34104	-82.0092	11/5/2021
19874	EMRI-NC121-002	28	8.53	Nassau	30.41197	-82.0291	1/20/2022
19875	EMRI-NC121-003	40	12.19	Nassau	30.44203	-82.0089	1/21/2022
19876	EMRI-NC121-004	24	7.32	Nassau	30.51338	-81.9938	1/20/2022
19877	EMRI-NC121-005	43	13.11	Nassau	30.62574	-82.009	1/27/2022
19878	EMRI-NC121-006	43	13.11	Nassau	30.69617	-82.027	1/28/2022
19838	EMRI-RSSF001	44	13.41	Nassau	30.81632	-81.9372	9/14/2021
19839	EMRI-RSSF002	28	8.53	Nassau	30.81269	-81.9537	9/15/2021
19840	EMRI-RSSF003	34	10.36	Nassau	30.79763	-81.9513	9/15/2021
19841	EMRI-RSSF004	32	9.75	Nassau	30.78733	-81.9528	9/16/2021
19837	EMRI-SL001	20	6.10	Nassau	30.78451	-81.9696	9/14/2021
19879	EMRI-TIITF-Baldwin to Jax-001	48	14.63	Duval	30.30645	-82.0073	2/10/2022

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Table 6. Secondary sample data for mineral and chemical analyses.

<i>FGS W No.</i>	<i>Borehole Name</i>	<i>Latitude (DD)</i>	<i>Longitude (DD)</i>	<i>Elev (ft)</i>	<i>TD (ft)</i>	<i>Top BLS (ft)</i>	<i>Bottom BLS (ft)</i>	<i>Top MSL (ft)</i>	<i>Bottom MSL (ft)</i>	<i>Weight (g)</i>	<i>Drill Year</i>	<i>Second. Sample ID</i>
10473	Trail Ridge #3	30.31722	-82.0854	167	288	56	58	111	109	100.69	1970	FFA10473-1
10481	Union Camp #1	29.87533	-81.7055	87	108	53	55.5	34	31.5	135.66	1970	FFA10481-1
10481	Union Camp #1	29.87533	-81.7055	87	108	89	91.5	-2	-4.5	126.3	1970	FFA10481-2
10482	Boulogne #1	30.73361	-81.9843	95	98	71.5	73.5	23.5	21.5	126.04	1970	FFA10482-1
10489	DuPont #2	30.04703	-82.0328	214	146	25	26	189	188	100.2	1968	FFA10489-1
10489	DuPont #2	30.04703	-82.0328	214	146	39	40	175	174	100.34	1968	FFA10489-2
12360	N.L. #1	30.11957	-82.0509	200	493	22	23.5	178	176.5	101.19	1974	FFA12360-1
12360	N.L. #1	30.11957	-82.0509	200	493	39	40	161	160	106.22	1974	FFA12360-2
12361	National-Lead #2	30.16433	-82.0502	189	127	12.5	13.5	176.5	175.5	100.55	1974	FFA12361-1
12361	National-Lead #2	30.16433	-82.0502	189	127	24.5	32	164.5	157	137.87	1974	FFA12361-2
12361	National-Lead #2	30.16433	-82.0502	189	127	56.5	56.5	132.5	132.5	105.3	1974	FFA12361-3
13769	Penney Farms	29.98429	-81.8375	94	319	35	50	59	44	118.89	1977	FFA13769-1
14346	Moody #1 Florahome	29.73134	-81.8968	89	182	40	45	33	31	123.83	1980	FFA14346-1
19587	Forbess/Walker Core	30.33033	-81.9079	85	340	61.5	62.5	23.5	22.5	123.3	2016	FFA19587-1
19805	EMRI-CB005	30.01407	-82.0088	185	44	38	40	147	145	102.13	2021	FFA19805-1
19838	EMRI-RSSF001	30.81631	-81.93715	68	44	20	28	48	40	87.64	2021	FFA19838-1
19841	EMRI-RSSF004	30.78733	-81.9528	74	32	20	28	54	46	118.2	2021	FFA19841-1

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Table 6. (Continued).

<i>FGS W No.</i>	<i>Borehole Name</i>	<i>Latitude (DD)</i>	<i>Longitude (DD)</i>	<i>Elev (ft)</i>	<i>TD (ft)</i>	<i>Top BLS (ft)</i>	<i>Bottom BLS (ft)</i>	<i>Top MSL (ft)</i>	<i>Bottom MSL (ft)</i>	<i>Weight (g)</i>	<i>Drill Year</i>	<i>Second. Sample ID</i>
19843	EMRI-FYRCS001	30.67176	-82.0473	68	50	39	41	29	27	122.59	2021	FFA19843-1
19877	EMRI-NC121-005	30.62574	-82.009	72	43	2	4	70	68	109.98	2022	FFA19877-1
19877	EMRI-NC121-005	30.62574	-82.009	72	43	24	32	48	40	107.58	2022	FFA19877-2
19878	EMRI-NC121-006	30.69617	-82.027	74	43	20	28	54	46	118.62	2022	FFA19878-1

APPENDIX C: QUANTATIVE MINERALOGY REPORTS FROM SGS CANADA INC.

Table 7. Samples volumes pre- and post- processing via heavy liquid separation. Methylene iodide was selected as a heavy medium and tailored to achieve a specific gravity of 2.9 g/cm³. The sink fraction was then split to accomplish the various analyses. The average, minimum, and maximum wt. % for each sink fraction was calculated as the following: 2.62, 0.57, and 7.78 respectively.

<i>Secondary Sample ID</i>	<i>Initial Weight (g)</i>	<i>Total</i>	<i>Loss</i>	<i>HLS Sink (g)</i>	<i>HLS Float (g)</i>	<i>HLS Sink wt. %</i>	<i>HLS Float wt. %</i>
<i>FFA10473-1</i>	100.57	99.25	1.32	2.74	96.51	2.76	97.24
<i>FFA10489-1</i>	100.11	99.95	0.16	7.78	92.17	7.78	92.22
<i>FFA10489-2</i>	100.28	99.87	0.41	5.44	94.43	5.45	94.55
<i>FFA19805-1</i>	101.6	100.52	1.08	1.99	98.53	1.98	98.02
<i>FFA12360-1</i>	101.03	100.41	0.62	5.47	94.94	5.45	94.55
<i>FFA12360-2</i>	106.1	105.81	0.29	4.12	101.69	3.89	96.11
<i>FFA12361-1</i>	100.41	100.21	0.2	4.36	95.85	4.35	95.65
<i>FFA12361-2</i>	137.53	137	0.53	6.24	130.76	4.55	95.45
<i>FFA12361-3</i>	103.21	101.75	1.46	2.91	98.84	2.86	97.14
<i>FFA13769-1</i>	118.8	118.31	0.49	0.68	117.63	0.57	99.43
<i>FFA19838-1</i>	114.28	112.86	1.42	0.99	111.87	0.88	99.12
<i>FFA19841-1</i>	117.89	117.28	0.61	1.11	116.17	0.95	99.05
<i>FFA19843-1</i>	120.45	119.83	0.62	1.88	117.95	1.57	98.43
<i>FFA19587-1</i>	123.1	121.71	1.39	2.22	119.49	1.82	98.18
<i>FFA14346-1</i>	123.5	123.43	0.07	5.48	117.95	4.44	95.56
<i>FFA10482-1</i>	125.09	122.85	2.24	1.55	121.3	1.26	98.74
<i>FFA10481-1</i>	135.66	134.52	1.14	1.22	133.3	0.91	99.09
<i>FFA10481-2</i>	126.12	125.43	0.69	1.23	124.2	0.98	99.02
<i>FFA19877-1</i>	109.02	106.79	2.23	0.92	105.87	0.86	99.14
<i>FFA19877-2</i>	107.04	105.27	1.77	0.7	104.57	0.66	99.34
<i>FFA19878-1</i>	118.03	117.15	0.88	1.2	115.95	1.02	98.98

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Table 8. A complete list of minerals identified via TIMA-X. The fraction listed as “other” includes mineral species not categorized by the analysis. A couple of float fractions were analyzed to provide a more complete view of the bulk mineral suite and sample characterization. Mineral fractions represent sinks where not specified.

<i>Modal Mineralogy / Fraction</i>	<i>FFA 10473-1</i>	<i>FFA 12360-1</i>	<i>FFA 12360-2</i>	<i>FFA 12360-2</i>	<i>FFA 12361-1</i>	<i>FFA 12361-2</i>	<i>FFA 12361-3</i>	<i>FFA 19843-1</i>	<i>FFA 10489-1</i>	<i>FFA 10489-1</i>	<i>FFA 10489-2</i>	<i>FFA 19878-1</i>
			<i>Float</i>	<i>Sink</i>					<i>Float</i>	<i>Sink</i>		
<i>Monazite</i>	0.85	0.02	0.00	0.01	0.01	0.04	1.92	1.27	0.00	0.01	0.01	2.00
<i>Xenotime</i>	0.09	0.00	0.00	0.00	0.00	0.00	0.26	0.13	0.00	0.00	0.00	0.15
<i>Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Pyrochlore/ Columbite</i>	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
<i>Gorceixite</i>	0.02	0.00	0.00	0.00	0.00	0.08	0.03	0.06	0.00	0.00	0.01	0.00
<i>Chromite</i>	0.03	0.00	0.00	0.01	0.03	0.04	0.05	0.05	0.00	0.07	0.00	0.06
<i>Spinel</i>	0.00	0.06	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.16	0.03	0.02
<i>Gahnite</i>	0.03	0.10	0.00	0.05	0.08	0.04	0.02	0.02	0.00	0.15	0.07	0.03
<i>Fe-Oxides</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
<i>Goethite</i>	0.01	0.00	0.00	0.00	0.00	0.00	0.11	0.03	0.00	0.00	0.00	0.00
<i>Ilmenite</i>	0.17	0.03	0.00	0.05	0.02	0.07	0.30	8.90	0.00	0.03	0.04	1.30
<i>Altered Ilmenite</i>	9.86	38.88	1.10	37.09	39.16	45.03	28.44	34.79	0.92	31.93	35.49	35.93
<i>Ilmenorutile</i>	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.01
<i>Rutile</i>	9.72	5.64	0.12	4.68	10.34	5.21	21.59	11.79	0.18	3.74	4.79	14.93
<i>Mineralogic data continued on the next page for the samples above.</i>												

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Table 8. Continued.

<i>Modal Mineralogy / Fraction</i>	<i>FFA 10473-1</i>	<i>FFA 12360-1</i>	<i>FFA 12360-2</i>	<i>FFA 12360-2</i>	<i>FFA 12361-1</i>	<i>FFA 12361-2</i>	<i>FFA 12361-3</i>	<i>FFA 19843-1</i>	<i>FFA 10489-1</i>	<i>FFA 10489-1</i>	<i>FFA 10489-2</i>	<i>FFA 19878-1</i>
			<i>Float</i>	<i>Sink</i>					<i>Float</i>	<i>Sink</i>		
<i>Pseudorutile</i>	0.02	0.00	0.00	0.01	0.01	0.01	0.13	0.06	0.00	0.00	0.01	0.08
<i>Zircon</i>	8.52	20.02	0.37	10.25	28.32	26.03	15.82	13.75	0.34	12.41	8.63	13.28
<i>Baddeleyite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Thorite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Fluorite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Anhydrite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Amphibole/ Pyroxene</i>	2.11	4.97	0.04	5.66	3.05	2.30	2.44	3.35	0.17	6.50	6.87	2.69
<i>Biotite</i>	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Chlorite</i>	0.12	0.12	0.01	0.19	0.13	0.13	0.23	0.05	0.00	0.11	0.10	0.04
<i>Almandine</i>	0.22	0.12	0.01	0.24	0.11	0.14	0.28	0.19	0.00	0.12	0.16	0.20
<i>Staurolite</i>	1.90	21.42	0.79	33.05	16.38	19.04	3.88	6.40	0.61	23.54	26.45	5.67
<i>Kyanite</i>	7.71	7.62	0.05	7.51	1.98	1.32	7.93	12.59	0.17	9.44	12.49	14.88
<i>Quartz</i>	55.88	0.51	97.42	0.32	0.07	0.11	9.45	3.25	97.57	11.21	3.97	4.10
<i>Epidote</i>	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00
<i>Ti-Silicates</i>	0.72	0.13	0.01	0.35	0.09	0.16	3.00	2.07	0.01	0.12	0.16	2.18
<i>Olivine</i>	0.15	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.03
<i>Apatite</i>	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00
<i>Titanite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.01
<i>Mineralogic data continued on the next page for the samples above.</i>												

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Table 8. Continued.

<i>Modal Mineralogy / Fraction</i>	<i>FFA 10473-1</i>	<i>FFA 12360-1</i>	<i>FFA 12360-2</i>	<i>FFA 12360-2</i>	<i>FFA 12361-1</i>	<i>FFA 12361-2</i>	<i>FFA 12361-3</i>	<i>FFA 19843-1</i>	<i>FFA 10489-1</i>	<i>FFA 10489-1</i>	<i>FFA 10489-2</i>	<i>FFA 19878-1</i>
			<i>Float</i>	<i>Sink</i>					<i>Float</i>	<i>Sink</i>		
<i>Orthoclase</i>	1.22	0.00	0.01	0.00	0.00	0.00	3.13	0.15	0.00	0.00	0.01	0.16
<i>Muscovite</i>	0.03	0.01	0.01	0.01	0.00	0.01	0.04	0.03	0.00	0.01	0.01	0.05
<i>Plagioclase</i>	0.21	0.02	0.02	0.05	0.01	0.02	0.22	0.26	0.01	0.09	0.07	1.02
<i>Carbonates</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
<i>Sulphides</i>	0.02	0.00	0.01	0.01	0.01	0.01	0.20	0.00	0.00	0.01	0.01	0.00
<i>Ni-(Cu-Co) Alloy</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Marshite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Gibbsite</i>	0.03	0.17	0.00	0.25	0.06	0.01	0.02	0.09	0.00	0.22	0.34	0.04
<i>Tin</i>	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
<i>Wollastonite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Clays</i>	0.20	0.04	0.01	0.10	0.02	0.02	0.25	0.39	0.01	0.05	0.13	0.96
<i>Schorl (Tourmaline)</i>	0.09	0.11	0.02	0.10	0.11	0.12	0.12	0.28	0.00	0.07	0.16	0.10
<i>Other</i>	0.03	0.00	0.00	0.00	0.00	0.02	0.05	0.00	0.00	0.00	0.00	0.07
<i>Total</i>	100	100	100	100	100	100	100	100	100	100	100	100

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Table 8. (Continued).

<i>Modal Mineralogy / Fraction</i>	<i>FFA 19877- 1</i>	<i>FFA 19877-2 Float</i>	<i>FFA 19877-2 Sink</i>	<i>FFA 19805-1</i>	<i>FFA 10482-1</i>	<i>FFA 19841-1</i>	<i>FFA 19838-1</i>	<i>FFA 19587-1</i>	<i>FFA 14346-1</i>	<i>FFA 13769-1</i>	<i>FFA 10481-1</i>	<i>FFA 10481-2</i>
<i>Monazite</i>	1.09	0.01	0.83	0.02	1.33	1.22	2.02	0.82	0.02	0.34	0.92	0.39
<i>Xenotime</i>	0.05	0.00	0.07	0.01	0.12	0.12	0.22	0.04	0.00	0.00	0.13	0.03
<i>Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Pyrochlore/ Columbite</i>	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
<i>Gorceixite</i>	0.00	0.00	0.04	0.00	0.02	0.02	0.03	0.03	0.01	0.04	0.03	0.26
<i>Chromite</i>	0.01	0.00	0.02	0.00	0.05	0.06	0.05	0.03	0.00	0.02	0.07	0.00
<i>Spinel</i>	0.01	0.00	0.02	0.06	0.00	0.01	0.01	0.00	0.08	0.00	0.01	0.00
<i>Gahnite</i>	0.02	0.00	0.01	0.07	0.02	0.03	0.02	0.01	0.15	0.00	0.02	0.01
<i>Fe-Oxides</i>	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.29	0.00	0.00	0.00
<i>Goethite</i>	0.24	0.00	0.06	0.00	0.06	0.01	0.02	0.01	0.08	0.01	0.00	0.01
<i>Ilmenite</i>	0.06	0.01	1.35	0.03	11.77	4.50	8.16	10.18	0.08	0.78	5.28	3.28
<i>Altered Ilmenite</i>	8.25	0.00	23.62	18.00	18.34	30.31	27.79	17.52	33.91	29.67	27.35	22.99
<i>Ilmenorutile</i>	0.01	0.00	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.01
<i>Rutile</i>	37.80	0.02	10.99	2.77	8.04	13.19	12.43	7.10	3.09	12.36	12.65	8.60
<i>Pseudorutile</i>	0.01	0.00	0.07	0.03	0.05	0.10	0.12	0.02	0.01	0.01	0.09	0.02
<i>Zircon</i>	17.81	0.01	6.98	6.52	10.77	11.25	13.10	6.97	12.30	8.99	8.63	5.44
<i>Mineralogic data continued on the next page for the samples above.</i>												

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Table 8. (Continued).

