A PRELIMINARY REPORT ON THE ACHONDRITE METEORITES IN THE 1979 U. S. ANTARCTIC METEORITE COLLECTION

Arch M. Reid

Department of Geology, University of Cape Town, Rondebosch, South Africa

and

Roberta Score

Northrop Services, Inc., P.O. Box 34416, Houston, Texas 77034, U.S.A.

Abstract: The 1979 U.S. Antarctic meteorite collection comprises 73 meteorites, 7 of which are achondrites. The achondrite collection consists of one eucrite (390 g), three polymict eucrites (86; 310; 451 g), one howardite (716 g), one shergottite (7.9 kg), and one diogenite (2.8 kg). Also present in the 1979 collection is a unique iron meteorite (10 kg) with abundant silicate (orthopyroxene) inclusions.

The most interesting meteorite is the shergottite in which two distinct lithologies are joined along what appears to be an undisturbed igneous contact. The fine grained lithology present at one end of the sample is texturally and mineralogically similar to Shergotty but is finer grained. The major portion of the meteorite consists of large complex zoned pyroxenes in a groundmass of pyroxene and maskelynite. The overall pyroxene to feldspar ratio is higher than in the Shergotty-like portion and the pyroxenes are more Mg-rich and Ca-poor. Plagioclase has been converted to maskelynite in both lithologies and glass veinlets and pockets of black glass occur throughout the meteorite.

Five of the seven achondrites were found in a new collection site, Elephant Moraine (EET). This site will be further investigated in the future.

1. Introduction

Seventy-three meteorite samples were collected in Antarctica during the austral summer of 1979–80. Fifty-three of these samples were collected from Allan Hills (ALH) and ten from Reckling Peak (RKP), both previously searched sites (Cassidy *et al.*, 1980). Ten samples were found in a new collection site, Elephant Moraine (EET). The meteorites range in mass from 2 g to 10000 g.

The meteorites were shipped to the Meteorite Processing Laboratory at the Johnson Space Center in Houston, Texas in April, 1980. All 73 samples have been unpacked and initial processing is complete. Preliminary descriptions of the achondrite meteorites were presented at the La Jolla meeting of the Meteoritical Society (King *et al.*, 1980). Processing of the samples to provide allocations to interested scientists is now underway and the first detailed studies of the achondrites will begin in the near future. The meteorite descriptions reported here are based on preliminary examination of the actual samples and on petrographic study of a limited number of thin sections.

Of the 53 Allan Hills meteorites, 52 are chondrites and one, ALHA79017, is a polymict eucrite (for definition see TAKEDA *et al.*, 1980). Ten samples from Reckling Peak are chondrites except for an iron meteorite with silicate inclusions (RKPA79015). At the Elephant Moraine site, 4 chondrites and 6 achondrites were collected. The achondrites comprise 1 shergottite, 1 diogenite, 1 eucrite, 2 polymict eucrites and 1 howardite.

The 1979 achondrite collection thus contains 7 meteorites. One of these is a unique shergottite containing two different lithologies (EETA79001), one is a diogenite (EETA79002), three are polymict eucrites (ALHA79017, EETA79005, EETA79011), one is an eucrite (EETA79004), and one is a howardite (EETA79006).

The individual achondrite samples are described in the remainder of this paper. Detailed studies of these meteorites have not yet begun and the data reported here are preliminary descriptions based on examination of the bulk sample and, in most cases, of a single thin section.

2. Individual Achondrite Descriptions

2.1. ALHA79017–polymict eucrite

This 310 g sample, partly covered by black fusion crust, is similar to the eucrites in the 1976, 1977 and 1978 collections from the Allan Hills area. Parts of the meteorite not covered by fusion crust comprise a fine-grained gray breccia with a variety of angular mineral and rock clasts generally 1 mm or less in size. A few larger clasts up to 1.2 cm, were exposed on chipping (Fig. 1).

Examination of a single thin section (Fig. 2) shows that monomineralic pyroxene and feldspar clasts are abundant, ranging in size from extremely fine grains up to 2 mm. All pyroxenes analyzed are pigeonites with a range of compositions from $Wo_6En_{66}Fs_{28}$ to $Wo_8En_{41}Fs_{52}$ (Fig. 3). More extensive analyses may well extend this range. The analyzed pyroxenes thus show a range of Mg/Fe ratios with a limited spread in Ca contents and no obvious development of exsolution. Individual pyroxene grains appear homogeneous and some show evidence of deformation. Some of the larger pyroxene grains have distinct rims approximately 0.03 mm wide. The rims are more iron-rich than the bulk of the pyroxene grain ($Wo_7En_{40}Fs_{53}$ rim, $Wo_6En_{65}Fs_{29}$ core) and may have formed from an originally homogeneous pyroxene introduced into a more iron-rich matrix. Feldspar clasts also show a range in composition from $Or_{0.1}Ab_{8.4}An_{91.5}$ to $Or_{0.3}Ab_{11.6}An_{88.1}$. The range in composition is extended by the presence in some of the igneous clasts of more sodic feldspars, up to $Or_2Ab_{21}An_{77}$ (Fig. 4).

