Appendix 1.

<u>A. Weigh (<2mm) dry sample and sieve to separate coarse and size fraction</u>

A1–Coarse fraction

Wet sieving to separate fine (<63 um) and coarse (>63 um) fractions. (The coarse fraction will be separated into 63-150, 150-500 and > 500 um fractions.)

<u>A1-A. Abundance of coarse fraction (% or lithics/gm)</u>

Counting lithics/gram and type of lithics/gram allowed the identification of North Atlantic Heinrich Events (Fig. 2) and the correlation of them to the Greenland Ice Core as shown in Figure 4 (e.g. Bond et al., 1992, Bond and Lotti, 1995, Schafer et al, 2004). Although Heinrich events seem to be a North Atlantic phenomenon, peaks of ice-rafting have been recorded in the South Atlantic. For example, at Site 1089 (TTN057-21), in the South Atlantic, near Bouvet Island and just north of the Weddell Sea Gyre, the record of lithics/g shows the potential for identifying changes in ice rafted detritus (IRD) abundance through time and these high depositional intervals can be tied with the North Atlantic and even Greenland ice core record (Fig. 3). Such changes may be used to address the question of East and West Antarctic stability in the Pliocene. IRD that can be strictly identified as sourced from either provenance will enhance the hypotheses of ice sheet instability in those locations.

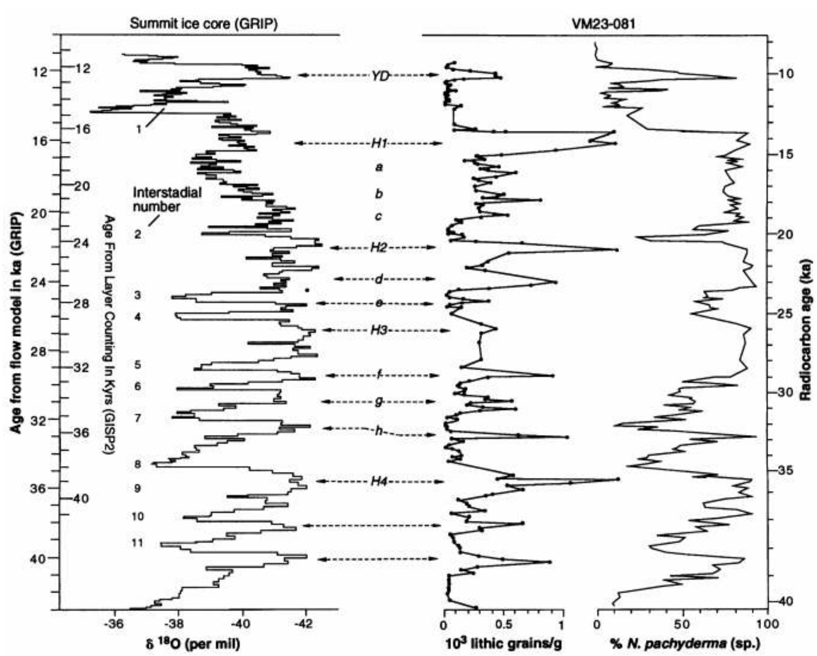

Figure 4. Correlation of abundance of lithic grains (Heinrich Events) with *Neogloboquadrina pachyderma*, left coiling, a planktonic foraminifera found in cold-water masses and living in sea ice. Heinrich events occur in some of the cold phases (lighter d^{18}O) of the Dansgaard-Oeschger (D-O) events observed in the Greenland ice cores (from Bond et al., 1995).

A1-B. Composition of IRD

In addition to counting the number of lithics, it is also possible to separate the heavy (e.g. hornblende, garnet, pyroxene) from light minerals (e.g. quartz and feldspars) and do a mineralogic analysis of these samples. Hauptvogel analyzed just twenty-four such Miocene samples from the Andrill 2A core for a Master's thesis (Hauptvogel and Passchier, 2012). (Andrill is an Antarctic Drilling program that drilled through the Ross Sea Ice Shelf into continental shelf sediments. Because ice is more stable than a ship at sea and drill holes did not have to be terminated because of ice bergs, the recovery at these sites is easily twice as high as those cored by ocean drilling. http://www.andrill.org/) Although an important and fascinating study with the potential to identify changes in the source of area, preparing coarse fraction samples can be time consuming. However, if this was the choice of a student with a strong petrology background, we have separated coarse fraction from Cores 693A-2R and 8R. We could develop a sub-sampling strategy and prepare the samples so that a student could immediately begin to analyze the samples during the summer. For example, samples could be selected from most and least abundant lithic samples from these cores and grain mounts made prior to July.