<i>Modal Mineralogy / Fraction</i>	<i>FFA 19877-1</i>	<i>FFA 19877-2 Float</i>	<i>FFA 19877-2 Sink</i>	<i>FFA 19805-1</i>	<i>FFA 10482-1</i>	<i>FFA 19841-1</i>	<i>FFA 19838-1</i>	<i>FFA 19587-1</i>	<i>FFA 14346-1</i>	<i>FFA 13769-1</i>	<i>FFA 10481-1</i>	<i>FFA 10481-2</i>
<i>Baddeleyite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
<i>Thorite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Fluorite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
<i>Anhydrite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Amphibole/ Pyroxene</i>	4.08	0.05	5.02	8.51	3.90	4.11	3.46	4.94	8.41	10.26	5.56	5.89
<i>Biotite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Chlorite</i>	0.05	0.00	0.08	0.09	0.30	0.30	0.07	0.29	0.23	0.65	0.58	0.38
<i>Almandine</i>	0.24	0.03	0.36	0.23	0.31	0.30	0.19	0.25	0.28	0.69	0.71	0.38
<i>Staurolite</i>	6.40	0.00	6.39	18.14	5.05	6.30	5.53	5.35	29.18	12.55	5.74	6.55
<i>Kyanite</i>	16.41	0.04	22.96	15.94	9.34	18.21	15.15	9.94	9.35	18.60	19.37	13.34
<i>Quartz</i>	3.02	91.62	9.31	28.00	3.12	5.01	6.44	1.83	0.71	3.71	8.74	3.76
<i>Epidote</i>	0.00	0.00	0.02	0.00	22.78	0.00	0.64	25.00	0.47	0.01	0.09	26.64
<i>Ti-Silicates</i>	0.74	0.02	4.83	0.37	1.34	1.67	2.93	0.68	0.20	0.44	1.90	0.71
<i>Olivine</i>	0.01	0.00	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Apatite</i>	0.00	0.00	0.00	0.01	0.10	0.00	0.00	6.13	0.44	0.08	0.00	0.00
<i>Titanite</i>	0.01	0.00	0.01	0.01	0.65	0.01	0.01	0.76	0.02	0.00	0.01	0.50
<i>Orthoclase</i>	0.04	2.15	0.54	0.01	0.31	0.15	0.40	0.10	0.00	0.02	0.89	0.13
<i>Muscovite</i>	0.01	0.09	0.88	0.02	0.06	0.05	0.19	0.02	0.01	0.01	0.17	0.01
<i>Mineralogic data continued on the next page for the samples above.</i>												

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Table 8. (Continued).

<i>Modal Mineralogy / Fraction</i>	<i>FFA 19877-1</i>	<i>FFA 19877-2 Float</i>	<i>FFA 19877-2 Sink</i>	<i>FFA 19805-1</i>	<i>FFA 10482-1</i>	<i>FFA 19841-1</i>	<i>FFA 19838-1</i>	<i>FFA 19587-1</i>	<i>FFA 14346-1</i>	<i>FFA 13769-1</i>	<i>FFA 10481-1</i>	<i>FFA 10481-2</i>
<i>Plagioclase</i>	0.61	2.58	3.46	0.24	0.54	0.19	0.47	0.30	0.13	0.14	0.23	0.19
<i>Carbonates</i>	0.03	0.00	0.01	0.00	0.00	0.01	0.00	0.06	0.01	0.01	0.00	0.00
<i>Sulphides</i>	0.00	0.00	0.02	0.01	0.19	2.36	0.00	1.12	0.00	0.02	0.03	0.05
<i>Ni-(Cu-Co) Alloy</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Marshite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Gibbsite</i>	0.08	0.00	0.07	0.06	0.05	0.08	0.05	0.04	0.40	0.12	0.03	0.06
<i>Tin</i>	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00
<i>Wollastonite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Clays</i>	0.17	3.35	1.69	0.72	0.34	0.20	0.36	0.04	0.10	0.08	0.30	0.10
<i>Schorl (Tourmaline)</i>	0.46	0.01	0.21	0.12	1.01	0.23	0.10	0.30	0.06	0.22	0.30	0.20
<i>Other</i>	2.24	0.00	0.07	0.00	0.03	0.00	0.00	0.09	0.00	0.18	0.16	0.04
<i>Total</i>	100	100	100	100	100	100	100	100	100	100	100	100

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Table 9. Particle size data for sink fractions analyzed via TIMA-X. Note the data provided in column 1 for variations in particle size fractions. This is a result of the TIMA analysis for samples submitted in multiple shipments.

<i>Particle size (μm)</i>	<i>FFA 10473- 1</i>	<i>FFA 12360- 1</i>	<i>FFA 12360- 2</i>	<i>FFA 12361- 1</i>	<i>FFA 12361- 2</i>	<i>FFA 12361- 3</i>	<i>FFA 19843- 1</i>	<i>FFA 10489- 1</i>	<i>FFA 10489- 2</i>
<3.30	0	0	0	0	0	0	0	0	0
<3.98	0.04	0.01	0.38	0.31	0.41	0.8	0.11	0	0
<4.80	0.04	0.01	0.38	0.31	0.41	0.8	0.11	0	0
<5.78	0.08	0.02	0.53	0.43	0.57	1.16	0.19	0.01	0.01
<6.97	0.13	0.03	0.74	0.59	0.79	1.68	0.32	0.01	0.01
<8.40	0.2	0.04	0.9	0.71	0.93	2.1	0.44	0.01	0.02
<10.13	0.3	0.05	1.03	0.8	1.05	2.52	0.54	0.02	0.03
<12.21	0.53	0.07	1.23	0.96	1.25	3.44	0.67	0.03	0.04
<14.72	0.99	0.09	1.47	1.15	1.46	4.92	0.8	0.06	0.06
<17.75	1.73	0.12	1.69	1.33	1.67	7.22	0.93	0.09	0.09
<21.40	2.5	0.15	1.87	1.48	1.84	9.74	1.1	0.11	0.12
<25.79	3.5	0.18	2	1.59	1.96	13.03	1.32	0.13	0.14
<31.09	5.22	0.22	2.1	1.69	2.05	18.18	1.7	0.15	0.17
<37.48	8.64	0.29	2.19	1.82	2.14	27.56	2.4	0.18	0.22
<45.19	14.85	0.42	2.29	2.01	2.27	42.51	3.65	0.24	0.31
<54.48	22.62	0.67	2.49	2.35	2.48	59.54	6.29	0.35	0.48
<65.67	31	1.3	2.83	3.05	2.91	72.04	12.56	0.53	0.83
<79.17	40.27	2.68	3.51	4.51	3.83	79.86	26.63	0.99	1.57
<95.45	51.06	5.59	5.17	7.93	6.05	85.53	48.85	2.05	3.09
<115.06	63.45	12.32	9.11	15.42	12.01	91.42	72.09	4.37	6.59
<138.71	77.74	24.11	17.44	29.26	25.26	95.46	88.85	10.05	14.55
<167.22	90.22	39.93	32.02	48.74	45.28	97.82	96.35	20.7	27.53
<201.59	97.04	56.93	52.25	70.2	67.38	98.85	98.84	36.22	45.5
<243.03	99.2	71.59	72.15	86.33	83.03	99.35	99.62	53.45	64.82
<292.98	99.66	83.69	85.98	94.71	93.09	99.76	99.81	71.28	81.04
<353.20	100	92.7	94.53	98.77	97.69	99.85	99.81	85.62	91.86
<i>Particle data continued on the next page for the samples above.</i>									

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Table 9. (Continued).

<i>Particle size (μm)</i>	<i>FFA 10473- 1</i>	<i>FFA 12360- 1</i>	<i>FFA 12360- 2</i>	<i>FFA 12361- 1</i>	<i>FFA 12361- 2</i>	<i>FFA 12361- 3</i>	<i>FFA 19843- 1</i>	<i>FFA 10489- 1</i>	<i>FFA 10489- 2</i>
<425.79	100	98.06	97.47	99.73	99.24	100	100	95.22	97.44
<513.30	100	99.5	99.49	99.87	99.85	100	100	98.6	99.29
<618.81	100	100	100	100	100	100	100	99.88	99.86
<745.99	100	100	100	100	100	100	100	100	100
<899.32	100	100	100	100	100	100	100	100	100
<1084.17	100	100	100	100	100	100	100	100	100
<1307.00	100	100	100	100	100	100	100	100	100
<i>All particles</i>	100	100	100	100	100	100	100	100	100

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Table 9. (Continued).

<i>Particle size (μm)</i>	<i>FFA 19805- 1</i>	<i>FFA 10482- 1</i>	<i>FFA 19841- 1</i>	<i>FFA 19838- 1</i>	<i>FFA 19587- 1</i>	<i>FFA 14346- 1</i>	<i>FFA 13769- 1</i>	<i>FFA 10481- 1</i>	<i>FFA 10481- 2</i>
<3.30	0	0	0	0	0	0	0	0	0
<3.98	0.11	0.1	0.09	0.19	0.04	0.03	0.03	0.18	0.04
<4.80	0.11	0.1	0.09	0.19	0.04	0.03	0.03	0.18	0.04
<5.78	0.17	0.17	0.14	0.3	0.07	0.04	0.05	0.27	0.06
<6.97	0.25	0.32	0.23	0.5	0.13	0.07	0.09	0.45	0.11
<8.40	0.3	0.47	0.31	0.69	0.19	0.09	0.12	0.61	0.16
<10.13	0.36	0.6	0.37	0.83	0.23	0.1	0.15	0.73	0.2
<12.21	0.44	0.78	0.44	1.03	0.29	0.12	0.18	0.9	0.25
<14.72	0.53	0.95	0.51	1.22	0.35	0.14	0.22	1.07	0.31
<17.75	0.62	1.17	0.61	1.46	0.42	0.15	0.26	1.27	0.38
<21.40	0.7	1.46	0.76	1.77	0.52	0.17	0.3	1.52	0.47
<25.79	0.77	1.91	0.99	2.32	0.68	0.19	0.38	2.01	0.63
<31.09	0.84	2.77	1.48	3.51	0.96	0.21	0.51	2.87	0.94
<37.48	0.93	4.52	2.45	5.9	1.51	0.26	0.72	4.43	1.47
<45.19	1.08	8.11	4.49	11.21	2.59	0.32	1.15	7.72	2.55
<54.48	1.4	14.97	9.04	23.51	4.71	0.48	1.88	14.13	4.83
<65.67	1.92	25.89	18.81	43.45	9.25	0.7	3.6	25.88	9.37
<79.17	3.02	40.77	37.18	63.13	18.47	1.19	7.59	44.54	18.16
<95.45	5.19	57.02	61.08	75.55	34.93	2.17	16.98	66.87	33.78
<115.06	9.68	72.79	80.62	84.49	56.84	4.48	33.49	83.5	53.85
<138.71	17.52	83.97	91.93	91.81	76.8	9.6	54.78	92.63	74.87
<167.22	27.9	91.27	96.58	96.26	90.35	19.91	74.18	97.23	89.76
<201.59	41.96	95.27	98.15	98.48	95.87	37.7	87.74	98.96	96.95
<243.03	58.04	96.96	98.84	99.64	97.71	59.63	95.1	99.57	99.39
<292.98	74	98.78	98.89	100	98.4	77.82	98.53	99.7	99.89
<353.20	86.1	99.12	99.09	100	99.11	90.61	99.59	100	100
<425.79	93.69	99.77	99.36	100	99.85	97.68	99.81	100	100

Particle data continued on the next page for the samples above.

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Table 9. (Continued).

<i>Particle size (μm)</i>	<i>FFA 19805- 1</i>	<i>FFA 10482- 1</i>	<i>FFA 19841- 1</i>	<i>FFA 19838- 1</i>	<i>FFA 19587- 1</i>	<i>FFA 14346- 1</i>	<i>FFA 13769- 1</i>	<i>FFA 10481- 1</i>	<i>FFA 10481- 2</i>
<513.30	97.9	100	100	100	100	99.23	100	100	100
<618.81	99.13	100	100	100	100	100	100	100	100
<745.99	99.67	100	100	100	100	100	100	100	100
<899.32	100	100	100	100	100	100	100	100	100
<1084.17	100	100	100	100	100	100	100	100	100
<1307.00	100	100	100	100	100	100	100	100	100
<i>All particles</i>	100	100	100	100	100	100	100	100	100

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Table 9. (Continued).

<i>Particle size (μm)</i>	<i>FFA- 19877- 1</i>	<i>FFA- 19877- 2</i>	<i>FFA- 19878- 1</i>
<3.30	0	0	0
<3.97	0.05	0.07	0.05
<4.78	0.05	0.07	0.05
<5.74	0.09	0.11	0.08
<6.91	0.16	0.18	0.13
<8.31	0.23	0.27	0.2
<10.00	0.31	0.37	0.29
<12.03	0.52	0.64	0.51
<14.47	0.82	1.05	0.9
<17.40	1.19	1.54	1.41
<20.93	1.57	2.05	1.98
<25.18	1.96	2.52	2.55
<30.29	2.42	3.06	3.25
<36.44	3.25	3.92	4.53
<43.83	5.05	5.49	6.97
<52.73	8.86	8.51	12.1
<63.42	16.48	14.41	22.26
<76.29	29.15	26.98	40.07
<91.78	46.14	47.41	62.4
<110.40	64.89	68.7	81.6
<132.80	80.69	83.29	93.25
<159.75	90.28	91.03	97.95
<192.16	95.15	94.32	99.31
<231.15	97.4	95.2	99.76
<278.06	98.37	95.6	99.87
<334.48	99	95.75	99.93
	<i>Particle data continued on the next page for the samples above.</i>		

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Table 9. (Continued).

<i>Particle size (μm)</i>	<i>FFA- 19877- 1</i>	<i>FFA- 19877- 2</i>	<i>FFA- 19878- 1</i>
<402.35	99.15	96.14	100
<483.99	99.2	96.47	100
<582.19	99.47	96.79	100
<700.33	99.68	97.19	100
<842.43	99.68	98.61	100
<1013.37	100	99.16	100
<1219.00	100	100	100
<i>All particles</i>	100	100	100

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Table 10. Zircon association where sample mass has been normalized. Pure = 100% of the particle volume is zircon, free = >95% of the particle volume is zircon, liberated = >80% of the particle volume is zircon, and associated = where <80% of the particle volume is zircon.

<i>Zircon Association / Sample</i>	<i>FFA</i> <i>10473-1</i>	<i>FFA</i> <i>10489-1</i>	<i>FFA</i> <i>10489-2</i>	<i>FFA</i> <i>19805-1</i>	<i>FFA</i> <i>12360-1</i>	<i>FFA</i> <i>12360-2</i>	<i>FFA</i> <i>12361-1</i>	<i>FFA</i> <i>12361-2</i>	<i>FFA</i> <i>12361-3</i>
<i>Pure Zircon</i>	66.8	27.5	27.2	10.9	35.8	34.2	45.6	35.9	79.2
<i>Free Zircon</i>	24.6	55.5	48.2	78.9	57.7	56.7	45.8	61.6	16.0
<i>Liberated Zircon</i>	4.12	1.41	3.96	8.11	1.58	2.6	1.55	1.63	3.19
<i>Zircon:Xenotime</i>	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
<i>Zircon:Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Zircon:Pyrochlore/Columbite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Zircon:Spinel</i>	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00
<i>Zircon:Ilmenite</i>	0.66	8.17	10.92	0.63	2.93	3.89	5.01	0.54	0.44
<i>Zircon:Ilmenorutile</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Zircon:Monazite</i>	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
<i>Zircon:Rutile</i>	0.76	1.33	0.70	0.14	0.67	0.37	1.45	0.08	0.25
<i>Zircon:Amphibole/Pyroxene/Garnet</i>	0.18	0.27	1.08	0.26	0.19	0.24	0.08	0.00	0.06
<i>Zircon:Staurolite</i>	0.10	2.32	3.08	0.03	0.17	0.67	0.24	0.10	0.04
<i>Zircon:Kyanite</i>	0.19	1.13	1.20	0.06	0.56	1.04	0.00	0.00	0.08
<i>Zircon:Quartz/Feldpars</i>	2.06	0.55	0.22	0.56	0.00	0.00	0.00	0.12	0.25
<i>Zircon:Other Minerals</i>	0.07	0.00	0.12	0.15	0.00	0.15	0.00	0.00	0.14
<i>Complex</i>	0.38	1.85	3.33	0.24	0.25	0.15	0.25	0.01	0.20
<i>Total Liberation</i>	95.5	84.4	79.4	97.9	95.0	93.5	93.0	99.2	98.4

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Table 10. (Continued).