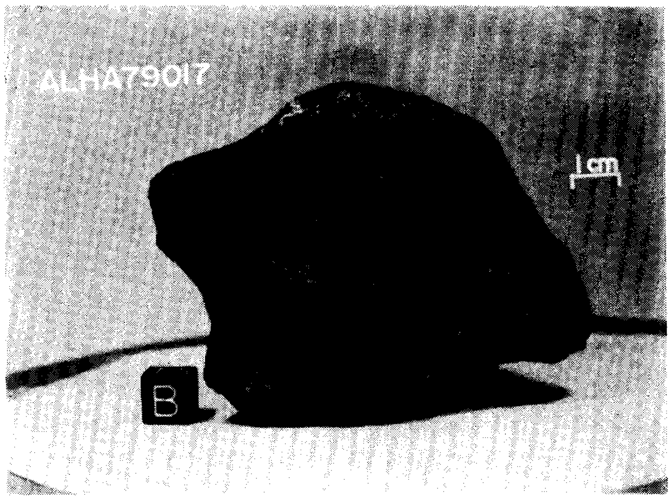
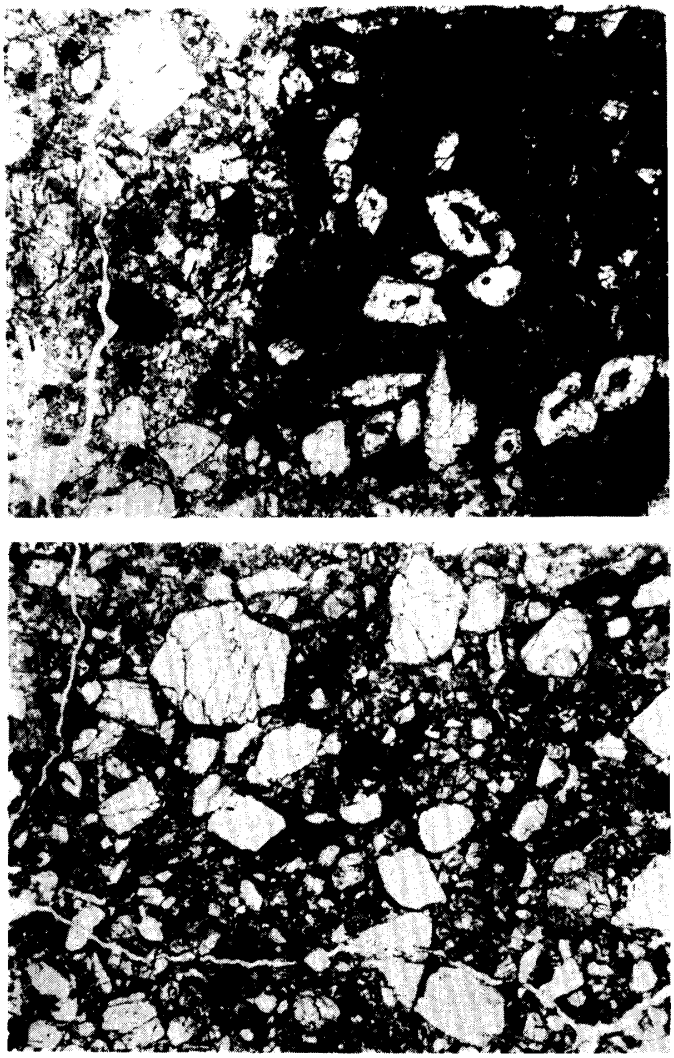


Fig. 1. ALHA79017–polymict eucrite (310 g).



(*a*)

(*b*)

Fig. 2. Photomicrographs of ALHA-79017: (a) pyroxene vitrophyre clast, (b) large rimmed pyroxenes in the breccia matrix. Width of field in all photomicrographs is 3.2 mm.

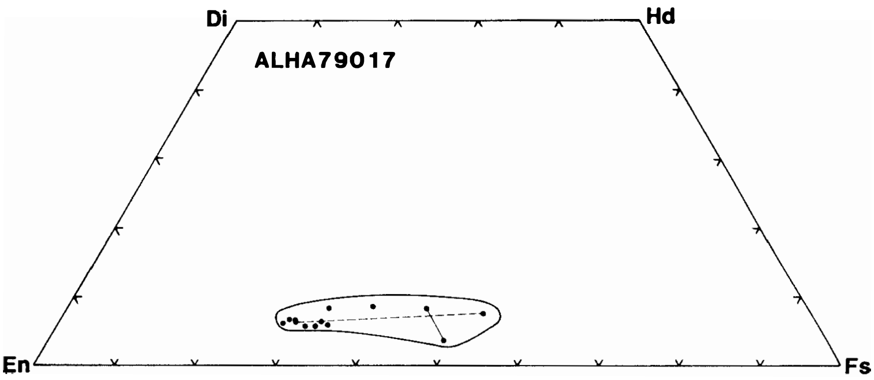


Fig. 3. Pyroxene quadrilateral showing compositions of pyroxenes in ALHA79017. Solid line joins two analyses of pyroxenes from the pyroxene vitrophyre shown in Fig. 2a. Dashed line connects the composition of a large pyroxene in the matrix to that of its thin iron-rich outer rim.

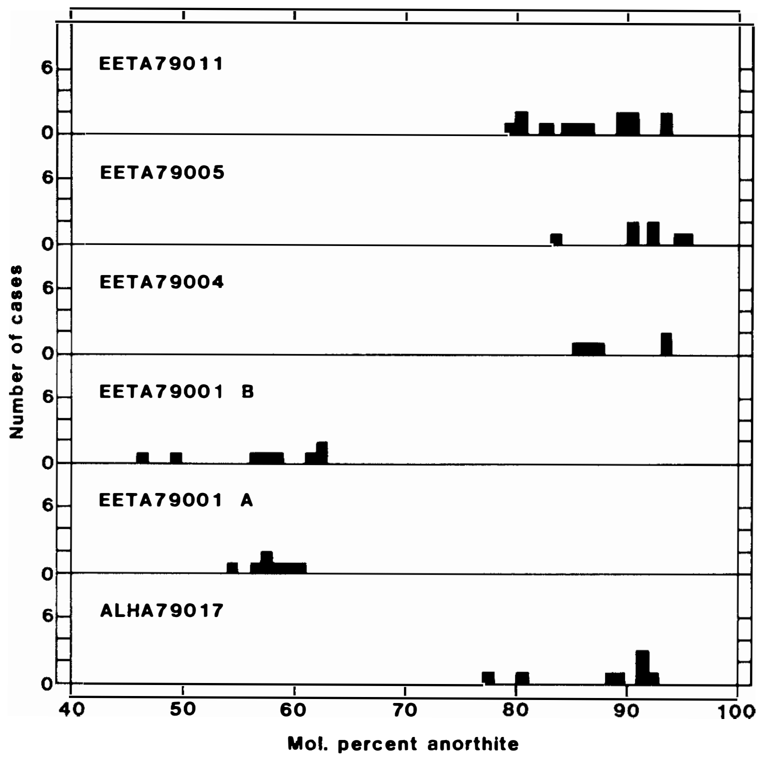


Fig. 4. Histogram of plagioclase compositions for some of the meteorites described in the text. EETA79011, EETA79005 and ALHA79017 are polymict eucrites: EETA79004 is a eucrite: EETA79001 A and B are parts of a shergottite.

The meteorite contains a variety of lithic clasts several of which are angular fragments of eucrite basalt with igneous textures and grain size around 0.3 mm. In addition, and in common with other Allan Hills eucrites (ALHA76005, 77302, 78040, 78132, 78158, 78165) there are dark aphanitic clasts with pyroxene-feldspar intergrowths that are extremely fine grained so that the clast appears almost opaque in normal thickness sections. There also are two types of clast in ALHA79017 that are not common in the other Antarctic eucrites. One type is a clinopyroxene vitrophyre (Fig. 2a) with euhedral to skeletal pyroxenes up to 0.6 mm in length set in extremely fine grained pyroxene plus feldspar matrix. The pyroxene phenocrysts are pigeonites, $Wo_4En_{48}Fs_{49}$, with more calcic rims. A clast of this type was described in Yamato-75011 by TAKEDA *et al.* (1979). The second unusual clast type is a rare fine grained clast with feldspar more abundant than pyroxene.