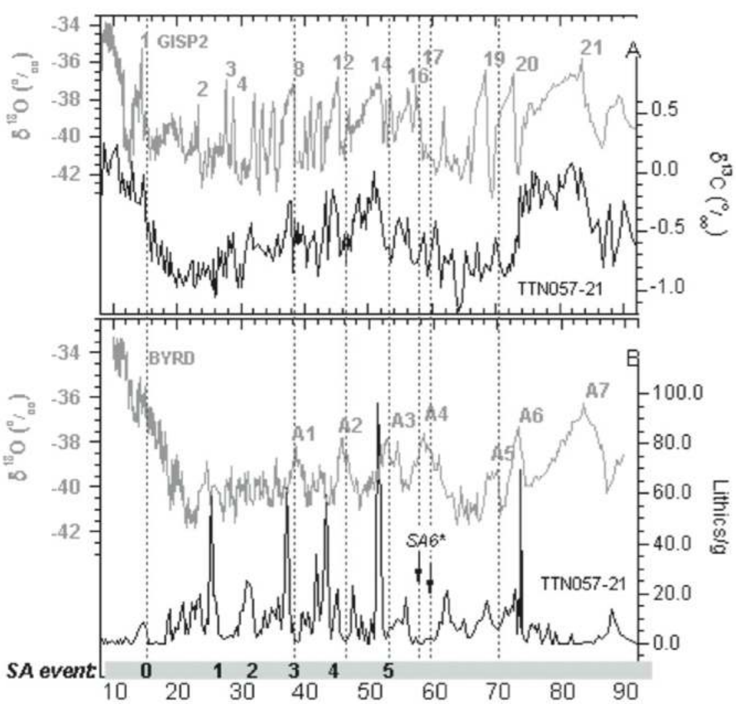

Figure 3. Lithics/g at Site 1089 (South Atlantic Ocean) for the past 90,000 compared with $\delta^{18}O$ signal for northern hemisphere (GISP2) and Western Antarctic (Byrd) ice core records (Kanfoush 2013).

A1-C. Large diatom abundance and identification

The habitat of large epiphytic diatoms (those that grow attached to macroalgae) is an emerging field (Majewska et al., 2013a, 2013b). At this time about ten geneses have been described from modern environments, and the same genus are also observed in Miocene and Pliocene Antarctic sediments (Harwood, pers. com.). I can identify these geniuses and their identification in these sediments could become a senior thesis research project. In addition identifying and counting species abundance, these changes could be correlated with lithic abundance and changes in core chemistry, such as high iron content (Konfirst et al., 2012).

A2. Fine fraction

A2-A. % Biosilica

Biosilica is abundant in the Southern Ocean and is an indicator of primary productivity. Since most diatoms are < 63 um in size, percent biosilica is determined by weighing the < 63 um fraction, removing biosilica with H_2O_2, HCl and NaOH, drying and reweighing the sample. In the Wilkes Land Basin, off of the Ross Sea, high %biosilica, and higher Ba/Al occurred during warmer time intervals. The warmer intervals were also was accompanied by erosion and retreat of the East Antarctic Ice sheet (Cook et al. 2013, Fig. 4). Cook et al.'s (2013) model suggests dynamic melting in the low-lying Wilkes Subglacial Basin. Such a basin does not exist near Site 693. Data from Site 693 will help to address the stability of a different part of the East Antarctic Ice sheet. In DeConto and Pollard's (2003) model, the East Antarctic craton, which borders the southern Weddell Sea and Site 693, is shown as more stable than the ice sheets near the Wilkes Land Basin. Students choosing this project will be able to test the strength of DeConto and Pollard's 2003 model.