<i>Zircon Association / Sample</i>	<i>FFA</i> <i>19841-1</i>	<i>FFA</i> <i>10481-1</i>	<i>FFA</i> <i>10481-2</i>	<i>FFA</i> <i>10482-1</i>	<i>FFA</i> <i>13769-1</i>	<i>FFA</i> <i>14346</i>	<i>FFA</i> <i>19587-1</i>	<i>FFA</i> <i>19838-1</i>	<i>FFA</i> <i>19843-1</i>
<i>Pure Zircon</i>	50.8	53.8	48.1	46.7	40.5	25.6	47.5	53.7	49.7
<i>Free Zircon</i>	43.1	39.9	42.0	42.0	46.3	67.0	45.7	32.3	40.6
<i>Liberated Zircon</i>	2.77	3.91	2.16	7.47	2.26	2.19	2.11	8.41	2.78
<i>Zircon:Xenotime</i>	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
<i>Zircon:Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Zircon:Pyrochlore/Columbite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Zircon:Spinel</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
<i>Zircon:Ilmenite</i>	1.44	0.78	3.41	1.53	4.92	2.51	1.67	3.07	4.36
<i>Zircon:Ilmenorutile</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Zircon:Monazite</i>	0.00	0.03	0.00	0.11	0.07	0.00	0.11	0.22	0.13
<i>Zircon:Rutile</i>	0.32	0.28	0.65	0.50	1.05	0.15	0.86	0.57	0.81
<i>Zircon: Amphibole/Pyroxene/Garnet</i>	0.14	0.14	0.30	0.06	1.28	0.16	0.39	0.17	0.00
<i>Zircon:Staurolite</i>	0.10	0.10	0.36	0.08	0.45	1.63	0.00	0.04	0.29
<i>Zircon:Kyanite</i>	0.40	0.26	0.47	0.14	1.23	0.28	0.12	0.34	0.49
<i>Zircon:Quartz/Feldpars</i>	0.24	0.37	0.23	0.15	0.57	0.00	0.25	0.38	0.03
<i>Zircon:Other Minerals</i>	0.01	0.08	1.65	1.00	0.16	0.12	0.97	0.13	0.04
<i>Complex</i>	0.55	0.34	0.71	0.29	1.18	0.37	0.32	0.64	0.70
<i>Total Liberation</i>	96.6	97.6	92.2	96.1	89.1	94.8	95.3	94.4	93.1

FLORIDA GEOLOGICAL SURVEY

Table 11. Ilmenite association where sample mass has been normalized. Pure = 100% of the particle volume is ilmenite, free = >95% of the particle volume is ilmenite, liberated = >80% of the particle volume is ilmenite, and associated = where <80% of the particle volume is ilmenite.

<i>Ilmenite Association / Sample</i>	<i>FFA</i> <i>10473-1</i>	<i>FFA</i> <i>10489-1</i>	<i>FFA</i> <i>10489-2</i>	<i>FFA</i> <i>19805-1</i>	<i>FFA</i> <i>12360-1</i>	<i>FFA</i> <i>12360-2</i>	<i>FFA</i> <i>12361-1</i>	<i>FFA</i> <i>12361-2</i>	<i>FFA</i> <i>12361-3</i>
<i>Pure Ilmenite</i>	47.42	43.36	39.56	10.28	47.10	42.51	54.25	50.43	53.34
<i>Free Ilmenite</i>	34.69	43.68	46.12	76.99	46.59	51.57	38.51	46.34	29.17
<i>Liberated Ilmenite</i>	11.38	2.59	3.54	9.16	3.01	2.31	2.29	2.56	11.41
<i>Ilmenite:Xenotime</i>	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
<i>Ilmenite:Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Ilmenite:Pyrochlore/Columbite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Ilmenite:Spinel</i>	0.00	0.07	0.00	0.00	0.00	0.00	0.08	0.00	0.00
<i>Ilmenite:Monazite</i>	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
<i>Ilmenite:Ilmenorutile</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Ilmenite:Rutile</i>	2.34	0.75	1.47	0.51	0.74	0.67	0.98	0.30	2.89
<i>Ilmenite:Zircon</i>	0.49	3.58	2.40	0.16	1.57	0.71	3.29	0.20	0.25
<i>Ilmenite:Amph/Pyr/Grt</i>	0.05	0.93	0.82	0.07	0.03	0.36	0.04	0.00	0.01
<i>Ilmenite:Staurolite</i>	0.00	2.43	2.76	0.12	0.42	1.27	0.42	0.08	0.02
<i>Ilmenite:Kyanite</i>	0.06	0.70	1.11	0.59	0.24	0.36	0.00	0.00	0.02
<i>Ilmenite:Quartz/Feldspars</i>	0.86	0.76	0.20	0.90	0.00	0.00	0.00	0.00	0.08
<i>Ilmenite:Other Minerals</i>	0.80	0.03	0.07	0.30	0.08	0.07	0.04	0.05	1.28
<i>Complex</i>	1.83	1.12	1.95	0.91	0.21	0.17	0.11	0.04	1.45
<i>Total Liberation</i>	93.5	89.6	89.2	96.4	96.7	96.4	95.1	99.3	93.9

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Table 11. (Continued).

<i>Ilmenite Association / Sample</i>	<i>FFA 19841-1</i>	<i>FFA 10481-1</i>	<i>FFA 10481-2</i>	<i>FFA 10482-1</i>	<i>FFA 13769-1</i>	<i>FFA 14346</i>	<i>FFA 19587-1</i>	<i>FFA 19838-1</i>	<i>FFA 19843-1</i>
<i>Pure Ilmenite</i>	27.90	23.75	36.27	28.59	44.56	30.59	37.68	28.34	31.88
<i>Free Ilmenite</i>	49.46	51.46	46.36	50.17	43.31	63.58	47.35	40.94	51.46
<i>Liberated Ilmenite</i>	15.62	17.26	8.73	14.54	5.26	3.78	8.57	20.06	10.65
<i>Ilmenite:Xenotime</i>	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.00
<i>Ilmenite:Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Ilmenite:Pyrochlore/Columbite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Ilmenite:Spinel</i>	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Ilmenite:Monazite</i>	0.03	0.07	0.18	0.11	0.02	0.00	0.26	0.15	0.02
<i>Ilmenite:Ilmenorutile</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Ilmenite:Rutile</i>	3.07	2.94	2.65	1.96	2.40	0.18	1.94	3.15	1.39
<i>Ilmenite:Zircon</i>	0.38	0.27	0.58	0.44	1.38	0.62	0.36	0.87	1.20
<i>Ilmenite:Amph/Pyr/Grt</i>	0.02	0.03	0.21	0.07	0.46	0.03	0.13	0.02	0.07
<i>Ilmenite:Staurolite</i>	0.09	0.15	0.30	0.08	0.75	0.64	0.23	0.12	0.20
<i>Ilmenite:Kyanite</i>	0.22	0.04	0.28	0.07	0.88	0.21	0.17	0.20	0.29
<i>Ilmenite:Quartz/Feldspars</i>	0.13	0.34	0.18	0.01	0.15	0.00	0.02	0.23	0.06
<i>Ilmenite:Other Minerals</i>	0.73	1.10	2.65	1.52	0.15	0.16	2.15	1.87	0.88
<i>Complex</i>	2.34	2.57	1.61	2.43	0.69	0.21	1.14	4.04	1.90
<i>Total Liberation</i>	93.0	92.5	91.4	93.3	93.1	97.9	93.6	89.3	94.0

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Table 12. Rutile association where sample mass has been normalized. Pure = 100% of the particle volume is rutile, free = >95% of the particle volume is rutile, liberated = >80% of the particle volume is rutile, and associated = where <80% of the particle volume is rutile.

<i>Rutile Association / Sample</i>	<i>FFA 10473-1</i>	<i>FFA 10489-1</i>	<i>FFA 10489-2</i>	<i>FFA 19805-1</i>	<i>FFA 12360-1</i>	<i>FFA 12360-2</i>	<i>FFA 12361-1</i>	<i>FFA 12361-2</i>	<i>FFA 12361-3</i>
<i>Pure Rutile</i>	62.75	39.46	32.35	14.51	47.49	37.21	41.96	33.44	63.64
<i>Free Rutile</i>	23.74	43.34	36.61	58.51	36.16	49.45	44.63	55.97	20.90
<i>Liberated Rutile</i>	5.44	2.00	6.60	9.20	5.51	4.42	5.38	4.58	7.13
<i>Rutile:Xenotime</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rutile:Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rutile:Pyrochlore/Columbite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rutile:Spinel</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rutile:Ilmenite</i>	2.76	7.16	12.69	5.35	6.69	6.39	4.90	5.27	4.33
<i>Rutile:Ilmenorutile</i>	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00
<i>Rutile:Monazite</i>	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
<i>Rutile:Zircon</i>	0.61	2.26	1.45	0.40	1.93	0.96	2.84	0.13	0.23
<i>Rutile:Amph/Pyr/Grt</i>	0.04	0.17	1.38	0.04	0.24	0.01	0.01	0.00	0.01
<i>Rutile:Staurolite</i>	0.01	0.68	3.17	0.06	0.62	0.84	0.04	0.18	0.01
<i>Rutile:Kyanite</i>	0.06	0.93	1.21	0.09	0.16	0.10	0.01	0.05	0.04
<i>Rutile:Quartz/Feldpars</i>	1.67	0.04	0.00	2.96	0.66	0.00	0.00	0.00	0.16
<i>Rutile:Other Minerals</i>	0.83	0.05	0.02	4.84	0.01	0.05	0.01	0.09	1.38
<i>Complex</i>	2.03	3.91	4.51	3.94	0.54	0.58	0.23	0.29	2.13
<i>Total Liberation</i>	91.9	84.8	75.6	82.2	89.2	91.1	92.0	94.0	91.7

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Table 12. (Continued).

<i>Rutile Association / Sample</i>	<i>FFA</i> <i>19841-1</i>	<i>FFA</i> <i>10481-1</i>	<i>FFA</i> <i>10481-2</i>	<i>FFA</i> <i>10482-1</i>	<i>FFA</i> <i>13769-1</i>	<i>FFA</i> <i>14346</i>	<i>FFA</i> <i>19587-1</i>	<i>FFA</i> <i>19838-1</i>	<i>FFA</i> <i>19843-1</i>
<i>Pure Rutile</i>	34.08	27.59	35.45	28.20	36.90	23.03	40.75	29.92	37.28
<i>Free Rutile</i>	37.93	42.30	40.37	39.68	43.92	62.47	37.76	29.46	38.78
<i>Liberated Rutile</i>	9.67	12.50	7.41	12.21	6.54	4.41	5.94	15.89	8.24
<i>Rutile:Xenotime</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.03
<i>Rutile:Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rutile:Pyrochlore/Columbite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rutile:Spinel</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rutile:Ilmenite</i>	9.38	8.48	9.29	8.05	7.53	7.01	9.36	9.87	7.47
<i>Rutile:Ilmenorutile</i>	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Rutile:Monazite</i>	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.15
<i>Rutile:Zircon</i>	0.28	0.07	0.13	0.49	0.59	0.60	0.65	0.63	0.98
<i>Rutile:Amph/Pyr/Grt</i>	0.06	0.05	0.51	0.15	0.32	0.27	0.23	0.10	0.16
<i>Rutile:Staurolite</i>	0.05	0.01	0.00	0.00	0.61	0.29	0.13	0.07	0.33
<i>Rutile:Kyanite</i>	0.25	0.05	0.23	0.00	0.71	1.03	0.11	0.12	0.54
<i>Rutile:Quartz/Feldpars</i>	0.55	0.34	0.39	0.28	0.61	0.00	0.00	0.37	0.21
<i>Rutile:Other Minerals</i>	1.20	2.06	1.99	2.49	0.62	0.05	1.67	2.50	0.90
<i>Complex</i>	6.38	6.56	4.23	8.42	1.66	0.83	3.40	10.91	4.94
<i>Total Liberation</i>	81.7	82.4	83.2	80.1	87.4	89.9	84.4	75.3	84.3

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Table 13. Monazite association where sample mass has been normalized. Pure = 100% of the particle volume is monazite, free = >95% of the particle volume is monazite, liberated = >80% of the particle volume is monazite, and associated = where <80% of the particle volume in monazite.

<i>Monazite Association / Sample</i>	<i>FFA 10473-1</i>	<i>FFA 10489-1</i>	<i>FFA 10489-2</i>	<i>FFA 19805-1</i>	<i>FFA 12360-1</i>	<i>FFA 12360-2</i>	<i>FFA 12361-1</i>	<i>FFA 12361-2</i>	<i>FFA 12361-3</i>
<i>Pure Monazite</i>	66.4	58.7	57.4	12.4	54.4	1.8	80.1	72.1	79.1
<i>Free Monazite</i>	23.5	0.0	0.0	69.6	38.9	4.7	0.0	19.3	15.3
<i>Liberated Monazite</i>	2.86	0.00	0.00	0.87	0.38	7.7	8.34	2.29	2.35
<i>Monazite:Xenotime</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Pyrochlore/Columbite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Spinel</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Ilmenite</i>	0.34	1.83	27.50	0.33	0.77	2.04	0.00	1.33	1.00
<i>Monazite:Ilmenorutile</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Rutile</i>	0.75	0.00	0.00	0.00	2.36	0.00	0.00	0.31	0.39
<i>Monazite:Zircon</i>	0.42	1.78	0.00	0.00	0.54	6.12	1.01	0.58	0.79
<i>Monazite:Amph/Pyr/Grt</i>	0.04	7.81	2.47	4.91	0.28	6.27	0.00	0.08	0.13
<i>Monazite:Staurolite</i>	0.07	12.53	7.60	0.43	1.45	9.62	0.93	1.38	0.01
<i>Monazite:Kyanite</i>	0.02	9.43	2.04	10.51	0.00	12.83	0.69	0.00	0.00
<i>Monazite:Quartz/Feldspars</i>	4.12	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.09
<i>Monazite:Other Minerals</i>	1.00	0.00	0.24	0.00	0.00	1.17	0.00	1.94	0.43
<i>Complex</i>	0.44	7.89	2.74	0.58	0.93	47.70	8.95	0.76	0.31
<i>Total Liberation</i>	92.8	58.7	57.4	82.9	93.7	14.2	88.4	93.6	96.8

REPORT OF INVESTIGATION 123

Table 13. (Continued).

<i>Monazite Association / Sample</i>	<i>FFA</i> <i>19841-1</i>	<i>FFA</i> <i>10481-1</i>	<i>FFA</i> <i>10481-2</i>	<i>FFA</i> <i>10482-1</i>	<i>FFA</i> <i>13769-1</i>	<i>FFA</i> <i>14346</i>	<i>FFA</i> <i>19587-1</i>	<i>FFA</i> <i>19838-1</i>	<i>FFA</i> <i>19843-1</i>
<i>Pure Monazite</i>	44.80	37.05	66.59	51.64	51.50	88.92	56.46	48.09	54.50
<i>Free Monazite</i>	49.19	51.60	18.25	35.70	38.71	0.00	35.60	40.84	35.71
<i>Liberated Monazite</i>	2.04	6.28	0.02	4.57	0.00	0.00	2.46	5.03	2.69
<i>Monazite:Xenotime</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Synchysite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Pyrochlore/Columbite</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Spinel</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Ilmenite</i>	0.66	3.87	5.78	1.80	1.42	0.00	4.02	2.51	0.43
<i>Monazite:Ilmenorutile</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Monazite:Rutile</i>	0.45	0.00	0.10	0.13	0.40	0.00	0.00	1.03	1.64
<i>Monazite:Zircon</i>	0.01	0.45	0.00	0.75	1.02	0.00	0.62	0.91	2.21
<i>Monazite:Amph/Pyr/Grt</i>	0.58	0.00	1.52	0.14	2.57	0.41	0.00	0.01	0.01
<i>Monazite:Staurolite</i>	0.01	0.01	0.00	0.01	1.16	2.38	0.00	0.13	0.00
<i>Monazite:Kyanite</i>	0.91	0.02	2.95	0.53	0.09	4.97	0.03	0.00	1.24
<i>Monazite:Quartz/Feldspars</i>	0.19	0.55	0.07	0.00	0.00	0.12	0.00	0.24	0.00
<i>Monazite:Other Minerals</i>	0.02	0.05	1.70	3.55	0.18	0.00	0.00	0.55	0.27
<i>Complex</i>	1.16	0.10	3.02	1.17	2.96	3.20	0.81	0.65	1.29
<i>Total Liberation</i>	96.0	94.9	84.9	91.9	90.2	88.9	94.5	94.0	92.9

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APPENDIX D: GRADISTAT REPORTS

REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA10473-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