The general petrographic characteristics of ALHA79017 (particularly the fine grain size, the dominance of mineral fragments, the small size of clasts, the preponderance of eucrite fragments in the lithic clasts, and the range in mineral compositions and textures) are very similar to those of the other Allan Hills polymict eucrites (*e.g.*, MIYAMOTO *et al.*, 1979, REID and SCHWARZ, 1980). Distinguishing features of ALHA 79017 are the rimmed pyroxene grains and the presence of pigeonite vitrophyre clasts. No pyroxene grains or igneous clasts were noted to show any evidence of slow cooling (*e.g.*, well-developed exsolution, very large grain size).

2.2. *EETA79001-shergottite*

EETA79001 is classified as a shergottite: it is not identical with any of the other three members of this class (Shergotty, Zagami, ALHA77005) but appears to be closely related to this group and is distinctly different from any other meteorite class. At 7942 g it is easily the largest stony meteorite in the 1979 collection. Most of the surface is covered by black fusion crust and there is a large deep fusion crust covered regmaglypt (Fig. 5). Most interesting is the presence of a distinct contact between two contrasting lithologies at one end of the sample. The approximately planar contact shows no evidence for movement along the contact plane and appears to be the first recorded example of a large-scale igneous (not breccia) contact between contrasting but related lithologies (Fig. 6). The interior of the meteorite is gray and the main mass (lithology A) consists of large pyroxene grains, up to 5 mm, in a fine-grained matrix. The second rock type present, lithology B, makes up about 10–15 percent of the rock and consists of a fine grained pyroxene-feldspar intergrowth. Both lithologies are crisscrossed by very thin black glass veinlets which are abundant in the meteorite. A third type of material (lithology C), present most abundantly within the main mass (lithology A), is a series of dark inclusions (Fig. 6). These rounded dark regions within the meteorite consist of black glass with mineral inclusions and commonly contain rounded gas cavities. Glass veinlets are more abundant adjacent to the black glass inclusions and the glass veinlets in many cases join up with the larger glass volumes of the in-

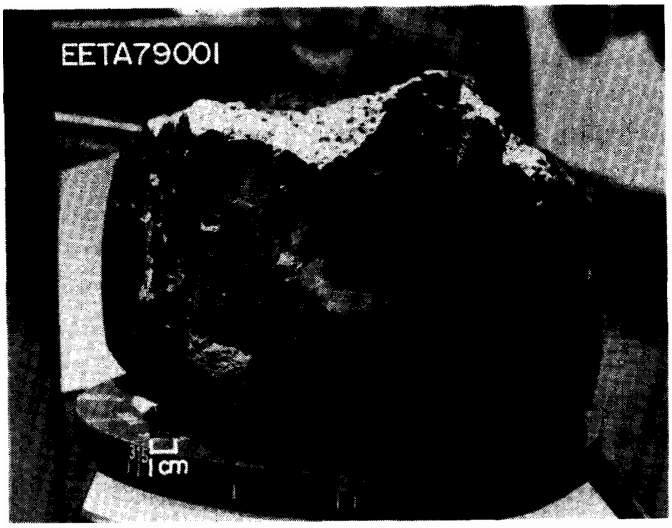


Fig. 5. EETA79001–shergottite (7.9 kg).

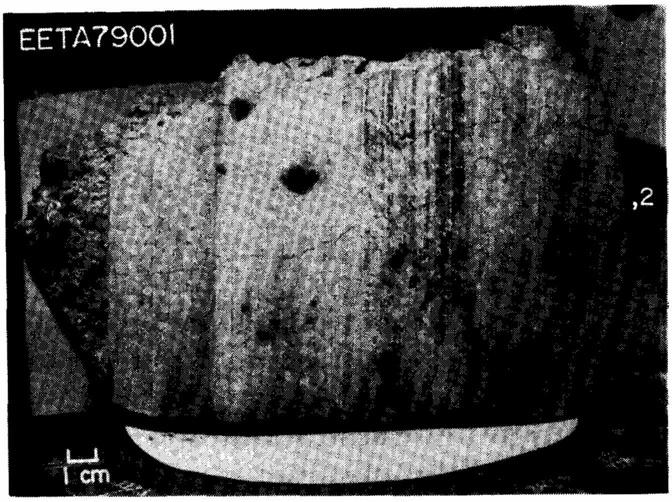


Fig. 6. Interior of EETA79001 after sawing. The contact between the two major lithologies is nearly vertical at the left hand side of the sample just at the termination of the saw cut. The main mass (lithology A, see text) has larger pyroxene crystals (light colored areas) than the fine-grained portion (lithology B) at the extreme left hand side. Dark areas in the sample are pockets and veinlets of dark glass.

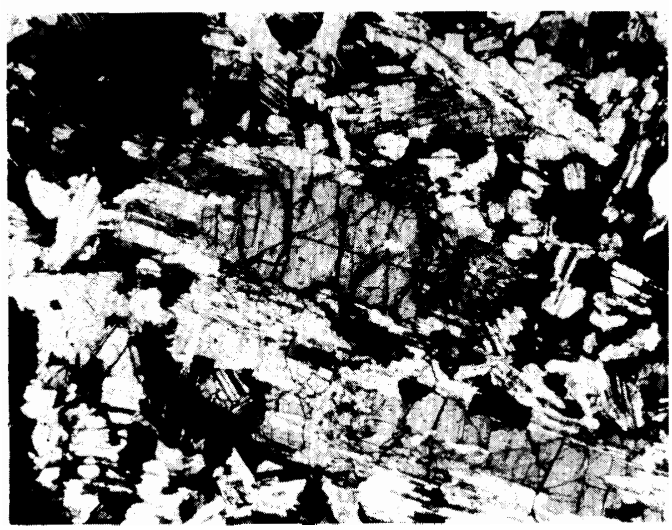


Fig. 7. Photomicrograph of lithology A in sample EETA79001. Medium gray areas (left center and lower right) are pyroxene. The untwinned core is zoned outward to multiply twinned pigeonite (light area). Dark grains within this pyroxene are chromites. The groundmass around the large pyroxene comprises twinned pigeonite (light areas) and maskelynite (dark areas). Crossed nicols.