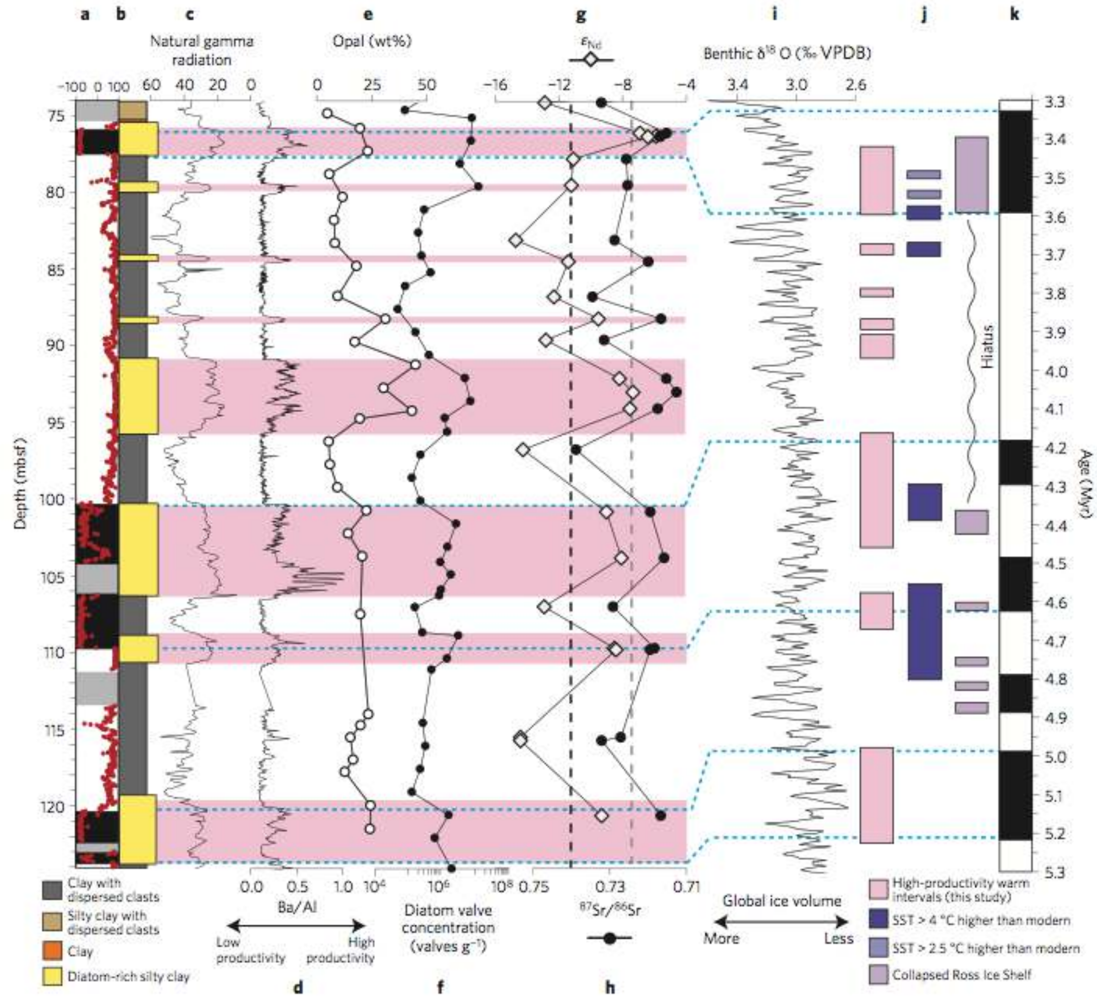
Figure 4. Pliocene records from Site 1361 (Wilkes Land Basin) in comparison to other Circum-Antarctic and global records. For this Keck project we will have access to or be able to generate columns b, Lithostratigraphy, d. Ba/Al, e. opal wt%, and try to put it in the context of i, Global benthic oxygen isotope stack (LR04; ref. 29). j, Circum-Antarctic indicators for warm temperatures; pink, Pliocene high-productivity intervals at Site 1361; dark blue, diatom and silicoflagellate assemblages from the Kerguelen Plateau and Prydz Bay; light blue, silicoflagellate assemblages from Prydz Bay,1; lilac, diatomite deposits from ANDRILL cores in the Ross Sea. **k,** Paleomagnetic timescale (Cook et al., 2013).

<u>A2-C. Grain- size analysis</u>

The biosilica-free size distribution of the < 63 um fraction can be determined with a particle size analyzer. Today most rapid size analyzers use lasers. These analyzers also provide information about particle shape (Passchier, pers com.). Particle shape is important because flat, clay minerals are counted as larger grains when analyzed by laser sizers (Buurman et al., 2001). If this were a student's interest and the home institution did not have a laser particle size analyzer, we have we have access to the Passchier's analyzer at Montclair State University in New Jersey.