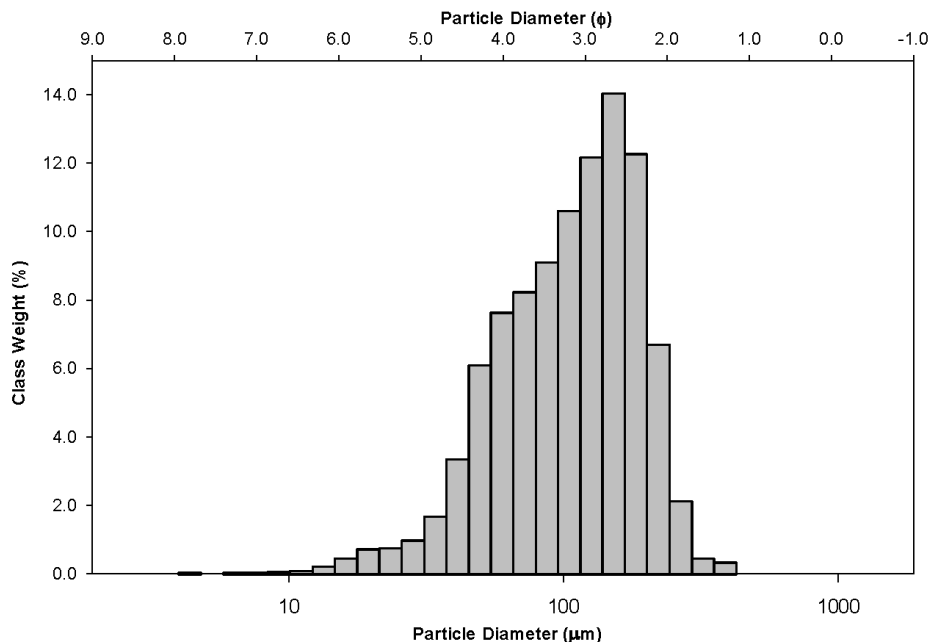
SAMPLE TYPE: Unimodal, Moderately Sorted

TEXTURAL GROUP: Muddy Sand

SEDIMENT NAME: Very Coarse Silty Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	153.0	2.715	GRAVEL: 0.0%	COARSE SAND: 0.0%		
MODE 2:			SAND: 79.4%	MEDIUM SAND: 2.6%		
MODE 3:			MUD: 20.6%	FINE SAND: 40.8%		
D ₁₀ :	47.08	2.315		V FINE SAND: 36.0%		
MEDIAN or D ₅₀ :	113.0	3.146	V COARSE GRAVEL: 0.0%	V COARSE SILT: 17.0%		
D ₉₀ :	200.9	4.409	COARSE GRAVEL: 0.0%	COARSE SILT: 2.9%		
(D ₉₀ / D ₁₀):	4.268	1.904	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.6%		
(D ₉₀ - D ₁₀):	153.8	2.094	FINE GRAVEL: 0.0%	FINE SILT: 0.1%		
(D ₇₅ / D ₂₅):	2.330	1.464	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	92.08	1.220	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	120.4	102.7	3.284	105.1	3.250	Very Fine Sand
SORTING (σ):	62.29	1.819	0.863	1.778	0.830	Moderately Sorted
SKEWNESS (Sk):	0.702	-0.791	0.791	-0.204	0.204	Fine Skewed
KURTOSIS (k):	3.610	3.902	3.902	0.890	0.890	Platykurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA10481-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

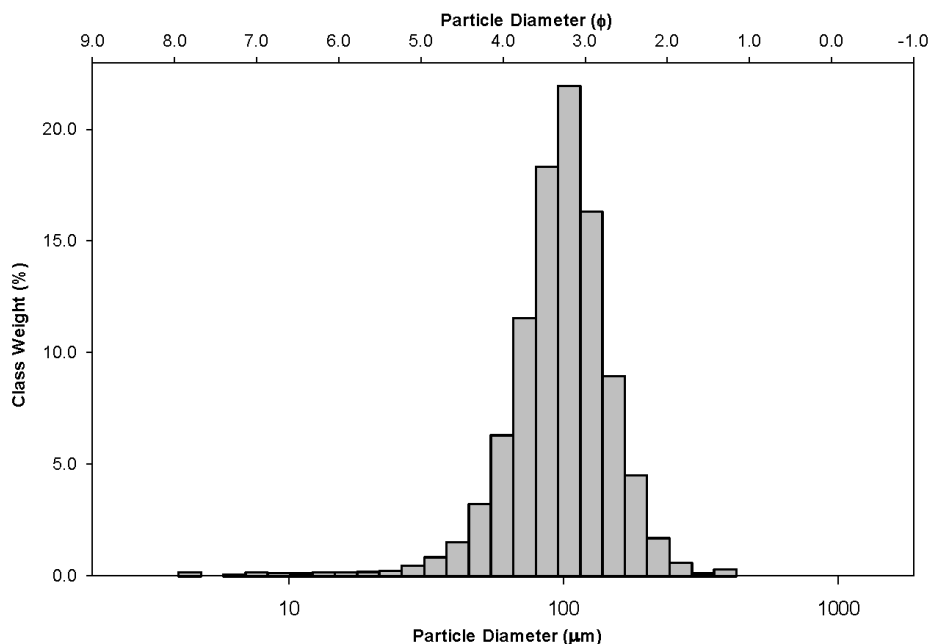
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Muddy Sand

SEDIMENT NAME: Very Coarse Silty Very Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	105.3	3.254	GRAVEL: 0.0%	COARSE SAND: 0.0%		
MODE 2:			SAND: 87.6%	MEDIUM SAND: 0.9%		
MODE 3:			MUD: 12.4%	FINE SAND: 24.8%		
D ₁₀ :	58.22	2.658		V FINE SAND: 61.8%		
MEDIAN or D ₅₀ :	99.91	3.323	V COARSE GRAVEL: 0.0%	V COARSE SILT: 10.4%		
D ₉₀ :	158.5	4.102	COARSE GRAVEL: 0.0%	COARSE SILT: 1.1%		
(D ₉₀ / D ₁₀):	2.722	1.543	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.6%		
(D ₉₀ - D ₁₀):	100.2	1.444	FINE GRAVEL: 0.0%	FINE SILT: 0.4%		
(D ₇₅ / D ₂₅):	1.615	1.231	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	48.00	0.691	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	105.7	95.94	3.382	98.21	3.348	Very Fine Sand
SORTING (σ):	44.27	1.596	0.675	1.477	0.563	Moderately Well Sorted
SKEWNESS (S_k):	1.500	-1.612	1.612	-0.090	0.090	Symmetrical
KURTOSIS (K):	9.013	10.60	10.60	1.174	1.174	Leptokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA10481-2**

ANALYST & DATE: SGS Canada Inc., 2020-2022

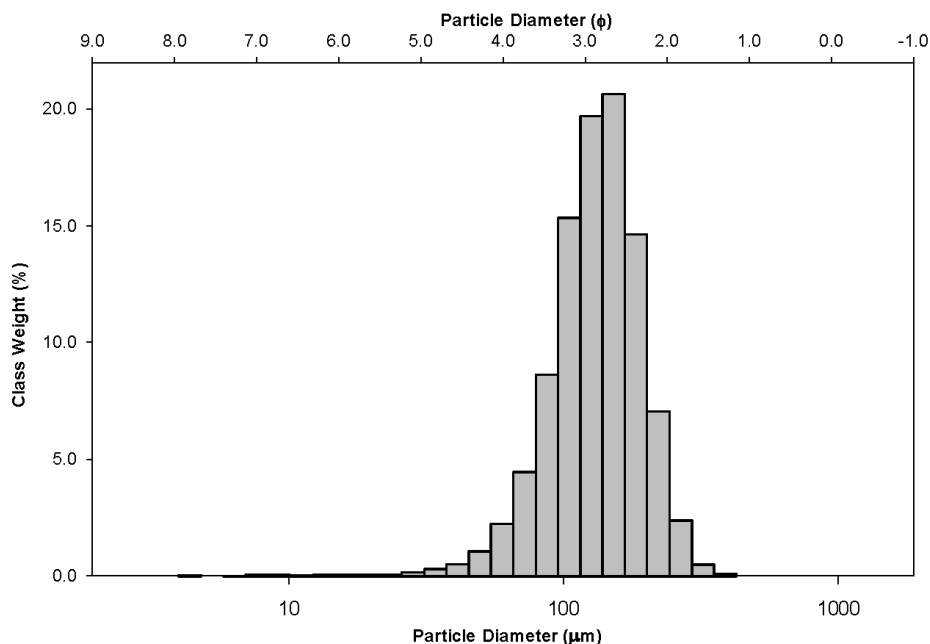
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	153.0	2.715	GRAVEL: 0.0%	COARSE SAND: 0.0%		
MODE 2:			SAND: 95.8%	MEDIUM SAND: 2.7%		
MODE 3:			MUD: 4.2%	FINE SAND: 54.6%		
D ₁₀ :	80.24	2.302		V FINE SAND: 38.5%		
MEDIAN or D ₅₀ :	133.8	2.902	V COARSE GRAVEL: 0.0%	V COARSE SILT: 3.6%		
D ₉₀ :	202.9	3.640	COARSE GRAVEL: 0.0%	COARSE SILT: 0.4%		
(D ₉₀ / D ₁₀):	2.528	1.581	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.2%		
(D ₉₀ - D ₁₀):	122.6	1.338	FINE GRAVEL: 0.0%	FINE SILT: 0.1%		
(D ₇₅ / D ₂₅):	1.617	1.269	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	63.90	0.693	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	139.4	129.1	2.954	131.8	2.924	Fine Sand
SORTING (σ):	50.40	1.502	0.587	1.448	0.534	Moderately Well Sorted
SKEWNESS (Sk):	0.651	-1.349	1.349	-0.096	0.096	Symmetrical
KURTOSIS (K):	4.083	9.225	9.225	1.067	1.067	Mesokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA10482-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

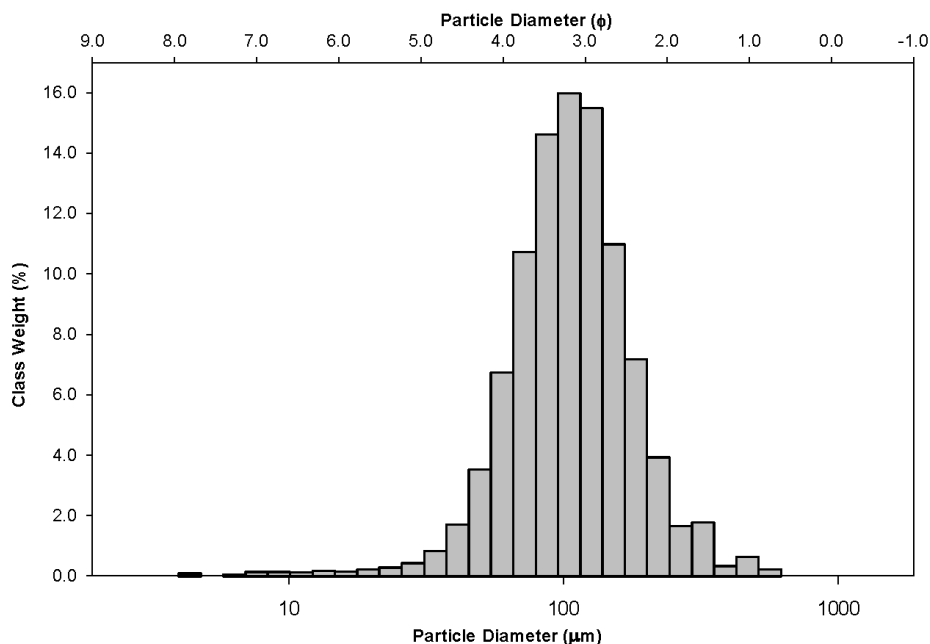
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Muddy Sand

SEDIMENT NAME: Very Coarse Silty Very Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	105.3	3.254	GRAVEL: 0.0%	COARSE SAND: 0.3%		
MODE 2:			SAND: 86.8%	MEDIUM SAND: 4.2%		
MODE 3:			MUD: 13.2%	FINE SAND: 31.5%		
D ₁₀ :	57.36	2.357		V FINE SAND: 50.9%		
MEDIAN or D ₅₀ :	106.1	3.236	V COARSE GRAVEL: 0.0%	V COARSE SILT: 11.2%		
D ₉₀ :	195.1	4.124	COARSE GRAVEL: 0.0%	COARSE SILT: 1.1%		
(D ₉₀ / D ₁₀):	3.402	1.749	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.6%		
(D ₉₀ - D ₁₀):	137.8	1.766	FINE GRAVEL: 0.0%	FINE SILT: 0.3%		
(D ₇₅ / D ₂₅):	1.846	1.316	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	65.96	0.884	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	120.8	104.8	3.254	105.9	3.239	Very Fine Sand
SORTING (σ):	68.60	1.720	0.783	1.614	0.691	Moderately Well Sorted
SKEWNESS (S_k):	2.264	-0.698	0.698	-0.008	0.008	Symmetrical
KURTOSIS (K):	11.48	6.587	6.587	1.100	1.100	Mesokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA10489-1**

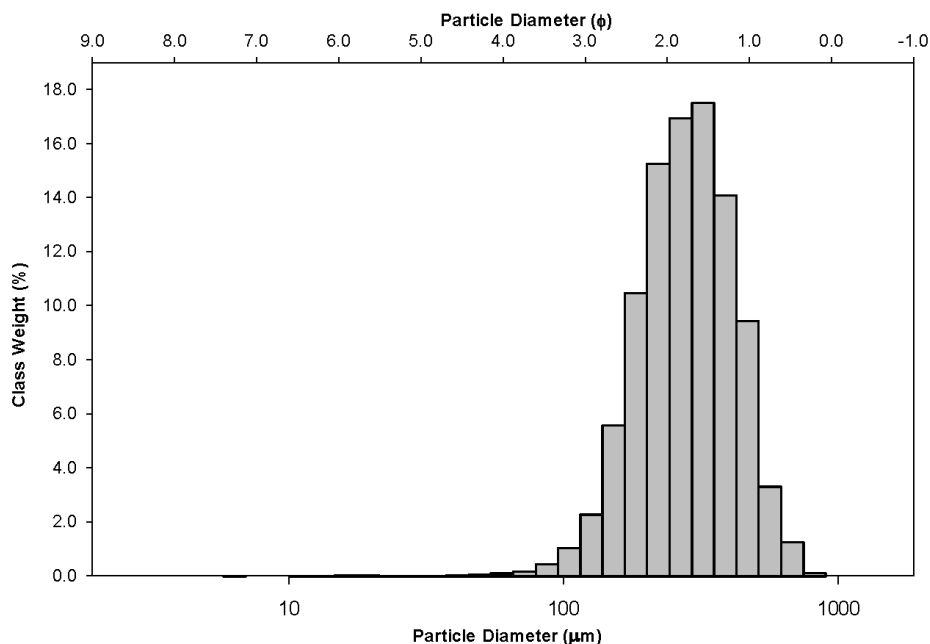
ANALYST & DATE: SGS Canada Inc., 2020-2022

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Medium Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	323.1	1.636	GRAVEL: 0.0%	COARSE SAND: 6.1%		
MODE 2:			SAND: 99.7%	MEDIUM SAND: 55.0%		
MODE 3:			MUD: 0.3%	FINE SAND: 35.7%		
D ₁₀ :	166.9	1.109		V FINE SAND: 2.8%		
MEDIAN or D ₅₀ :	282.2	1.825	V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.2%		
D ₉₀ :	463.7	2.583	COARSE GRAVEL: 0.0%	COARSE SILT: 0.1%		
(D ₉₀ / D ₁₀):	2.778	2.329	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.0%		
(D ₉₀ - D ₁₀):	296.7	1.474	FINE GRAVEL: 0.0%	FINE SILT: 0.0%		
(D ₇₅ / D ₂₅):	1.746	1.562	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	158.4	0.804	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	301.1	276.8	1.853	279.5	1.839	Medium Sand
SORTING (σ):	118.3	1.514	0.598	1.487	0.572	Moderately Well Sorted
SKEWNESS (Sk):	0.785	-0.716	0.716	-0.055	0.055	Symmetrical
KURTOSIS (K):	3.745	5.973	5.973	0.944	0.944	Mesokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA10489-2**

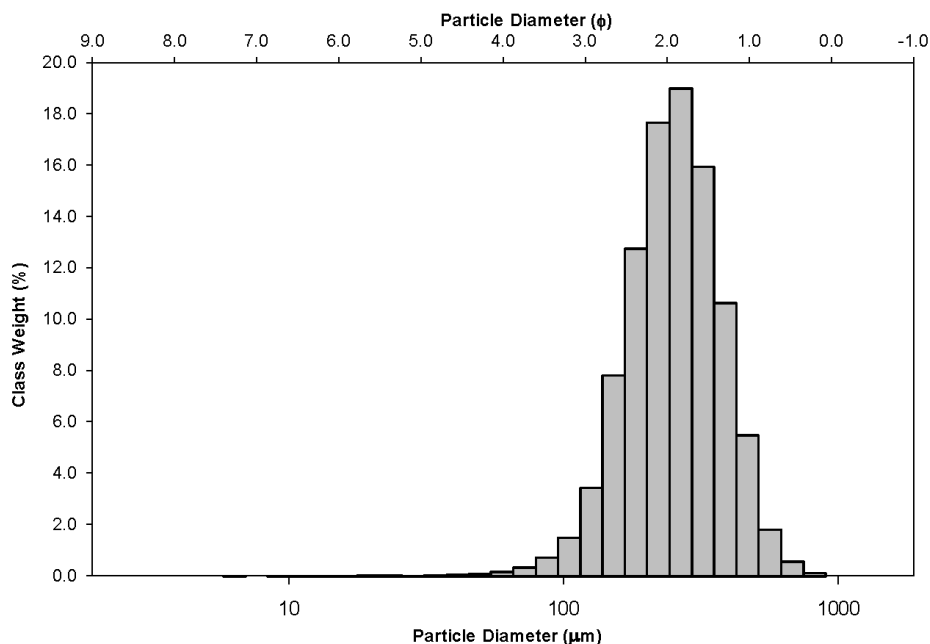
ANALYST & DATE: SGS Canada Inc., 2020-2022