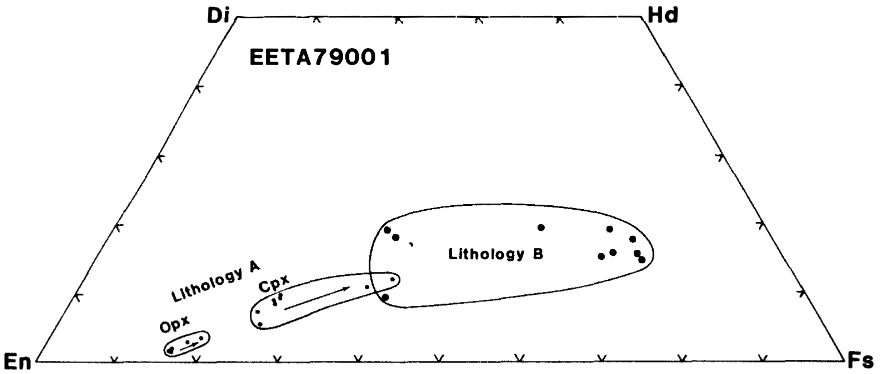


Fig. 8. Pyroxene quadrilateral showing the compositions of pyroxenes in EETA79001. Small circles represent lithology A: analyses marked Opx are the cores of large pyroxenes, those marked Cpx are the margins of large pyroxenes plus pyroxenes in the groundmass. Large circles represent lithology B.

clusions. Some black glass inclusions have sharp rounded boundaries, and separate easily from the surrounding matrix. Others have less well-defined borders and grade into the surrounding material through marginal regions unusually rich in glass veinlets. The whole sample then consists of two different but related igneous lithologies joined along an apparently undisturbed contact. Within each are a series of secondary black glass veinlets which in many cases are continuous with amoeboid-shaped patches of black glass.

Thin sections were cut from all three lithologies. The main mass (lithology A) is a pyroxenite that also contains maskelynite, Mg-Al chromite, iron sulphide and ilmenite (?). The large pyroxene grains, which do not show any obvious preferred orientation, are in large part untwinned orthopyroxenes more magnesian and less calcic than pyroxenes in Shergotty or Zagami (Fig. 7). Orthopyroxene forms the cores of these larger grains and is zoned outward with increasing Fe and Ca ($Wo_{1.5}En_{83}Fs_{16}$ to $Wo_3En_{78}Fs_{19}$). Orthopyroxene gives way to clinopyroxene with further increase in Fe and Ca towards the outer margin of the larger pyroxene grains somewhere between Mg/Mg+Fe 0.8 and 0.74 and around Wo_5 (Fig. 8, *cf.* Fig. 8 in TAKEDA *et al.*, 1979). The outer margins of the larger pyroxenes are polysynthetically twinned pigeonite: the habit is like that of twinned clinobronzite in chondrites. Twinned pigeonites ($Wo_5En_{70}Fs_{25}$ to $Wo_{12}En_{50}Fs_{38}$) make up the outer margins of the larger zoned pyroxene grains and are a major component of the finer-grained groundmass (0.3 to 1 mm) of lithology A. In the groundmass the zoned pigeonite is intergrown with maskelynite which also is zoned from $Or_1Ab_{39}An_{60}$ to $Or_{1.5}Ab_{44}An_{55}$. The meteorite containes several areas in which large olivine grains (up to 2.5 mm) are present (Fig. 9). The preliminary examination suggest olivine, which is Fo_{77} to Fo_{73}, is more common in the areas near the black glass inclusions. Shock effects are apparent in the transformation of the plagioclase to maskelynite, in the fracturing of pyroxene, in the deformation of the

Fig. 9. Photomicrograph of EETA 79001 showing an olivine-rich portion of lithology A. Section is broken into several pieces but does show large olivine grains (light areas) in a groundmass of twinned pigeonite and maskelynite (dark). Crossed nicols.

Fig. 10. Ordinary light photomicrograph of lithology B in EETA79001. Major phases are pigeonite and maskelynite (clear laths).

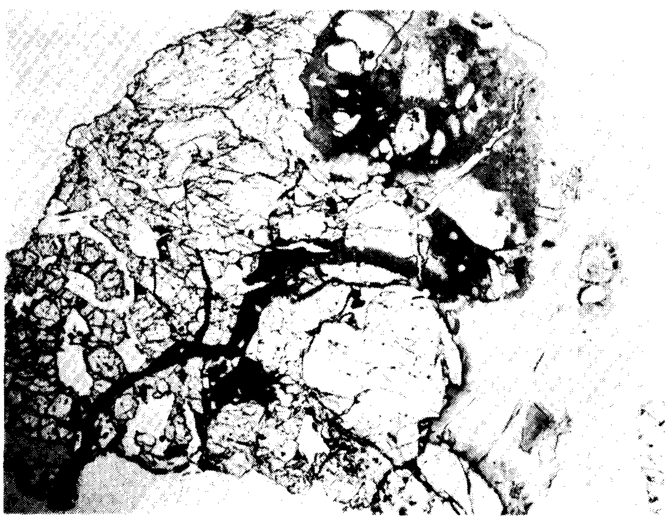


Fig. 11. Photomicrograph of a fragment chipped from one of the glass inclusions in EETA 79001. Note both clear and colored glass with mineral inclusions, on the right. The glass is continuous into a thin glass veinlet (lower left). Minerals adjacent to and included in the glass are pyroxene, maskelynite and olivine.

olivine and in the presence of glass.

The less abundant lithology (lithology B) is texturally similar to Shergotty but finer grained (Fig. 10). Pigeonite and plagioclase, converted to maskelynite, are intergrown in a subophitic texture that closely resembles Shergotty. Laths of maskelynite and elongate pigeonite grains are in subparallel alignment. Calcium phosphate, an SiO_2 polymorph, ilmenite (?) and magnetite (?) are also present. The pigeonites are strongly zoned ranging from $Wo_{15}En_{63}Fs_{21}$ to $Wo_{18}En_{15}Fs_{67}$ (Fig. 8). This resembles the low calcium pigeonite trend in Shergotty pyroxenes (*e.g.*, BINNS, 1967) but it is significant that to date no higher Ca clinopyroxenes, equivalent to the high Ca augite-ferroaugite trend in Shergotty, have been found*. Maskelynite also shows a compositional spread from $Or_{0.5}Ab_{38}An_{62}$ to $Or_4Ab_{50}An_{46}$.

The dark rounded inclusions (lithology C) are glass (Fig. 11) containing a few large or numerous small vesicles and relict grains of minerals equivalent to those in the surrounding matrix (pyroxene, maskelynite, olivine). In some regions devitrified glass rather than glass is present and in other areas highly vesicular regions with fine quench textures occur. The glass inclusions appear to represent melting of the local rock type as is evident by the relict mineral grains in the glass. The melting may have taken place in situ as there does appear to be a gradient in shock intensity increasing toward the glass inclusions. The glass in the inclusions is continuous with that in the glass veinlets which also are more abundant near the glass inclusions (Fig. 11).

Lithology B is very similar in mineral assemblage and in texture (though substantially finer grained) to the Shergotty meteorite. Like Shergotty it appears to have crystallized in a more oxidizing environment than most other meteorites, and to have undergone a complex history involving shock transformation of feldspar to maskelynite and possibly shock melting.

