Comparison of the Lithologies on the Surface of the Asteroid 4 Vesta based on the Petrology of 91 & 92 Series Antarctic Achondrites

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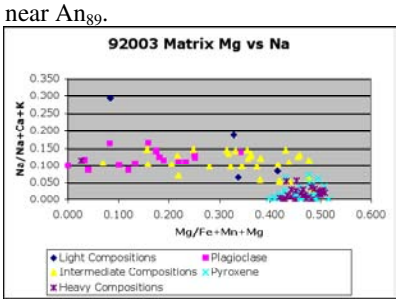
Introduction: We studied meteorite sections PCA91179,9; EET92003,14; EET92025,5; EET92026,4; and EET92027,5 t determine lithological variations on the surface of the asteroid 4 Vesta. These are brecciated polymict eucrites. The clasts contained within these samples and the matrix which surrounds them in each sample provide a random sampling of the characteristic compositions found on the surface of asteroid 4 Vesta.

Methods: We studied and photographed the samples on a polarizing microscope to make a map of the thin sections and aid with our understanding of the samples. We then studied the samples in the electron microprobe to get quantitative analyses of the samples. We did this by creating polygonal grids covering specific clasts and the overall matrix in each thin section. Backscattered electron images were also made for some of the clasts to better understand the compositional differences within specific grains. These methods provide random analyses targeting distinguishable clasts which can then be studied to distinguish differing compositions within the samples.

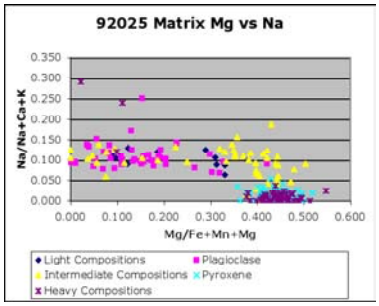
Results: Samples 91179, 92003, and 92026 are brecciated eucrites. Samples 92025 and 92027 are polymict howardites and polymict eucrites.

EET 92003,14: This sample has a fine-grained matrix surrounding coarse, medium, and fine-grained clasts. Darker clasts are finer grained and resemble the matrix material in color and texture. They also appear to have homogenous composition, but this could be a consequence of very fine- to fine-sized particles of varying compositions seemingly blending together. Small variations in color can be seen in some of the darker, finer grained clasts. The lighter clasts in this sample show less homogenous, medium- to coarse-grained material. Minerals found in this sample include pyroxenes, plagioclases, and quartz grains. Pyroxenes throughout the sample cluster around Wo_{10}. Feldspar grains range from An_{83}-An_{92} with the majority of feldspars near An_{89}.



EET 92025,5: This is an inhomogeneous sample with very coarse- to medium-grained clasts within a medium- to fine-grained matrix. Lithic clasts contain well-developed and zoned plagioclase grains with crushed pyroxene grains. The clasts within this sample are optically lighter than the matrix material and are mostly coarser grained. The matrix is composed of plagioclase and pyroxene minerals intermixed with other fine-grained minerals. The clasts, on the other hand, are mainly plagioclase or a mix of plagioclase and pyroxene minerals with relatively few accessory minerals such as chromites, ilmenites, and quartz grains.

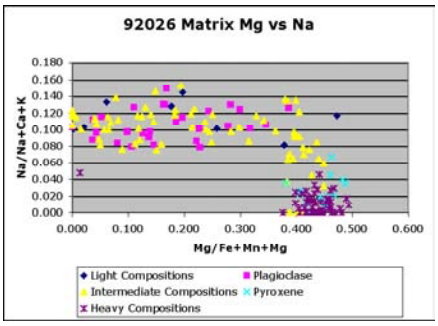
Most feldspar grains in the clasts have the same An numbers as the matrix, with An_{89-91}, but some clasts are more sodium-rich and cluster at An_{87}. Pyroxenes in the matrix vary with higher Wo and En concentrations as compared to the pyroxenes in the clasts. Pyroxenes in the clasts cluster at Fs_{47-56} (with values in the low- to mid-fifties being the most common) and Wo_{10-15} while those in the matrix extend out to Fs_{47} and up to Wo_{20}. The majority of the clasts have pyroxene compositions that fall on vertical tie lines connecting Wo_{08-16} except for some clasts which have, on average, Wo_{12} and Fs_{55-63}. When Mg/Fe+Mn+Mg values are plotted against Na/Na+Ca+K, plagioclase data points show Na/Na+Ca+K values ranging from 0.08-0.1 with Mg/Fe+Mn+Mg ranging from 0.00-0.40, and pyroxene data points center around Mg/Fe+Mn+Mg values from 0.35-0.45 with very low Na/Na+Ca+K amounts.