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Medium Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	268.0	1.906	GRAVEL: 0.0%	COARSE SAND: 3.3%		
MODE 2:			SAND: 99.6%	MEDIUM SAND: 48.2%		
MODE 3:			MUD: 0.4%	FINE SAND: 43.8%		
D ₁₀ :	150.3	1.278		V FINE SAND: 4.2%		
MEDIAN or D ₅₀ :	253.8	1.978	V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.3%		
D ₉₀ :	412.3	2.734	COARSE GRAVEL: 0.0%	COARSE SILT: 0.1%		
(D ₉₀ / D ₁₀):	2.744	2.139	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.0%		
(D ₉₀ - D ₁₀):	262.1	1.456	FINE GRAVEL: 0.0%	FINE SILT: 0.0%		
(D ₇₅ / D ₂₅):	1.695	1.475	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	135.1	0.761	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	271.2	249.6	2.002	252.6	1.985	Medium Sand
SORTING (σ):	107.0	1.508	0.593	1.482	0.567	Moderately Well Sorted
SKEWNESS (Sk):	0.976	-0.713	0.713	-0.035	0.035	Symmetrical
KURTOSIS (K):	4.717	6.223	6.223	1.019	1.019	Mesokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA12360-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

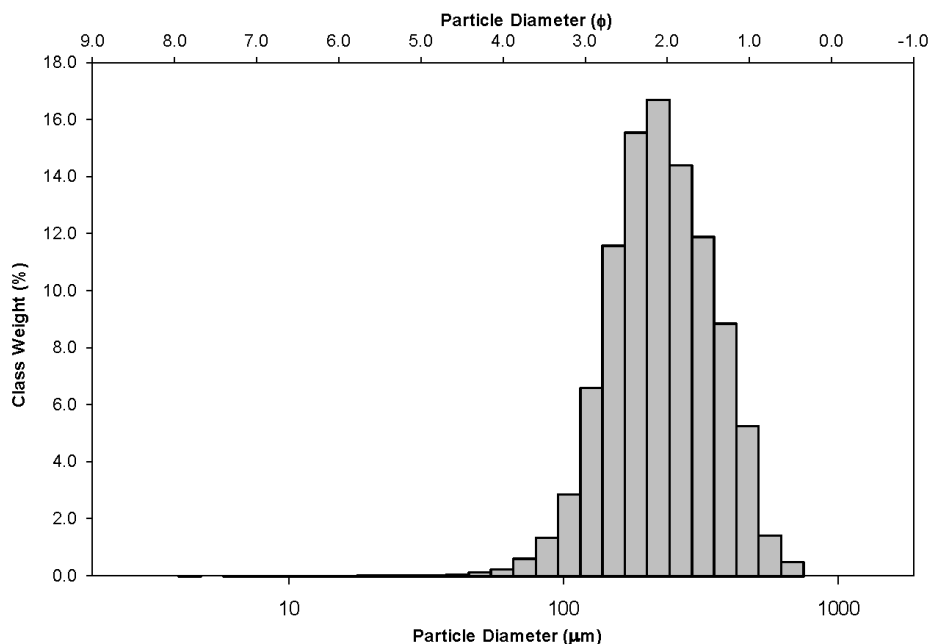
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	222.3	2.176	GRAVEL: 0.0%	COARSE SAND: 2.7%		
MODE 2:			SAND: 99.4%	MEDIUM SAND: 38.2%		
MODE 3:			MUD: 0.6%	FINE SAND: 50.6%		
D ₁₀ :	130.1	1.313		V FINE SAND: 8.0%		
MEDIAN or D ₅₀ :	225.2	2.151	V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.4%		
D ₉₀ :	402.6	2.943	COARSE GRAVEL: 0.0%	COARSE SILT: 0.1%		
(D ₉₀ / D ₁₀):	3.096	2.242	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.1%		
(D ₉₀ - D ₁₀):	272.5	1.630	FINE GRAVEL: 0.0%	FINE SILT: 0.0%		
(D ₇₅ / D ₂₅):	1.828	1.513	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	139.8	0.870	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	248.8	225.2	2.151	227.5	2.136	Fine Sand
SORTING (σ):	108.7	1.568	0.649	1.548	0.630	Moderately Well Sorted
SKEWNESS (Sk):	0.965	-0.570	0.570	0.020	-0.020	Symmetrical
KURTOSIS (K):	3.997	5.605	5.605	0.970	0.970	Mesokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA12360-2**

ANALYST & DATE: SGS Canada Inc., 2020-2022

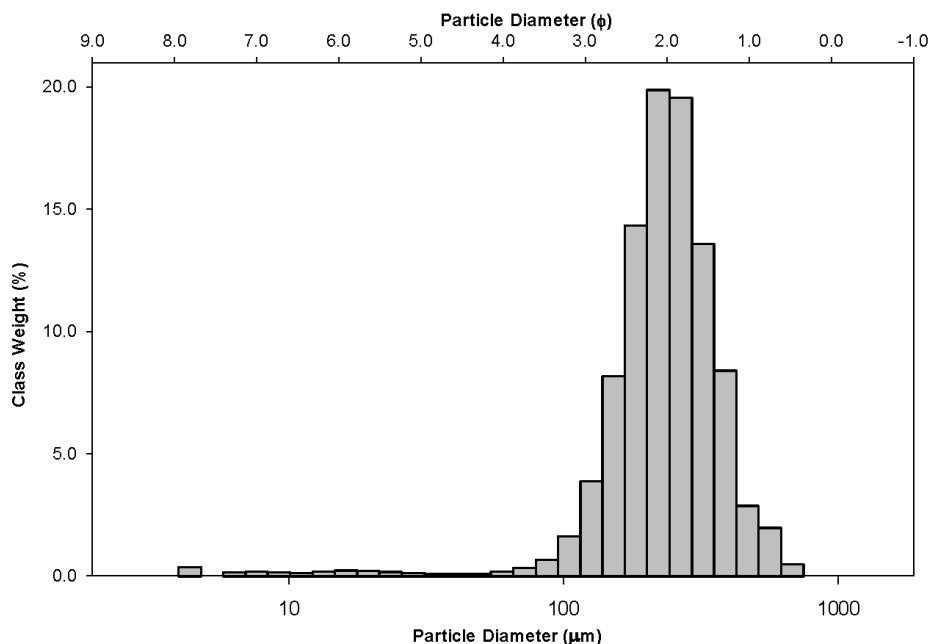
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	222.3	2.176	GRAVEL: 0.0%	COARSE SAND: 2.9%		
MODE 2:			SAND: 97.6%	MEDIUM SAND: 41.8%		
MODE 3:			MUD: 2.4%	FINE SAND: 48.3%		
D ₁₀ :	141.5	1.375		V FINE SAND: 4.5%		
MEDIAN or D ₅₀ :	238.0	2.071	V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.4%		
D ₉₀ :	385.6	2.821	COARSE GRAVEL: 0.0%	COARSE SILT: 0.7%		
(D ₉₀ / D ₁₀):	2.725	2.052	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.6%		
(D ₉₀ - D ₁₀):	244.1	1.446	FINE GRAVEL: 0.0%	FINE SILT: 0.7%		
(D ₇₅ / D ₂₅):	1.653	1.422	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	120.2	0.725	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	252.7	224.2	2.157	236.6	2.079	Fine Sand
SORTING (σ):	104.7	1.795	0.844	1.483	0.568	Moderately Well Sorted
SKEWNESS (S_k):	0.834	-3.067	3.067	-0.061	0.061	Symmetrical
KURTOSIS (K):	4.818	18.62	18.62	1.107	1.107	Mesokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA12361-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

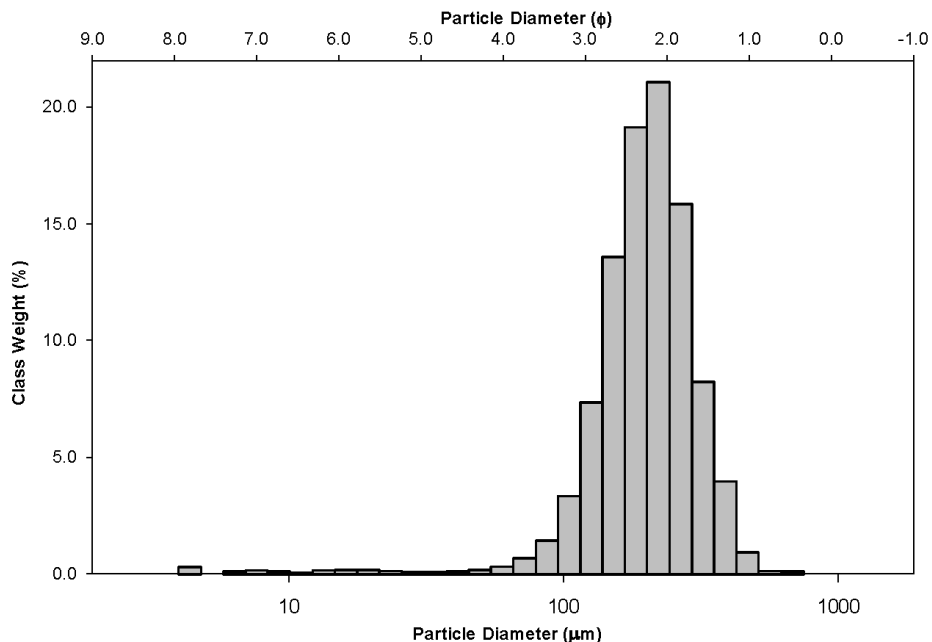
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	222.3	2.176	GRAVEL: 0.0%	COARSE SAND: 0.4%		
MODE 2:			SAND: 97.7%	MEDIUM SAND: 27.0%		
MODE 3:			MUD: 2.3%	FINE SAND: 61.4%		
D ₁₀ :	121.2	1.653		V FINE SAND: 9.0%		
MEDIAN or D ₅₀ :	203.8	2.295	V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.7%		
D ₉₀ :	318.0	3.045	COARSE GRAVEL: 0.0%	COARSE SILT: 0.6%		
(D ₉₀ / D ₁₀):	2.624	1.842	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.5%		
(D ₉₀ - D ₁₀):	196.8	1.392	FINE GRAVEL: 0.0%	FINE SILT: 0.5%		
(D ₇₅ / D ₂₅):	1.627	1.358	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	99.06	0.703	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	212.6	192.0	2.381	201.0	2.314	Fine Sand
SORTING (σ):	81.83	1.690	0.757	1.454	0.540	Moderately Well Sorted
SKEWNESS (Sk):	0.721	-2.983	2.983	-0.094	0.094	Symmetrical
KURTOSIS (k):	5.091	19.16	19.16	1.090	1.090	Mesokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA12361-2**

ANALYST & DATE: SGS Canada Inc., 2020-2022

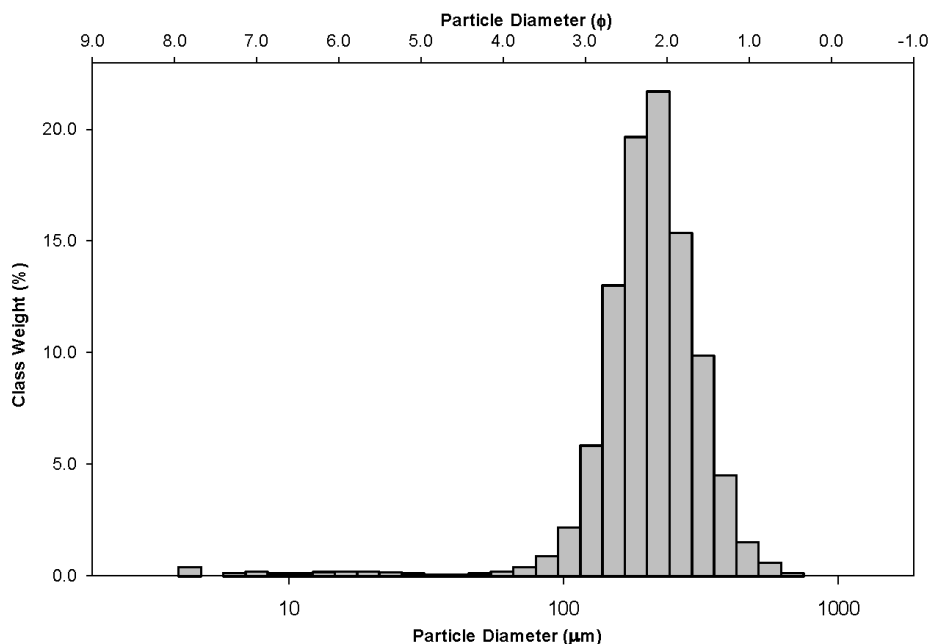
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	222.3	2.176	GRAVEL: 0.0%	COARSE SAND: 1.0%		
MODE 2:			SAND: 97.6%	MEDIUM SAND: 29.3%		
MODE 3:			MUD: 2.4%	FINE SAND: 61.1%		
D ₁₀ :	130.2	1.584		V FINE SAND: 6.3%		
MEDIAN or D ₅₀ :	209.8	2.253	V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.5%		
D ₉₀ :	333.5	2.941	COARSE GRAVEL: 0.0%	COARSE SILT: 0.6%		
(D ₉₀ / D ₁₀):	2.561	1.856	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.6%		
(D ₉₀ - D ₁₀):	203.3	1.357	FINE GRAVEL: 0.0%	FINE SILT: 0.7%		
(D ₇₅ / D ₂₅):	1.598	1.354	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	99.58	0.676	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	222.0	199.0	2.329	209.4	2.256	Fine Sand
SORTING (σ):	87.60	1.745	0.803	1.451	0.537	Moderately Well Sorted
SKEWNESS (Sk):	0.865	-3.211	3.211	-0.039	0.039	Symmetrical
KURTOSIS (K):	5.413	20.07	20.07	1.126	1.126	Leptokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA12361-3**

ANALYST & DATE: SGS Canada Inc., 2020-2022

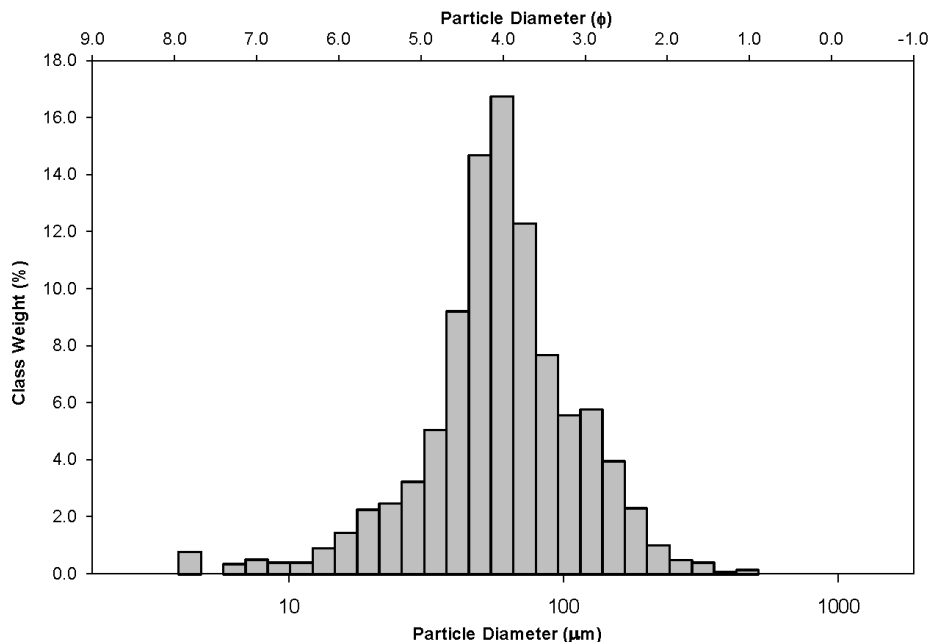
SAMPLE TYPE: Bimodal, Moderately Sorted

TEXTURAL GROUP: Sandy Mud

SEDIMENT NAME: Very Fine Sandy Very Coarse Silt

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	60.08	4.063	GRAVEL: 0.0%	COARSE SAND: 0.0%		
MODE 2:	126.9	2.985	SAND: 45.0%	MEDIUM SAND: 1.1%		
MODE 3:			MUD: 55.0%	FINE SAND: 10.8%		
D ₁₀ :	26.17	2.915		V FINE SAND: 33.1%		
MEDIAN or D ₅₀ :	59.15	4.080	V COARSE GRAVEL: 0.0%	V COARSE SILT: 41.9%		
D ₉₀ :	132.6	5.256	COARSE GRAVEL: 0.0%	COARSE SILT: 9.3%		
(D ₉₀ / D ₁₀):	5.066	1.803	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 2.4%		
(D ₉₀ - D ₁₀):	106.4	2.341	FINE GRAVEL: 0.0%	FINE SILT: 1.5%		
(D ₇₅ / D ₂₅):	1.979	1.277	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	42.04	0.985	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	71.72	58.14	4.104	60.74	4.041	Very Coarse Silt
SORTING (σ):	49.59	1.958	0.969	1.865	0.899	Moderately Sorted
SKEWNESS (Sk):	2.478	-0.659	0.659	-0.006	0.006	Symmetrical
KURTOSIS (K):	13.78	4.915	4.915	1.330	1.330	Leptokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA13769-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