Lithology A has many of the same phases as lithology B but is much more pyroxene rich, has more magnesian pyroxenes and also has olivine present. The nature of the contact between the two lithologies has not yet been studied in detail. It does appear that these are two genetically related igneous rocks, with lithology A being perhaps an earlier member of the sequence, which have undergone a similar post-crystallization history. The textures, minerals and composition relate EETA79001 to the other members of the shergottite class. The young ages of Shergotty ($\sim$620 m.y., NYQUIST *et al.*, 1979) and the other shergottites have raised interesting questions as to (1) the possible heat sources for igneous activity relatively late in solar system history and (2) the nature and location of the shergottite parent body. The availability of a new large shergottite containing two related lithologies should provide new information relevant to these intriguing puzzles.

2.3. *EETA79002–diogenite*

EETA79002 is a large meteorite (2843 g) covered by a black fusion crust ex-

* MCSWEEN and REID (1981) report augite in addition to pigeonite.

Fig. 12. EETA79002–diogenite (2843 g).

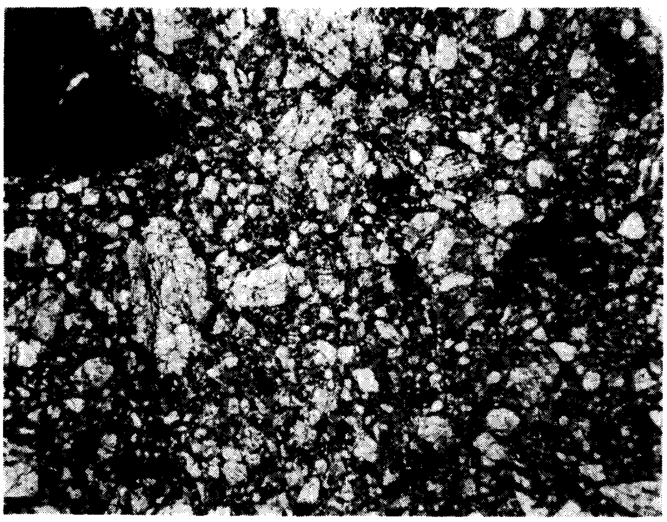


Fig. 13. Photomicrograph of EETA 79002 showing the brecciated matrix dominated by orthopyroxene fragments, an aphanitic clast (top left) and an area with abundant small opaque phases (center right).

cept on one fractured surface (Fig. 12). The interior is gray and oxidized to red-brown in several areas. Chipping through an orangish-brown weathering rind in places 1 cm thick reveals an unusual blue-gray fresh interior. Thin section study shows that the meteorite is a breccia with a very cohesive fine-grained matrix (Fig. 13). The clasts are monomineralic, highly angular and small, ranging up to 2 mm. These fragments are low calcium pyroxenes of nearly constant composition, $Wo_2En_{76}Fs_{22}$. Magnesian olivine, Fo_{75-76} is present in minor amounts. The preponderance of pyroxene and its composition place this meteorite in the class of diogenites. With its very finely brecciated texture it is unlike the common diogenites which carry large pyroxene fragments and also unlike the recrystallized textures recorded from several Antarctic diogenites (Takeda *et al.*, 1978). EETA79002 also is unusual in having small areas within the breccia that are rich in very fine opaque minerals and in showing

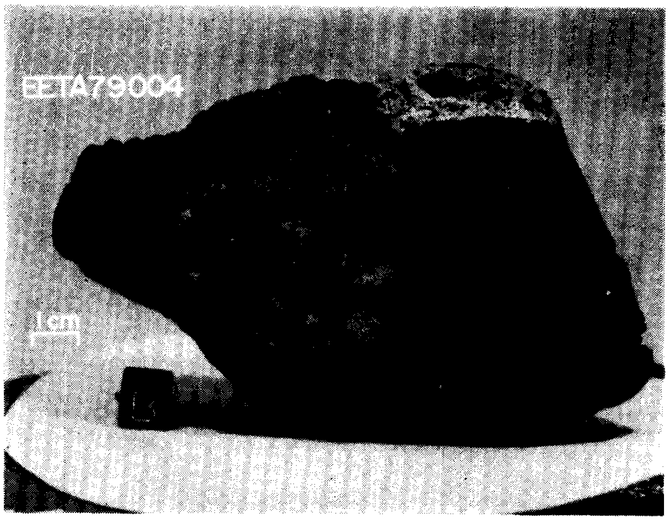


Fig. 14. EETA79004-eucrite (390 g). Note abundant vugs on surface.

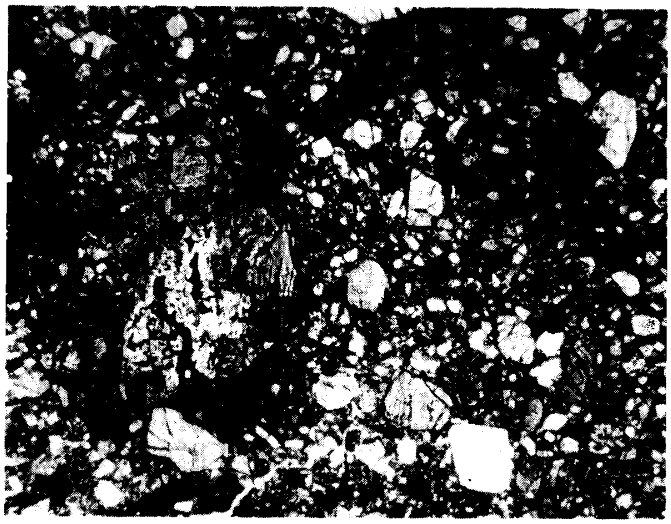


Fig. 15. Photomicrograph of EETA 79004 showing a lithic clast (center left) that may have undergone some reheating and the dark fine-grained, possibly recrystallized matrix.

at least one clast that is very fine-grained but apparently polymineralic (Fig. 13).