A2. -B. Fine fraction mineralogy

The XRD at Wesleyan can be used for non-clay mineral identification. If, however, clay mineralogy were the objective, a different analytical instrument would need to be used, as the Wesleyan instrument does not resolve minerals at low diffraction angles. This would be determined ahead of time with a Keck student's research mentor/supervisor. Previous shipboard work, based on one sample/section shows broad changes in clay mineralogy (Fig. 5).

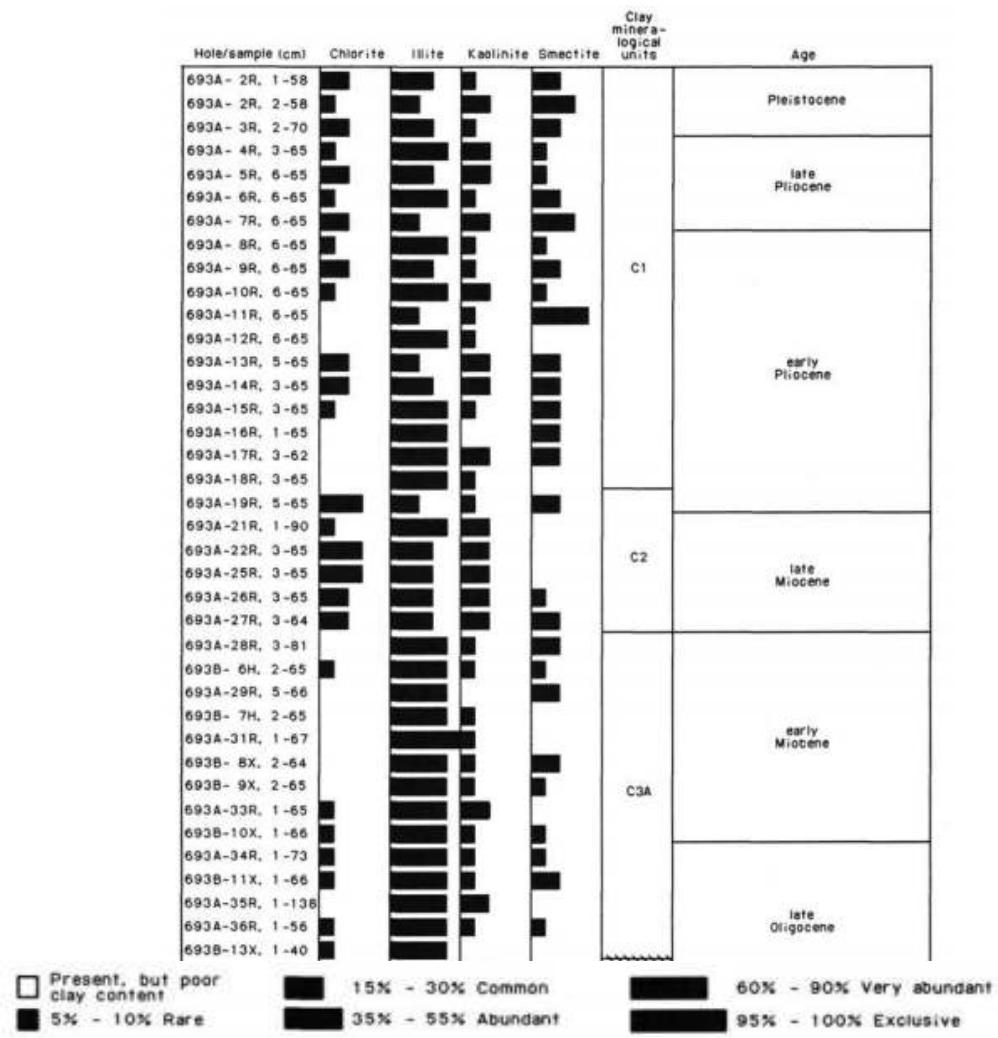

Figure 5. Clay mineralogy of the Cenozoic section from Site 693 (Shipboard Scientific Party, 1988).