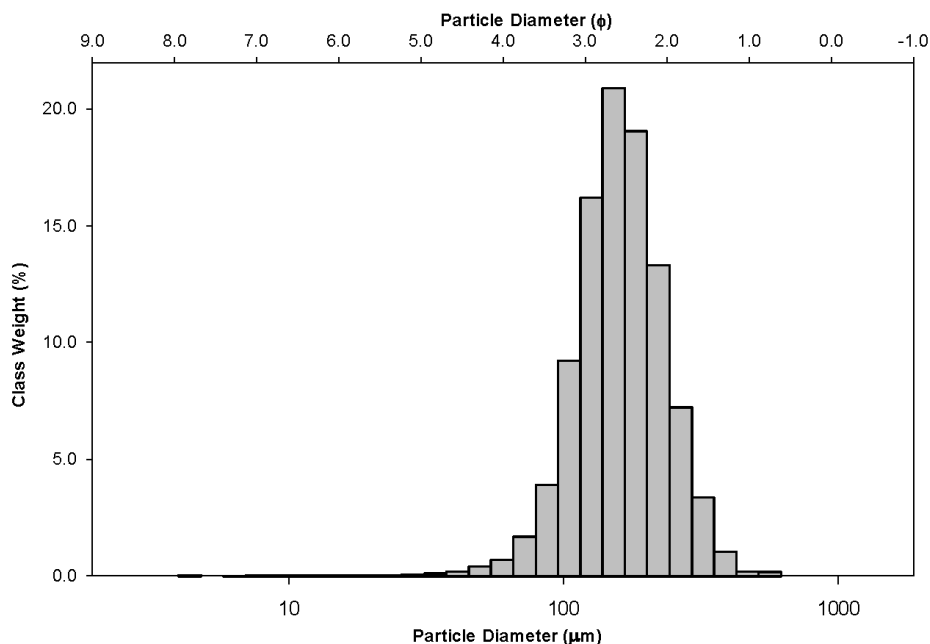
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	153.0	2.715	GRAVEL: 0.0%	COARSE SAND: 0.2%		
MODE 2:			SAND: 98.3%	MEDIUM SAND: 10.9%		
MODE 3:			MUD: 1.7%	FINE SAND: 64.6%		
D ₁₀ :	100.1	1.958		V FINE SAND: 22.6%		
MEDIAN or D ₅₀ :	160.3	2.641	V COARSE GRAVEL: 0.0%	V COARSE SILT: 1.3%		
D ₉₀ :	257.4	3.320	COARSE GRAVEL: 0.0%	COARSE SILT: 0.2%		
(D ₉₀ / D ₁₀):	2.570	1.696	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.1%		
(D ₉₀ - D ₁₀):	157.2	1.362	FINE GRAVEL: 0.0%	FINE SILT: 0.1%		
(D ₇₅ / D ₂₅):	1.618	1.303	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	77.88	0.694	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	171.9	158.9	2.654	161.0	2.635	Fine Sand
SORTING (σ):	66.50	1.499	0.584	1.443	0.529	Moderately Well Sorted
SKEWNESS (Sk):	1.220	-1.080	1.080	-0.007	0.007	Symmetrical
KURTOSIS (K):	6.322	9.556	9.556	1.056	1.056	Mesokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA14346-1**

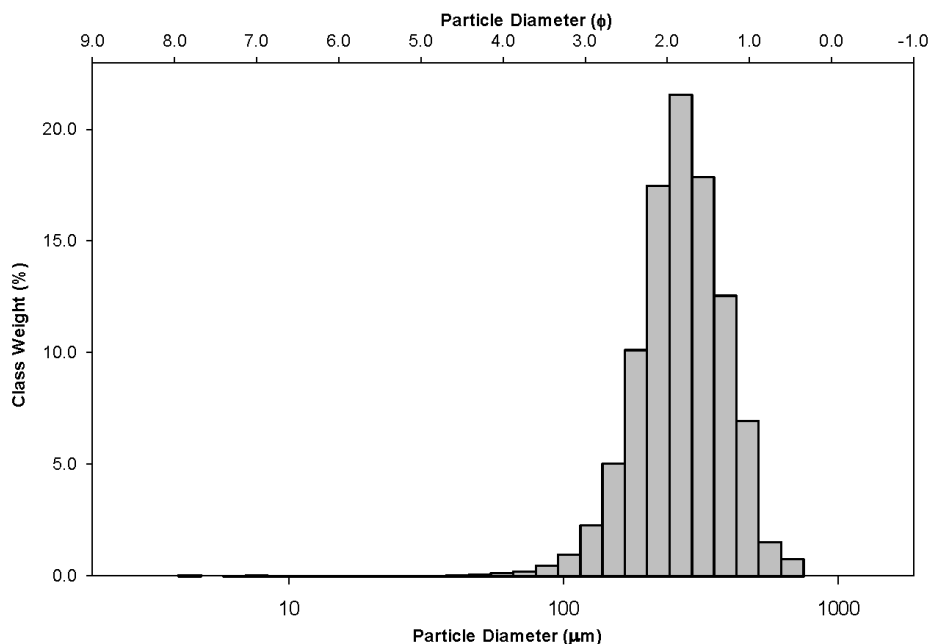
ANALYST & DATE: SGS Canada Inc., 2020-2022

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Medium Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	268.0	1.906	GRAVEL: 0.0%	COARSE SAND: 3.3%		
MODE 2:			SAND: 99.6%	MEDIUM SAND: 55.7%		
MODE 3:			MUD: 0.4%	FINE SAND: 37.8%		
D ₁₀ :	168.4	1.245		V FINE SAND: 2.8%		
MEDIAN or D ₅₀ :	269.9	1.890	V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.2%		
D ₉₀ :	422.0	2.570	COARSE GRAVEL: 0.0%	COARSE SILT: 0.1%		
(D ₉₀ / D ₁₀):	2.505	2.065	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.1%		
(D ₉₀ - D ₁₀):	253.6	1.325	FINE GRAVEL: 0.0%	FINE SILT: 0.1%		
(D ₇₅ / D ₂₅):	1.613	1.447	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	130.4	0.690	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	285.7	265.3	1.914	269.6	1.891	Medium Sand
SORTING (σ):	103.4	1.487	0.573	1.441	0.527	Moderately Well Sorted
SKEWNESS (Sk):	0.774	-1.430	1.430	-0.033	0.033	Symmetrical
KURTOSIS (k):	4.100	12.52	12.52	1.044	1.044	Mesokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA19587-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

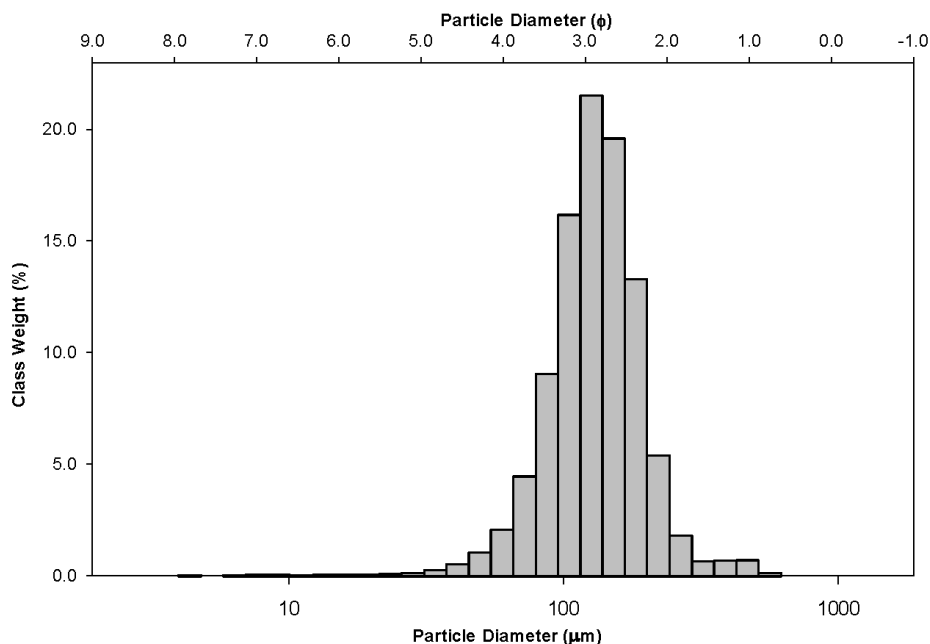
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	126.9	2.985	GRAVEL: 0.0%	COARSE SAND: 0.3%		
MODE 2:			SAND: 95.9%	MEDIUM SAND: 3.6%		
MODE 3:			MUD: 4.1%	FINE SAND: 51.5%		
D ₁₀ :	80.38	2.317		V FINE SAND: 40.5%		
MEDIAN or D ₅₀ :	130.8	2.934	V COARSE GRAVEL: 0.0%	V COARSE SILT: 3.5%		
D ₉₀ :	200.6	3.637	COARSE GRAVEL: 0.0%	COARSE SILT: 0.4%		
(D ₉₀ / D ₁₀):	2.496	1.569	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.2%		
(D ₉₀ - D ₁₀):	120.2	1.319	FINE GRAVEL: 0.0%	FINE SILT: 0.1%		
(D ₇₅ / D ₂₅):	1.600	1.260	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	61.63	0.678	V COARSE SAND: 0.0%	CLAY: 0.0%		
			METHOD OF MOMENTS			FOLK & WARD METHOD
			Arithmetic	Geometric	Logarithmic	Geometric Logarithmic Description
			μm	μm	ϕ	μm ϕ
MEAN ($\bar{x}$):	140.8	128.6	2.959	129.9	2.944	Fine Sand
SORTING (σ):	61.93	1.534	0.617	1.447	0.533	Moderately Well Sorted
SKEWNESS (Sk):	2.238	-0.922	0.922	-0.049	0.049	Symmetrical
KURTOSIS (K):	12.53	9.198	9.198	1.106	1.106	Mesokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA19805-1**

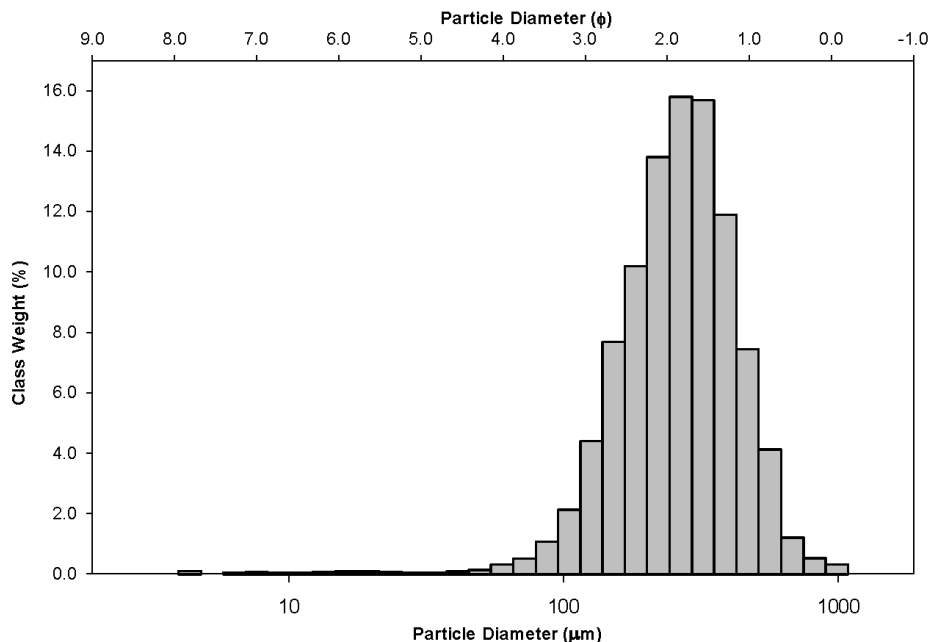
ANALYST & DATE: SGS Canada Inc., 2020-2022

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Medium Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	268.0	1.906	GRAVEL: 0.0%	COARSE SAND: 7.2%		
MODE 2:			SAND: 98.7%	MEDIUM SAND: 48.2%		
MODE 3:			MUD: 1.3%	FINE SAND: 37.2%		
D ₁₀ :	139.8	1.093		V FINE SAND: 5.9%		
MEDIAN or D ₅₀ :	266.8	1.906	V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.5%		
D ₉₀ :	468.7	2.839	COARSE GRAVEL: 0.0%	COARSE SILT: 0.3%		
(D ₉₀ / D ₁₀):	3.353	2.597	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.2%		
(D ₉₀ - D ₁₀):	328.9	1.746	FINE GRAVEL: 0.0%	FINE SILT: 0.2%		
(D ₇₅ / D ₂₅):	1.875	1.613	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	167.4	0.907	V COARSE SAND: 0.1%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	289.5	255.0	1.972	260.8	1.939	Medium Sand
SORTING (σ):	137.9	1.724	0.786	1.604	0.682	Moderately Well Sorted
SKEWNESS (Sk):	1.177	-1.659	1.659	-0.083	0.083	Symmetrical
KURTOSIS (k):	5.713	11.52	11.52	1.024	1.024	Mesokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA19838-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

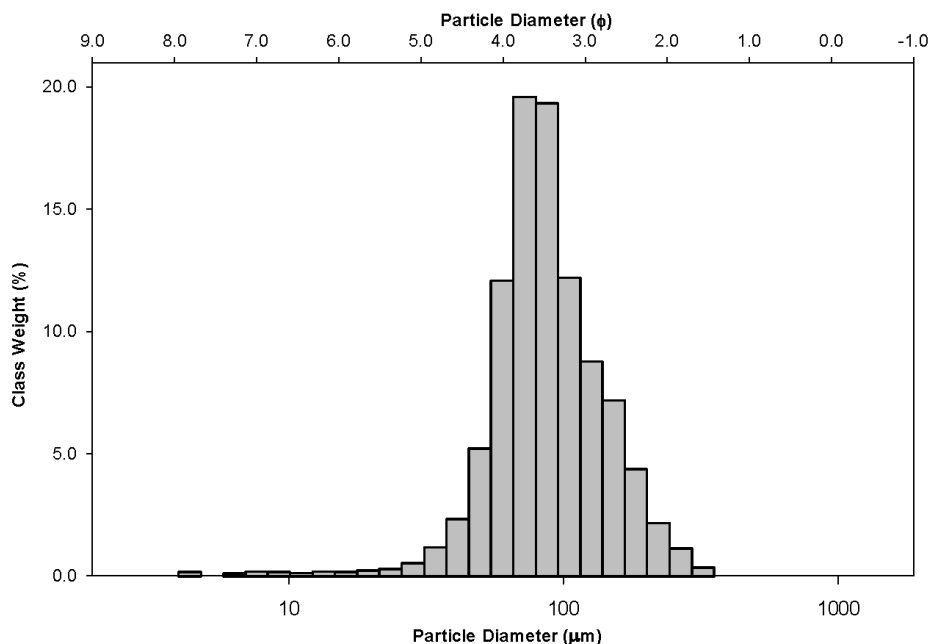
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Muddy Sand

SEDIMENT NAME: Very Coarse Silty Very Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	72.42	3.794	GRAVEL: 0.0%	COARSE SAND: 0.0%		
MODE 2:			SAND: 79.7%	MEDIUM SAND: 1.3%		
MODE 3:			MUD: 20.3%	FINE SAND: 19.1%		
D ₁₀ :	52.21	2.647		V FINE SAND: 59.3%		
MEDIAN or D ₅₀ :	84.25	3.569	V COARSE GRAVEL: 0.0%	V COARSE SILT: 17.9%		
D ₉₀ :	159.7	4.260	COARSE GRAVEL: 0.0%	COARSE SILT: 1.3%		
(D ₉₀ / D ₁₀):	3.058	1.609	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.7%		
(D ₉₀ - D ₁₀):	107.5	1.613	FINE GRAVEL: 0.0%	FINE SILT: 0.4%		
(D ₇₅ / D ₂₅):	1.714	1.248	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	47.52	0.777	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	96.48	85.73	3.544	87.84	3.509	Very Fine Sand
SORTING (σ):	47.16	1.650	0.723	1.556	0.638	Moderately Well Sorted
SKEWNESS (Sk):	1.502	-0.989	0.989	0.115	-0.115	Coarse Skewed
KURTOSIS (K):	6.164	7.962	7.962	1.151	1.151	Leptokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA19841-1**