2.4. *EETA79004–eucrite*

EETA79004 weighs 390 g and is covered on all but two sides by a thin dull fusion crust (Fig. 14). Irregular vugs, prominent in the area devoid of fusion crust, are as deep as 1 cm and as wide as 0.5 cm. The interior consists of a gray matrix and a variety of clasts up to 2 cm in size. The meteorite is rust stained in several spots. None of the larger clasts show up in the one thin section cut from this sample. As with the other eucrites the sample is a breccia with generally small clasts in a very fine grained matrix. Monomineralic pyroxene and feldspar clasts predominate and lithic clasts are less common. Portions of the matrix are very dark and may have recrystallized. While most of the clasts are angular some of them have less well-defined

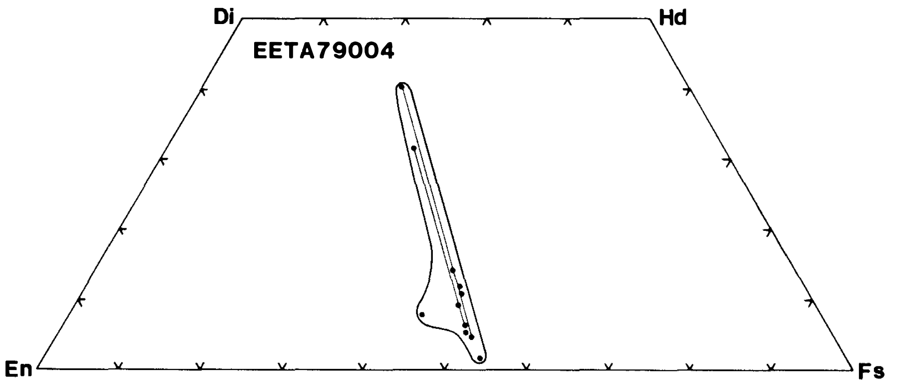


Fig. 16. Pyroxene quadrilateral showing the composition of pyroxenes in EETA79004. Tie lines connect lamallae composition in exsolved pyroxenes.

rims and partly grade into the matrix. There is thus a suggestion of reheating affecting portions of the breccia (Fig. 15).

Mineral fragments range in size from very fine material up to approximately 1.3 mm. In addition to pyroxene and feldspar a few of the larger grains are opaque. Pyroxenes embrace a range of Ca contents with little difference in Mg/Fe ratio: this range is in large part generated in electron probe microanalysis, using a small beam diameter, of pyroxene grains that have exsolved into Ca-poor and Ca-rich lamellae. The pyroxene analyses range from $Wo_2En_{45}Fs_{53}$ to $Wo_{40}En_{36}Fs_{24}$ with a preponderance of values at the low Ca end of the range (Fig. 16). Feldspar compositions show some variation, from $Or_1Ab_6An_{93}$ to $Or_1Ab_{14}An_{85}$. Lithic clasts present in the section studied are angular and of two major types; (1) fine grained eucrite clasts with igneous textures that range in size up to 2.5 mm, (2) dark aphanitic fragments that appear to consist of extremely fine pyroxene and feldspar in subparallel growth.

The characteristic features of EETA79004 are the somewhat tenuous evidence of reheating and recrystallization and the common presence of exsolution in the pyroxenes. The overall texture and nature of the clasts resemble the textures of the Allan Hills polymict eucrites. However the small number of pyroxenes analyzed show almost no variation in Mg/Fe ratio. On this evidence the meteorite is classified as a eucrite (monomict equilibrated eucrite) rather than a polymict eucrite. Further studies will document whether the meteorite is truly monomict and should also allow detailed work on the larger clasts.

2.5. EETA79005–polymict eucrite

This 451 g sample has a polygonally fractured fusion crust on one surface (Fig. 17). The interior consists of a gray matrix with abundant small clasts (up to 5 mm) ranging from white to black in color. As with the other eucrites in the collection the clasts are small and angular and pyroxene and feldspar clasts predominate (Fig. 18). The larger mineral fragments (up to 1.2 mm) commonly show evidence of deformation and several of the larger pyroxenes show exsolution lamellae. All the pyroxenes

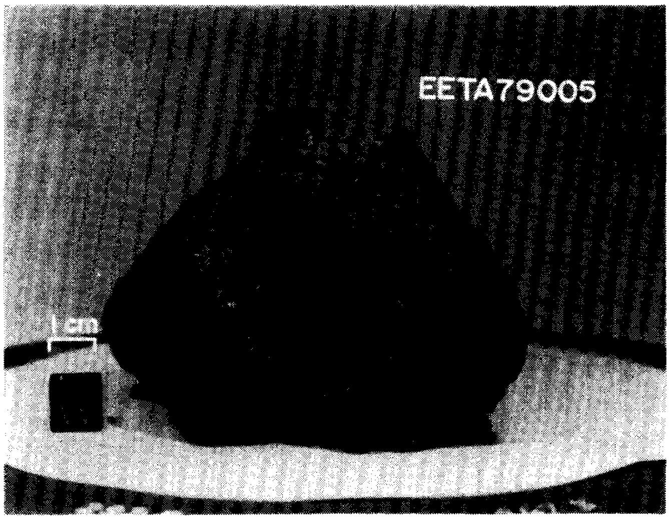


Fig. 17. EETA79005–polymict eucrite (451 g).

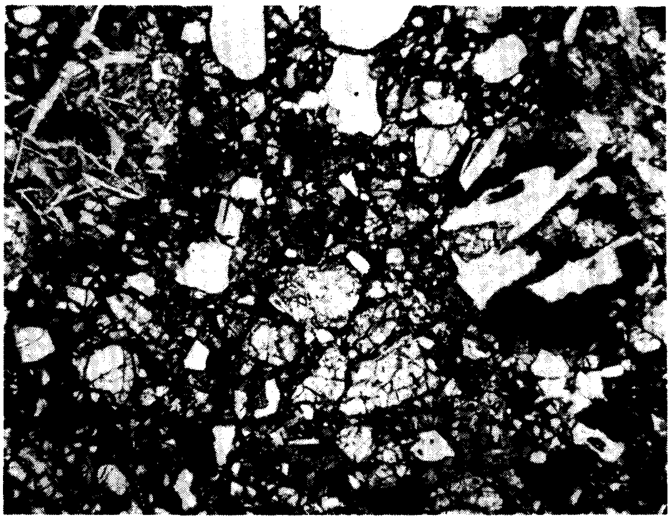


Fig. 18. Photomicrograph of EETA-79005 showing a range of eucrite and mineral clasts.

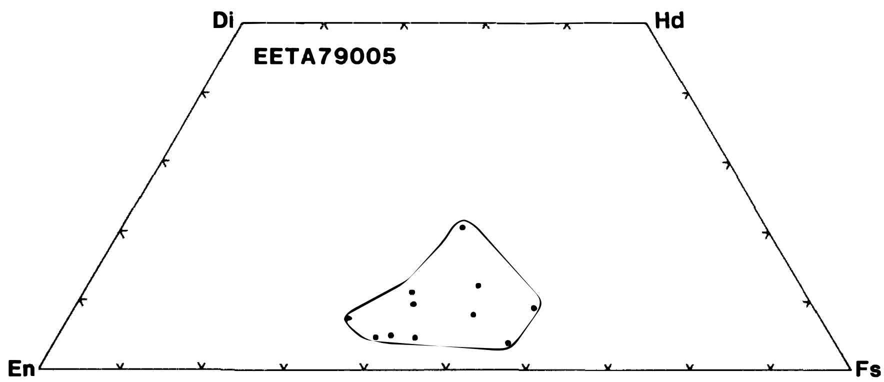


Fig. 19. Pyroxene quadrilateral showing the composition of pyroxenes in EETA79005.

analyzed are pigeonites (Fig. 19) with a range of Ca contents and Mg/Fe ratios ($Wo_7En_{59}Fs_{34}$ to $Wo_{14}En_{35}Fs_{52}$). A spectrum of feldspar compositions is also present, from $Or_{0.1}Ab_4An_{96}$ to $Or_{0.7}Ab_{16}An_{83}$.