B.XRF analysis for major element chemistry

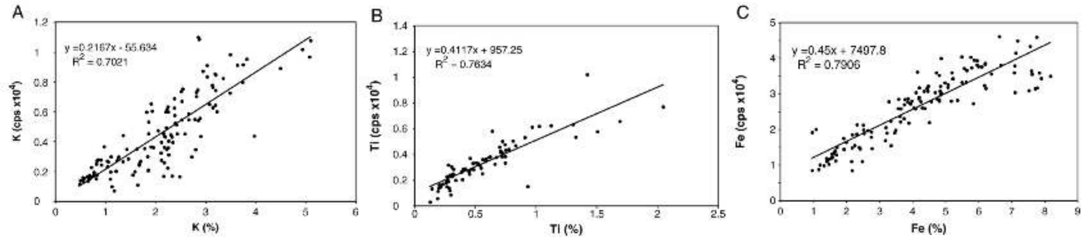

Figure 6. Example using linear regression to convert of XRF scanner counts to elemental weight percent for the elements K, Ti and Fe (from Monien et al., 2012).

The core scanned XRF analysis collected at the TAMU-ODP repository, will provide us with "elemental counts." This will enable us to look at relative downcore changes. However the ideal approach is to measure select samples with a standard XRF sample analyzer and convert core scanner counts to wt % oxide or element ppm (Fig. 6). Several papers, e.g. Lyle et al. 2012, Monien et al., 2012, and Weltje and Tjallingii, 2008, describe different methods for making this conversion normalized mean, linear regression and log-ratio transformation respectively. In our experience (on XRF samples that are not robust), for the Miocene at Site 694, using the Lyle Method, which scales the counts for each element and then normalizes the total elemental composition to 100%.

With this data downcore changes in elemental weight percent can be identified. A more robust approach is to use principal component analysis, which allows specific elemental clusters to be determined. Downcore changes in the clusters enhance the determination of provenance and can be used to identify source areas changes developing/determining a more robust paleoenvironmental interpretation. Monien et al. 2012, used this approach to identify three geochemical facies, sourced from different areas which allowed them to determine major changes in the East Antarctic Ice Sheet behavior recorded in the AND-1B site (Fig. 9).

The interval explored by Cook et al., (2013) at ODP Site 1361, is in the open water and down current from the AND-1B. In contrast to Cook et al. (2013), Monien et al. (2012), in shallower water, have a shelfal facies (diamictite) dominated by Geochemical Group 2 (GC2) sediments with high Fe/Ti ratios interbedded with diatomite and thin mudstone layers. Both sites however, do show a dynamic environment. Will the sedimentary record reveal such a dynamic environment off of Dronning Maud land on the Weddell Sea coast at Site 693?