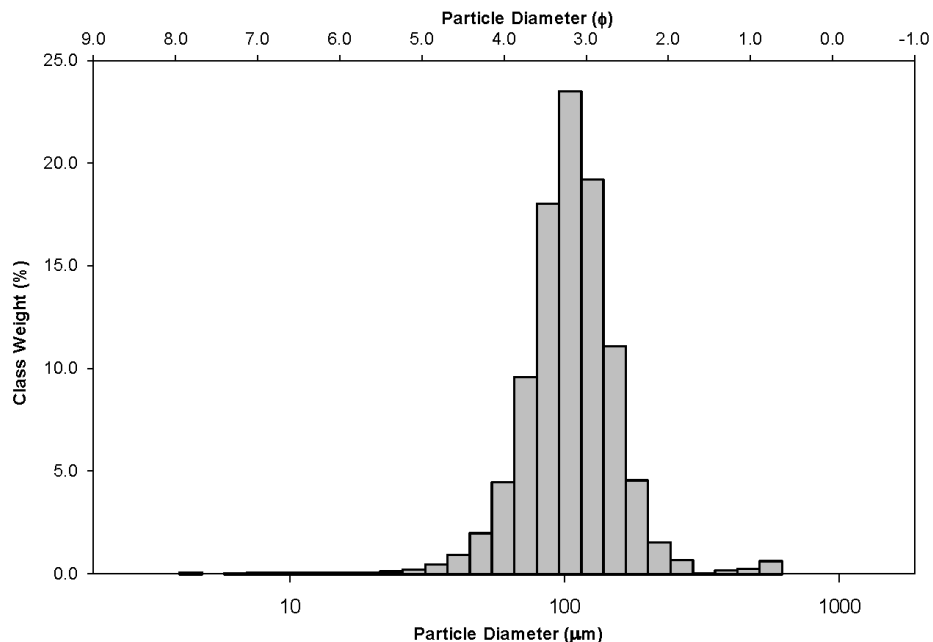
ANALYST & DATE: SGS Canada Inc., 2020-2022

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Very Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	105.3	3.254	GRAVEL: 0.0%	COARSE SAND: 0.7%		
MODE 2:			SAND: 92.2%	MEDIUM SAND: 1.1%		
MODE 3:			MUD: 7.8%	FINE SAND: 28.5%		
D ₁₀ :	66.89	2.626		V FINE SAND: 61.9%		
MEDIAN or D ₅₀ :	105.5	3.245	V COARSE GRAVEL: 0.0%	V COARSE SILT: 6.8%		
D ₉₀ :	162.0	3.902	COARSE GRAVEL: 0.0%	COARSE SILT: 0.5%		
(D ₉₀ / D ₁₀):	2.422	1.486	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.3%		
(D ₉₀ - D ₁₀):	95.08	1.276	FINE GRAVEL: 0.0%	FINE SILT: 0.2%		
(D ₇₅ / D ₂₅):	1.559	1.219	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	47.13	0.641	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	114.6	104.3	3.261	105.1	3.250	Very Fine Sand
SORTING (σ):	57.58	1.534	0.617	1.423	0.509	Moderately Well Sorted
SKEWNESS (Sk):	4.101	-0.800	0.800	-0.032	0.032	Symmetrical
KURTOSIS (K):	30.11	10.94	10.94	1.130	1.130	Leptokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA19843-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

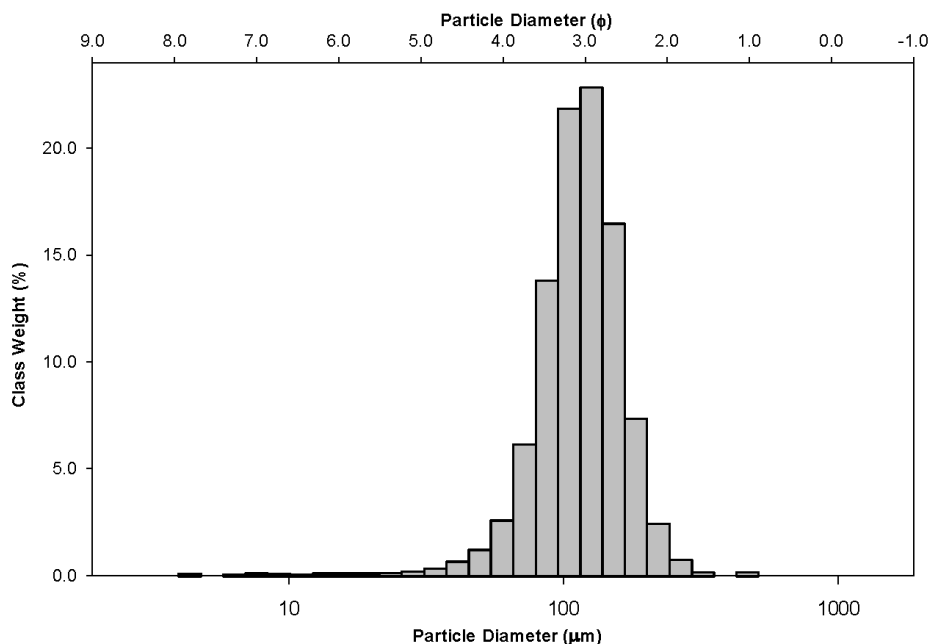
SAMPLE TYPE: Unimodal, Well Sorted

TEXTURAL GROUP: Sand

SEDIMENT NAME: Well Sorted Very Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	126.9	2.985	GRAVEL: 0.0%	COARSE SAND: 0.0%		
MODE 2:			SAND: 94.4%	MEDIUM SAND: 1.0%		
MODE 3:			MUD: 5.6%	FINE SAND: 39.8%		
D ₁₀ :	73.35	2.539		V FINE SAND: 53.6%		
MEDIAN or D ₅₀ :	116.1	3.106	V COARSE GRAVEL: 0.0%	V COARSE SILT: 4.3%		
D ₉₀ :	172.1	3.769	COARSE GRAVEL: 0.0%	COARSE SILT: 0.6%		
(D ₉₀ / D ₁₀):	2.346	1.485	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.4%		
(D ₉₀ - D ₁₀):	98.73	1.230	FINE GRAVEL: 0.0%	FINE SILT: 0.3%		
(D ₇₅ / D ₂₅):	1.534	1.220	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	49.88	0.617	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	121.1	112.1	3.157	115.1	3.119	Very Fine Sand
SORTING (σ):	44.24	1.524	0.608	1.406	0.491	Well Sorted
SKEWNESS (Sk):	1.445	-2.050	2.050	-0.082	0.082	Symmetrical
KURTOSIS (k):	11.01	14.18	14.18	1.129	1.129	Leptokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA19877-1**

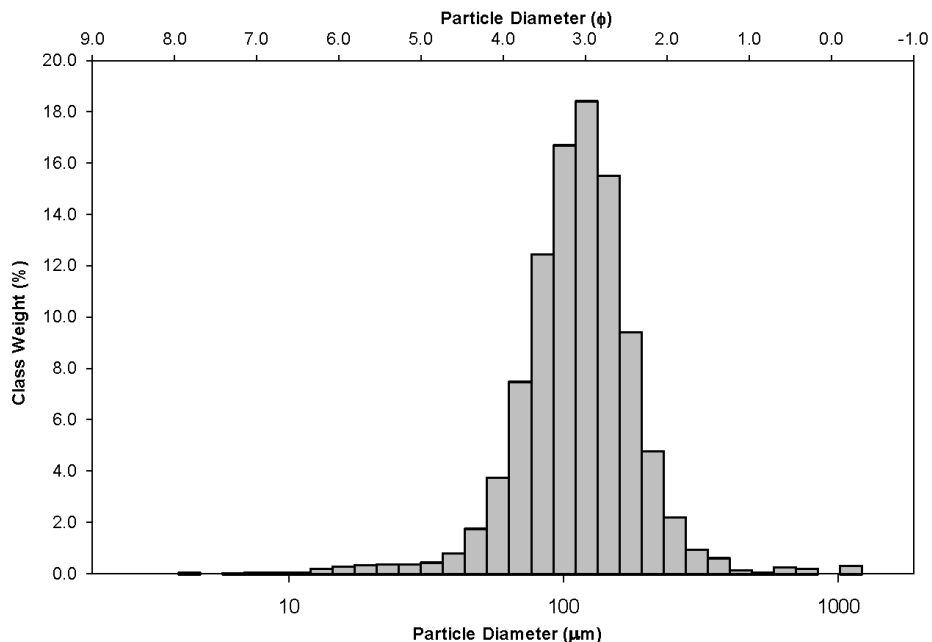
ANALYST & DATE: SGS Canada Inc., 2020-2022

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Very Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	121.6	3.046	GRAVEL: 0.0%	COARSE SAND: 0.5%		
MODE 2:			SAND: 91.4%	MEDIUM SAND: 3.1%		
MODE 3:			MUD: 8.6%	FINE SAND: 37.4%		
D ₁₀ :	65.20	2.387		V FINE SAND: 50.2%		
MEDIAN or D ₅₀ :	114.7	3.124	V COARSE GRAVEL: 0.0%	V COARSE SILT: 6.5%		
D ₉₀ :	191.1	3.939	COARSE GRAVEL: 0.0%	COARSE SILT: 1.4%		
(D ₉₀ / D ₁₀):	2.931	1.650	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.5%		
(D ₉₀ - D ₁₀):	125.9	1.552	FINE GRAVEL: 0.0%	FINE SILT: 0.1%		
(D ₇₅ / D ₂₅):	1.730	1.288	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	63.08	0.791	V COARSE SAND: 0.3%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	129.0	112.2	3.156	113.8	3.136	Very Fine Sand
SORTING (σ):	88.64	1.679	0.748	1.533	0.617	Moderately Well Sorted
SKEWNESS (Sk):	6.045	-0.524	0.524	-0.044	0.044	Symmetrical
KURTOSIS (K):	59.22	7.910	7.910	1.104	1.104	Mesokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA19877-2**

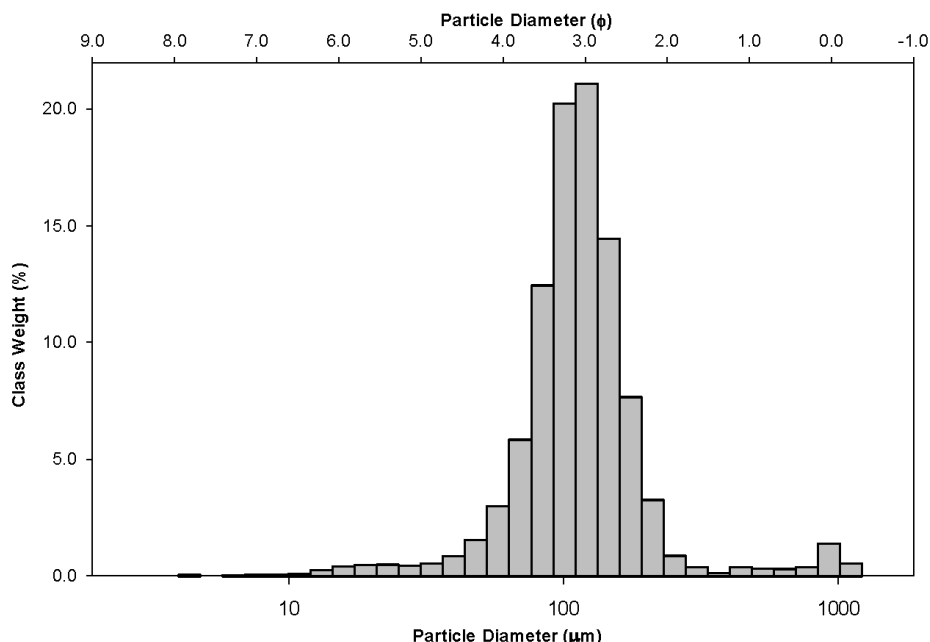
ANALYST & DATE: SGS Canada Inc., 2020-2022

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Moderately Well Sorted Very Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	121.6	3.046	GRAVEL: 0.0%	COARSE SAND: 2.3%		
MODE 2:			SAND: 91.7%	MEDIUM SAND: 1.5%		
MODE 3:			MUD: 8.3%	FINE SAND: 33.0%		
D ₁₀ :	66.45	2.415		V FINE SAND: 53.5%		
MEDIAN or D ₅₀ :	112.9	3.147	V COARSE GRAVEL: 0.0%	V COARSE SILT: 5.7%		
D ₉₀ :	187.5	3.912	COARSE GRAVEL: 0.0%	COARSE SILT: 1.8%		
(D ₉₀ / D ₁₀):	2.822	1.620	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.7%		
(D ₉₀ - D ₁₀):	121.0	1.497	FINE GRAVEL: 0.0%	FINE SILT: 0.2%		
(D ₇₅ / D ₂₅):	1.613	1.247	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	54.68	0.690	V COARSE SAND: 1.5%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	138.6	108.5	3.121	112.7	3.149	Very Fine Sand
SORTING (σ):	141.4	2.071	0.894	1.549	0.631	Moderately Well Sorted
SKEWNESS (Sk):	4.871	-2.001	-0.493	0.009	-0.009	Symmetrical
KURTOSIS (K):	28.84	18.12	8.226	1.438	1.438	Leptokurtic

GRAIN SIZE DISTRIBUTION



REPORT OF INVESTIGATION 123

SAMPLE STATISTICS

SAMPLE IDENTITY: **FFA19878-1**

ANALYST & DATE: SGS Canada Inc., 2020-2022

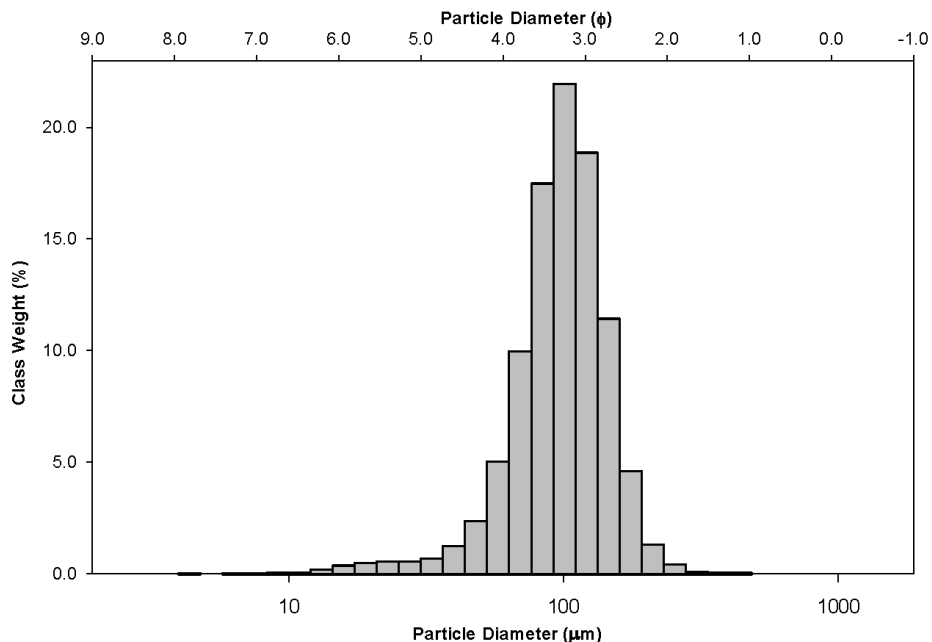
SAMPLE TYPE: Unimodal, Moderately Well Sorted

TEXTURAL GROUP: Muddy Sand

SEDIMENT NAME: Very Coarse Silty Very Fine Sand

	μm	ϕ	GRAIN SIZE DISTRIBUTION			
MODE 1:	101.1	3.312	GRAVEL: 0.0%	COARSE SAND: 0.0%		
MODE 2:			SAND: 88.3%	MEDIUM SAND: 0.5%		
MODE 3:			MUD: 11.7%	FINE SAND: 24.2%		
D ₁₀ :	58.80	2.720		V FINE SAND: 63.6%		
MEDIAN or D ₅₀ :	99.64	3.327	V COARSE GRAVEL: 0.0%	V COARSE SILT: 9.0%		
D ₉₀ :	151.7	4.088	COARSE GRAVEL: 0.0%	COARSE SILT: 2.0%		
(D ₉₀ / D ₁₀):	2.580	1.503	MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.6%		
(D ₉₀ - D ₁₀):	92.92	1.367	FINE GRAVEL: 0.0%	FINE SILT: 0.1%		
(D ₇₅ / D ₂₅):	1.588	1.222	V FINE GRAVEL: 0.0%	V FINE SILT: 0.0%		
(D ₇₅ - D ₂₅):	46.14	0.667	V COARSE SAND: 0.0%	CLAY: 0.0%		
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	103.6	94.98	3.396	97.81	3.354	Very Fine Sand
SORTING (σ):	39.78	1.555	0.637	1.459	0.545	Moderately Well Sorted
SKEWNESS (Sk):	1.162	-1.494	1.494	-0.132	0.132	Fine Skewed
KURTOSIS (K):	8.901	8.436	8.436	1.176	1.176	Leptokurtic

GRAIN SIZE DISTRIBUTION



FLORIDA GEOLOGICAL SURVEY

APPENDIX E: USGS GEOCHEMICAL REPORTS

Table 14. Major and minor element data reported in oxide wt. %. Analyses performed by USGS Denver Laboratory using C-ICPOES-16. All samples with the FFA annotation are heavy mineral separates. Lab No. corresponds to internal sample field associated with the FGS Sample name (Field No.).