EET 92026,4: Sample 92026 has a dark, fine-grained matrix with lighter medium sized grains surrounding lighter, medium- to coarse-grained clasts. Mixes of plagioclase and pyroxene grains comprise most of the matrix, and the clasts are mostly well-developed pyroxene and plagioclase grains. Some plagioclase grains in the clasts show zoning, and thin exsolution bands are visible in the pyroxene grains. Quartz grains and ilmenites are also present in this meteorite.

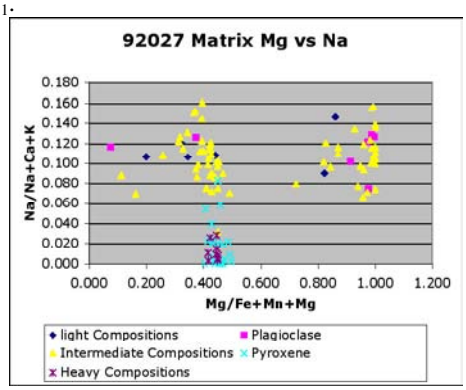
The An-content of the clasts and matrix peak at An_{87} and An_{89}, with the clasts having slightly lower An values. The pyroxenes in the clasts and the rock have compositions near Wo_{10-14} with iron content ranging

from Fs_{44-51}. Na/Na+Ca+K values range from 0.10 to 0.14 and Mg/Fe+Mn+Mg values range from 0.00 to 0.40 for most plagioclase grains. Pyroxenes plotted had Na/Na+Ca+K values from 0.00 to 0.05 and cluster around Mg/Fe+Mn+Mg values from 0.40 to 0.50.

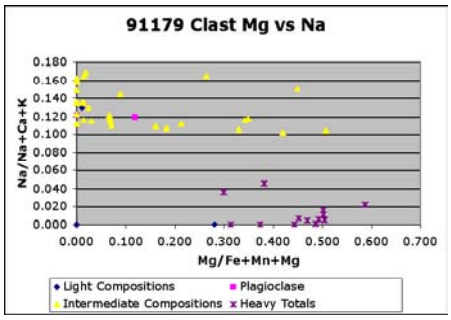


EET 92027,5: Sample 92027 has a dark, fine-grained matrix with lighter pyroxene grains and clasts. Clasts are medium- to coarse-grained. In addition to plagioclase and pyroxenes, quartz grains were also found in this sample. An content of the plagioclase grains in the matrix range from An_{87-90}, but the An content in the plagioclase grains in the clasts cover An values of An_{81-95}. Plagioclases in the matrix show An_{87} is the most common; clast plagioclases have two maximum values of An_{88} and An_{93}.

Mg/Fe+Mn+Mg values have a bimodal distribution with the majority of the Mg/Fe+Mn+Mg points from the plagioclase grains and grains intermediate between plagioclase and pyroxene compositions falling between 0.40-0.45 and 0.90-1.00. Pyroxenes plotted on this graph show Mg/Fe+Mn+Mg values between 0.40 and 0.45 and Na/Na+Ca+K values between 0.60 and 0.00. Pyroxenes also have wollastinite values ranging from Wo_{10-16} and ferrosilite values from Fs_{44-51}.



PCA 91179,9: This is a medium-grained sample with well-developed plagioclase grains in both the matrix and clasts. Quartz grains and iron grains are also present in the sample. Clasts are optically lighter than the surrounding matrix. Plagioclase grains in the matrix are slightly less An-rich than the clasts. The grains in the matrix have An values of An_{81} and An_{85}, while the plagioclase grains in the clasts cluster around An_{87-88}. The matrix has Mg/Fe+Mn+Mg values near 1.00, whereas the highest Mg/Fe+Mn+Mg value is 0.80 and the majorities are between 0.00-0.40.



Discussion: The samples included in this study differ in composition, texture, and color. These differences may be the result of planetary processes acting on the body of Vesta. There are two groups of pyroxene variations—pyroxenes such as those in EET 92025 fall along a tie line, whereas other pyroxene compositions either cluster around a central value like EET 92003 or vary horizontally such as samples EET 92026 and EET 92027. Plagioclase composition also varies from sample to sample. Some samples like EET 92026, EET 92027, and PCA 91179 show higher An numbers in the clasts compared to the matrix whereas EET 92025 has lower An numbers in the clasts compared to the matrix. These compositional differences can be directly attributed to differences in source material derived from planetary processes on the surface of the planet. More work involving these and other samples is needed to accurately determine what the nature of these differences is and how widespread they are across the surface of the body.

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