The most common lithic clast in the thin section is a fine-grained eucrite with basaltic texture, in fragments up to 1 mm. Small dark aphanitic clasts up to 0.7 mm are also present and one 2.1 mm clast has the mineral assemblage of a eucrite in an apparently wholly recrystallized texture. A few small angular fragments of a brown devitrified glass are also present.

The meteorite is a fine grained breccia with small angular clasts which are dominantly pyroxene and feldspar fragments. Lithic clasts are small and are mostly eucrite fragments but with a range of compositions and textures. The sample is classed as a polymict eucrite very similar to the polymict eucrites from the Allan Hills area. Distinguishing characteristics are the number of lithic clasts and the presence of clasts of brown devitrified glass.

2.6. *EETA79006–howardite*

EETA79006 is a 716 g sample that has fusion crust on only part of one surface and has irregular cavities over much of the surface of the meteorite (Fig. 20). It is a breccia with a variety of clasts, up to 1 cm long, set in a fine gray matrix. Rusty oxidation spots are present at several points on the surface. The thin section cut from EETA79006 shows a fine-grained breccia in which angular clasts of pyroxene and feldspar predominate (Fig. 21). Individual mineral clasts range from fine dust size up to 1 mm size fragments of pyroxene, feldspar and opaque minerals. The larger grains are commonly deformed and some of the larger pyroxenes show well developed exsolution textures. Pyroxene grains analyzed show a wide range of compositions from highly magnesian grains ($Wo_1En_{80}Fs_{19}$) to iron-rich pigeonites ($Wo_{15}En_{28}Fs_{57}$). The range of pyroxenes compositions, in this preliminary study, extends to more magnesian values than are common in the Antarctic polymict eucrites and overlaps the range of pyroxenes in diogenite meteorites (Fig. 22). There are a variety of clast types present and these include: eucrite fragments with igneous textures; small fragments up to 2 mm of fine-grained eucrite basalt; a recrystallized eucrite with mosaic texture (4.5 mm); a 2 mm clast with pyroxene more abundant than feldspar; and a 2 mm clast with feldspar more abundant than pyroxene. In addition several fragments, as large as 1 mm, of brown devitrified glass are present in the breccia.

EETA79006 closely resembles the other Antarctic achondrites. It is distinguished by the variety of clast types, by the presence of 'glass' fragments, and by the wide range of pyroxene compositions. It has been classed as a howardite as it is a polymict breccia with a wide range of pyroxene compositions. Unlike the polymict eucrites, the pyroxene compositions extend to highly magnesian values and include pyroxenes that are chemically identical with those in diogenites.

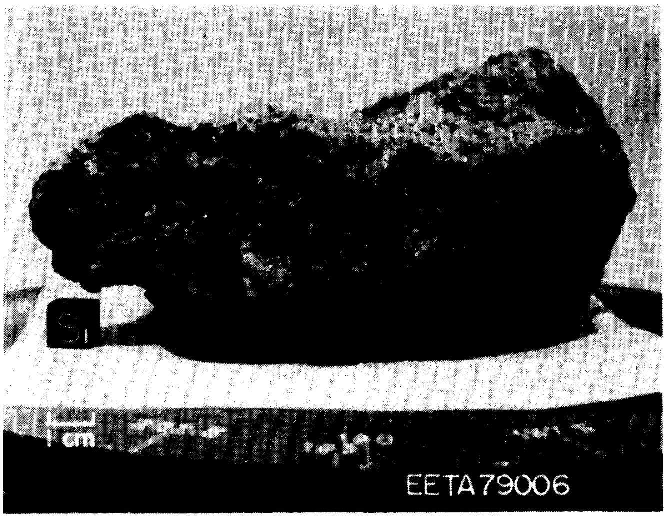
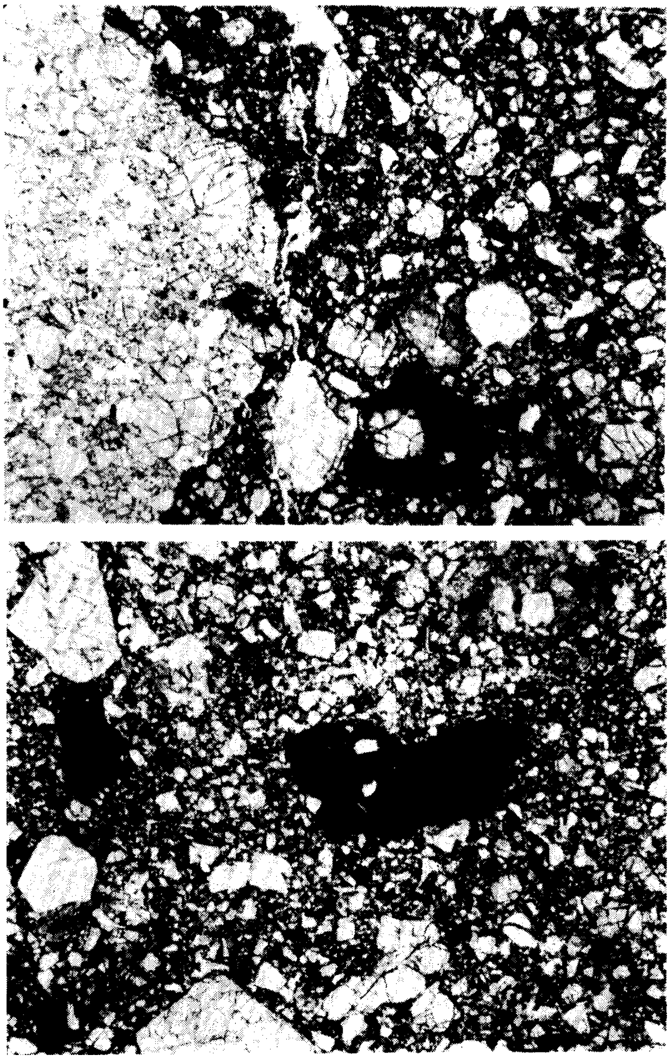


Fig. 20. *EETA79006-howardite (716 g). Note vugs on surface.*



(*a*)

(*b*)

Fig. 21. *Photomicrograph of EETA 79006. (a) Recrystallized eucrite clast (left) in fine breccia matrix. (b) Fragments of brown largely devitrified glass in breccia matrix.*