<i>Lab No.</i>	<i>Field No.</i>	<i>Rep</i>	<i>Al₂O₃</i> %	<i>CaO</i> %	<i>Cr₂O₃</i> %	<i>Fe₂O₃</i> %	<i>K₂O</i> %	<i>MgO</i> %	<i>MnO</i> %	<i>Na₂O</i> %	<i>P₂O₅</i> %	<i>SiO₂</i> %	<i>TiO₂</i> %	<i>V₂O₅</i> %
<i>C-552195</i>	FFA 12360-1	1	20.56	0.09	0.05	15.41	0.02	0.82	0.47	0.17	0.17	17.73	>25.00	0.05
<i>C-552198</i>	FFA 12361-2	1	25.72	0.1	0.04	15.99	0.02	1	0.47	0.2	0.15	20.29	23.96	0.05
<i>C-552202</i>	FFA 10489-1	1	18.37	0.07	0.08	13.36	0.01	0.71	0.38	0.14	0.12	34.74	22.57	0.04
<i>C-552203</i>	FFA 10489-2	1	21.84	0.07	0.04	15.36	0.01	0.73	0.5	0.14	0.16	24.49	>25.00	0.05
<i>C-552206</i>	FFA 14346-1	1	29.27	0.75	0.05	17.01	0.03	1.31	0.43	0.26	0.63	20.76	21.45	0.05

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Table 15. Elemental concentrations reported as a percentage (%) or parts per million (ppm). Analyses performed by USGS Denver Laboratory using C-ICPOES-MS-61. All samples with the FFA annotation are heavy mineral separates. Specific designation for FFA19877(1 or 2) has been requested. Boron and Rhenium are included as informational only. The USGS uses SAR-L.1 and SAR H as standards.

<i>Lab No.</i>	<i>Field No.</i>	<i>Rep</i>	<i>Al</i> %	<i>Ca</i> %	<i>Fe</i> %	<i>K</i> %	<i>Mg</i> %	<i>P</i> %	<i>S</i> %	<i>Si</i> %	<i>Ti</i> %
<i>C-552194</i>	FFA 10473-1	1	4.38	<0.1	2.99	0.3	0.15	0.13	0.11	>30.0	8.52
<i>C-552195</i>	FFA 12360-1	1	8.27	<0.1	10.11	<0.1	0.37	0.05	0.01	7.5	18.15
<i>C-552196</i>	FFA 12360-2	1	10.79	<0.1	10.37	<0.1	0.46	0.05	0.01	7.4	16.82
<i>C-552197</i>	FFA 12361-1	1	9.56	<0.1	9.52	<0.1	0.48	0.03	<0.01	7.4	17.55
<i>C-552198</i>	FFA 12361-2	1	8.71	<0.1	10.42	<0.1	0.43	0.06	0.01	7.6	16.99
<i>C-552199</i>	SAR-L.1	1	5.95	1	2.64	3	0.52	0.07	0.08	>30.0	0.32
<i>C-552200</i>	FFA 12361-3	1	6.74	<0.1	6.05	0.4	0.16	0.28	0.12	15.4	15.88
<i>C-552201</i>	FFA 19843-1	1	7.51	<0.1	13.02	<0.1	0.29	0.18	<0.01	8	21.19
<i>C-552202</i>	FFA 10489-1	1	8	<0.1	9.09	<0.1	0.39	0.04	<0.01	14.6	14.52
<i>C-552203</i>	FFA 10489-2	1	9.49	<0.1	9.82	<0.1	0.43	0.05	<0.01	10.3	16.63
<i>C-552204</i>	FFA 19805-1	1	8.39	<0.1	5.12	<0.1	0.32	0.02	<0.01	23.8	8.87
<i>C-552205</i>	FFA 19587-1	1	9.03	6.7	11.09	<0.1	0.33	0.35	0.45	10.3	12.82
<i>C-552206</i>	FFA 14346-1	1	9.7	0.7	11.41	<0.1	0.57	0.29	0.02	7.3	13.27
<i>C-552209</i>	FFA 19877	1	8.69	<0.1	>25.00	0.1	0.06	<0.01	0.07	12.7	0.92
<i>C-552210</i>	SAR-H	1	7.37	2.5	13.28	<0.1	0.58	0.23	0.05	9.3	18.04

Elemental data continued on the next page for the samples above.

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Table 15. (Continued).

<i>Lab No.</i>	<i>Field No.</i>	<i>Rep</i>	<i>Ag</i> (ppm)	<i>As</i> (ppm)	<i>B</i> (ppm)	<i>Ba</i> (ppm)	<i>Be</i> (ppm)	<i>Bi</i> (ppm)	<i>Cd</i> (ppm)	<i>Ce</i> (ppm)	<i>Co</i> (ppm)	<i>Cr</i> (ppm)	<i>Cs</i> (ppm)
<i>C-552194</i>	FFA 10473-1	1	<5	23	441	142	<5	0.9	0.3	1951	6.5	269	0.4
<i>C-552195</i>	FFA 12360-1	1	<5	<5	1882	58	20	0.9	0.5	120	23.2	282	<0.1
<i>C-552196</i>	FFA 12360-2	1	<5	<5	2200	65	15	0.9	0.2	88.5	27.3	304	0.3
<i>C-552197</i>	FFA 12361-1	1	<5	6	2601	40	10	0.7	0.5	52.6	24.1	381	0.3
<i>C-552198</i>	FFA 12361-2	1	<5	<5	2173	63	10	0.8	0.5	79.7	25.3	283	0.1
<i>C-552199</i>	SAR-L.1	1	<5	16	15	895	5	1.1	3.1	158	7	99	4.3
<i>C-552200</i>	FFA 12361-3	1	<5	10	573	261	<5	3.4	0.7	3794	13.1	462	0.8
<i>C-552201</i>	FFA 19843-1	1	<5	6	1194	117	<5	1.4	0.5	2307	26	446	0.5
<i>C-552202</i>	FFA 10489-1	1	<5	7	1941	54	44	0.7	0.3	51.1	20.6	415	0.3
<i>C-552203</i>	FFA 10489-2	1	<5	<5	2219	59	29	0.7	<0.2	168	23.6	274	0.5
<i>C-552204</i>	FFA 19805-1	1	<5	<5	1862	33	10	0.5	0.2	104	11.7	173	0.1
<i>C-552205</i>	FFA 19587-1	1	<5	<5	1155	144	<5	1.1	0.8	1211	17.7	374	0.4
<i>C-552206</i>	FFA 14346-1	1	<5	<5	3118	77	14	0.7	0.5	85.8	26.4	268	0.3
<i>C-552209</i>	FFA 19877	1	<5	29	1227	110	<5	1.4	0.4	2277	16.4	458	0.5
<i>C-552210</i>	SAR-H	1	91	402	118	852	20	5.3	30	99.8	53.8	244	5.7
<i>Elemental data continued on the next page for the samples above.</i>													

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Table 15. (Continued).

<i>Lab No.</i>	<i>Field No.</i>	<i>Rep</i>	<i>Cu</i> (ppm)	<i>Dy</i> (ppm)	<i>Er</i> (ppm)	<i>Eu</i> (ppm)	<i>Ga</i> (ppm)	<i>Gd</i> (ppm)	<i>Ge</i> (ppm)	<i>Hf</i> (ppm)	<i>Ho</i> (ppm)	<i>In</i> (ppm)	<i>La</i> (ppm)
<i>C-552194</i>	FFA 10473-1	1	26	107	65.45	10.45	24	130	<1	832	22.13	<0.2	914
<i>C-552195</i>	FFA 12360-1	1	<10	18.96	25.67	0.83	74	10.69	2	1639	6.04	0.3	59.2
<i>C-552196</i>	FFA 12360-2	1	<10	11.49	15.68	0.89	65	6.91	3	928	3.66	0.3	50
<i>C-552197</i>	FFA 12361-1	1	<10	12.88	18.67	0.5	87	5.87	2	1271	4.27	0.3	25.6
<i>C-552198</i>	FFA 12361-2	1	<10	14.85	20.73	0.98	54	7.96	2	1264	4.75	0.4	44.2
<i>C-552199</i>	SAR-L.1	1	388	10.89	6.68	1.52	17	10.53	2	14	2.33	0.3	72
<i>C-552200</i>	FFA 12361-3	1	<10	255	168	22.96	37	268	1	1558	55.78	0.3	1841
<i>C-552201</i>	FFA 19843-1	1	<10	104	61.01	12.6	39	140	1	1253	20.94	0.4	1096
<i>C-552202</i>	FFA 10489-1	1	40	10.96	16.73	0.59	49	4.9	2	1068	3.8	0.3	28.4
<i>C-552203</i>	FFA 10489-2	1	<10	12.6	14.99	1.04	56	10.81	2	838	3.64	0.3	85.5
<i>C-552204</i>	FFA 19805-1	1	<10	10.02	11.76	0.91	48	7.41	1	659	2.81	0.5	50.2
<i>C-552205</i>	FFA 19587-1	1	<10	65.12	40.44	10.07	41	82.97	3	297	13.52	0.4	574
<i>C-552206</i>	FFA 14346-1	1	<10	10.75	13.59	0.89	53	7.2	2	749	3.32	0.3	44.1
<i>C-552209</i>	FFA 19877	1	<10	105	62.97	11.36	57	136	1	1381	21.12	0.5	1080
<i>C-552210</i>	SAR-H	1	1213	4.56	2.75	1.26	15	5.13	2	9	0.96	10.7	49.7

Elemental data continued on the next page for the samples above.

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Table 15. (Continued).

<i>Lab No.</i>	<i>Field No.</i>	<i>Rep</i>	<i>Li</i> (ppm)	<i>Lu</i> (ppm)	<i>Mn</i> (ppm)	<i>Mo</i> (ppm)	<i>Nb</i> (ppm)	<i>Nd</i> (ppm)	<i>Ni</i> (ppm)	<i>Pb</i> (ppm)	<i>Pr</i> (ppm)	<i>Rb</i> (ppm)
<i>C-552194</i>	FFA 10473-1	1	22	12.4	1666	20	267	857	11	59	218	8.5
<i>C-552195</i>	FFA 12360-1	1	148	9.48	3897	10	422	51.8	13	99	13.88	0.4
<i>C-552196</i>	FFA 12360-2	1	220	5.76	3926	9	348	39.3	20	91	10.73	0.6
<i>C-552197</i>	FFA 12361-1	1	197	7.22	3262	19	364	22.9	16	107	5.96	0.4
<i>C-552198</i>	FFA 12361-2	1	159	7.53	4100	7	360	36.3	19	83	9.62	0.4
<i>C-552199</i>	SAR-L.1	1	26	1.04	2174	13	40	65.1	62	595	17.34	137
<i>C-552200</i>	FFA 12361-3	1	30	30.61	3513	11	425	1592	13	137	432	14.5
<i>C-552201</i>	FFA 19843-1	1	74	12.51	6372	7	591	965	16	97	266	3
<i>C-552202</i>	FFA 10489-1	1	151	6.42	3233	7	280	21.5	16	80	5.99	0.7
<i>C-552203</i>	FFA 10489-2	1	175	5.6	3741	7	370	72.6	16	88	19.34	0.7
<i>C-552204</i>	FFA 19805-1	1	79	4.21	1962	6	250	44.6	16	65	12.09	0.9
<i>C-552205</i>	FFA 19587-1	1	53	7.9	5730	7	172	537	11	56	135	2.9
<i>C-552206</i>	FFA 14346-1	1	224	4.72	3531	5	225	39.1	19	72	10.04	1.2
<i>C-552209</i>	FFA 19877	1	72	13.25	3527	24	563	960	22	148	258	2.8
<i>C-552210</i>	SAR-H	1	51	0.42	4030	66	23	39.6	236	3866	10.77	146
<i>Elemental data continued on the next page for the samples above.</i>												

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Table 15. (Continued).

<i>Lab No.</i>	<i>Field No.</i>	<i>Rep</i>	<i>Re</i> (ppm)	<i>Sb</i> (ppm)	<i>Sc</i> (ppm)	<i>Se</i> (ppm)	<i>Sm</i> (ppm)	<i>Sn</i> (ppm)	<i>Sr</i> (ppm)	<i>Ta</i> (ppm)	<i>Tb</i> (ppm)	<i>Te</i> (ppm)
<i>C-552194</i>	FFA 10473-1	1	<0.02	1.7	25	<1	160	21	29	28.4	19.06	<0.05
<i>C-552195</i>	FFA 12360-1	1	<0.02	2.3	34	<1	10.2	31	39	43.1	2.27	<0.05
<i>C-552196</i>	FFA 12360-2	1	<0.02	2.4	32	<1	7.2	14	75	29.5	1.37	<0.05
<i>C-552197</i>	FFA 12361-1	1	<0.02	3.2	30	<1	4.4	18	18	30.2	1.38	<0.05
<i>C-552198</i>	FFA 12361-2	1	<0.02	2	36	<1	7.3	13	56	29.6	1.71	<0.05
<i>C-552199</i>	SAR-L.1	1	<0.02	5.4	7	<1	12.4	8	152	2.4	1.78	0.53
<i>C-552200</i>	FFA 12361-3	1	<0.02	4	52	2	313	37	58	36	42.15	<0.05
<i>C-552201</i>	FFA 19843-1	1	<0.02	4.4	36	<1	184	21	50	43.2	19.73	0.05
<i>C-552202</i>	FFA 10489-1	1	<0.02	2.2	28	<1	4.2	12	45	24.6	1.21	<0.05
<i>C-552203</i>	FFA 10489-2	1	<0.02	2	30	<1	13.1	14	49	31.4	1.79	<0.05
<i>C-552204</i>	FFA 19805-1	1	<0.02	2.9	21	<1	8.5	10	27	22.6	1.35	0.1
<i>C-552205</i>	FFA 19587-1	1	<0.02	1.4	62	<1	101	8	493	16.3	11.79	<0.05
<i>C-552206</i>	FFA 14346-1	1	<0.02	2.7	28	<1	7.7	10	109	17.7	1.33	<0.05
<i>C-552209</i>	FFA 19877	1	<0.02	6.8	46	<1	179	37	33	41.4	19.32	0.17
<i>C-552210</i>	SAR-H	1	0.02	561	8	17	6.9	5	184	1.4	0.81	10.39

Elemental data continued on the next page for the samples above.

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Table 15. (Continued).

<i>Lab No.</i>	<i>Field No.</i>	<i>Rep</i>	<i>Th</i> (ppm)	<i>Tl</i> (ppm)	<i>Tm</i> (ppm)	<i>U</i> (ppm)	<i>V</i> (ppm)	<i>W</i> (ppm)	<i>Y</i> (ppm)	<i>Yb</i> (ppm)	<i>Zn</i> (ppm)	<i>Zr</i> (ppm)
<i>C-552194</i>	FFA 10473-1	1	413	<0.5	10.38	99.43	293	17	564	72.2	124	>10000
<i>C-552195</i>	FFA 12360-1	1	49.6	<0.5	5.3	50.68	395	16	176	45.5	639	>10000
<i>C-552196</i>	FFA 12360-2	1	39.5	<0.5	3.3	32.89	413	13	102	28.3	714	>10000
<i>C-552197</i>	FFA 12361-1	1	32.1	<0.5	3.89	40.95	419	14	124	34.2	770	>10000
<i>C-552198</i>	FFA 12361-2	1	41.2	<0.5	4.31	41.94	403	13	139	36.3	654	>10000
<i>C-552199</i>	SAR-L.1	1	19.2	1.3	1.05	4.97	130	4	60.6	6.9	448	422
<i>C-552200</i>	FFA 12361-3	1	749	<0.5	27.31	239	609	26	>1000	189	179	>10000
<i>C-552201</i>	FFA 19843-1	1	434	<0.5	9.72	99.71	512	32	551	68.4	475	>10000
<i>C-552202</i>	FFA 10489-1	1	27.8	<0.5	3.51	33.37	337	10	105	30.6	577	>10000
<i>C-552203</i>	FFA 10489-2	1	50.3	<0.5	3.09	31.87	392	15	98	26.5	575	>10000
<i>C-552204</i>	FFA 19805-1	1	46.2	<0.5	2.38	23.91	243	11	77.6	20.1	353	>10000
<i>C-552205</i>	FFA 19587-1	1	199	<0.5	6.48	57.58	412	17	348	45.5	276	>10000
<i>C-552206</i>	FFA 14346-1	1	31.5	<0.5	2.76	26.3	368	7	92.7	23.5	707	>10000
<i>C-552209</i>	FFA 19877	1	456	<0.5	10.36	129	617	35	566	74.2	361	>10000
<i>C-552210</i>	SAR-H	1	19.8	12	0.42	4.7	74	14	24.4	2.8	3812	261