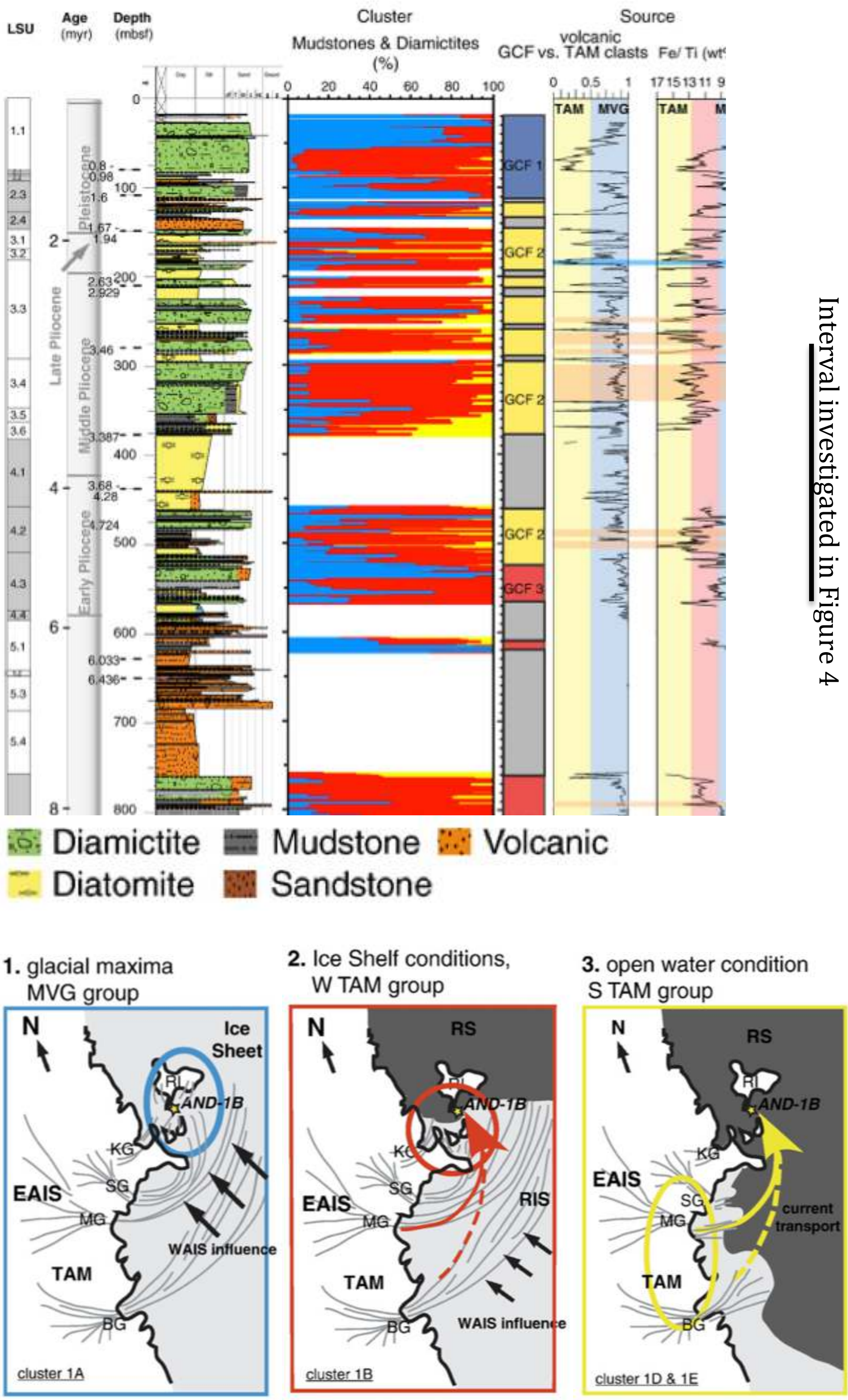

Figure 7. Scenario 1 shows a glacial maximum situation (blue, McMurdo Volcanic Group (MVG) dominating sediment record), scenario 2 represents a mixture in provenance of MVG and TAM and less glaciation influence (red) and scenario 3

shows a transport by the southern EAIS outlet glaciers and a retreated WAIS, with Transantarctic Mountain (TAM) sediments dominating. The circles and arrows highlight the source area and the transport path for deposits in the AND-1B sediments. KG = Koettlitz Glacier, MG = Mulock Glacier, BG = Byrd Glacier, SG = Skelton Glacier, RI = Ross Island, RIS = Ross Ice Shelf, RS = Ross Sea. The time interval analyzed at IODP Site 1361 is shown on the right.

C. Diatom investigation for chronostratigraphy and paleoenvironmental analysis.

The first step in the diatom investigation will be to use the diatoms to get some age control on the deposits at Site 693. In the twenty-five years since the site was cored many of the datums have moved and a higher resolution chronostratigraphy is available. This will be done in conjunction with David Harwood at the University of Nebraska, Lincoln.

D. Dropstone petrology

Over 50 dropstones have been collected from the Cenozoic section of Site 693. Figure 10 shows the downhole location and identity of ones that were analyzed during the expedition. Preliminary descriptions are available in initial report volumes 113, p. (Shipboard Scientific Party, 1988). Unfortunately, most of the thin sections made onboard the ship have been lost, however additional material from most of them is available at the repository to make additional thin sections. In addition, many more dropstones were identified in the shipboard photographs.

The initial petrographic descriptions indicate a wide variety of sources, volcanic, sedimentary, metamorphic, felsic plutonic and basic plutonic. Determining the source for these dropstones would be an important contribution to understanding the Cenozoic glacial history of Antarctica. The Transantarctic Mountains continue into the Weddell Sea, where it empties via the Ronne and Filchner Ice Sheet, but it is unlikely that material would be deposited at Site 693. This is because the circumpolar surface currents travel counterclockwise, and Site 693 is upstream and turbidity currents from these ice shelves would move downslope and be deposited deeper than Site 693.