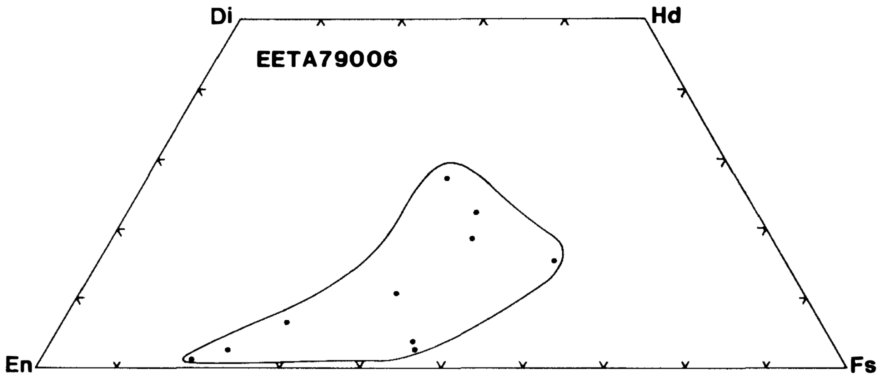


Fig. 22. Pyroxene quadrilateral showing the composition of pyroxenes in EETA79006.

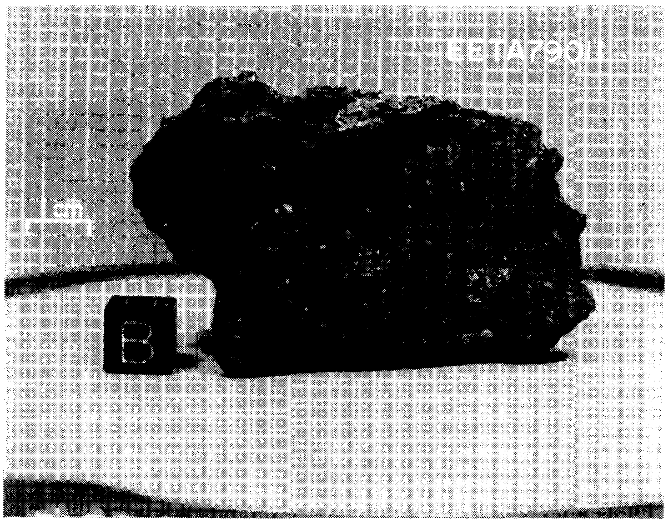


Fig. 23. EETA79011-polymict eucrite (86 g).

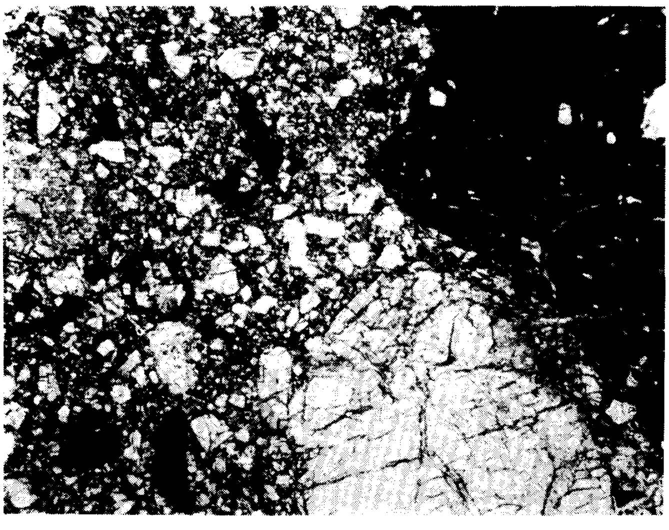


Fig. 24. Photomicrograph of EETA 79011 showing a large pyroxene (lower right), mineral and lithic clasts and part of a clast of dark matrix breccia (upper right).

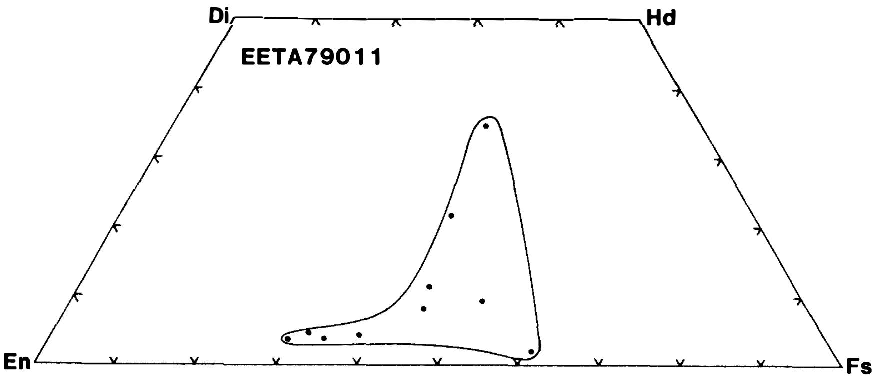


Fig. 25. Pyroxene quadrilateral showing compositions of pyroxenes in EETA79011.

2.7. EETA79011-polymict eucrite

This smaller sample (86 g) is similar in appearance to many of the Antarctic polymict eucrites (Fig. 23). It is medium gray in color with a dull black fusion crust on one surface. A variety of clasts up to 7 mm are visible on the exterior. As with the other eucrite breccias, the thin section reveals a very fine breccia with mineral fragments predominating (Fig. 24). Single pyroxene fragments range up to 2.5 mm. Several of the larger pyroxene grains are deformed and exsolved pyroxenes are fairly common. There is a range in pyroxene compositions (Fig. 25) with the more magnesian pyroxenes all having low Ca contents ($Wo_4En_{67}Fs_{30}$ to $Wo_2En_{37}Fs_{61}$). The more iron rich pyroxenes (approximately $Mg/Mg+Fe<0.5$) show a wide range in Ca contents ($Wo_2En_{37}Fs_{61}$ to $Wo_{35}En_{27}Fs_{38}$). Feldspars also show a range of values from $Or_{0.2}Ab_7An_{93}$ to $Or_{1.5}Ab_{19}An_{80}$. Medium-grained and fine-grained eucrite clasts are generally small, up to 1.6 mm. There also are a number of small clasts, up to 0.6 mm, of pyroxene and feldspar in a granoblastic texture. Fragments of brown devitrified glass are present as angular fragments up to 1.6 mm. EETA79011 is very similar to other polymict eucrites from the Antarctic. Distinguishing characteristics of this breccia are the presence of a number of eucrite clasts with granoblastic textures and the presence of brown 'glass' fragments.

2.8. RKPA79015-iron with silicate inclusions

A brief description of this very interesting meteorite is included here although it is not an achondrite. The highly irregularly shaped sample is approximately $26\times 18.5\times 13$ cm and weighs 10022 g (Fig. 26). The surface is reddish brown, and looks like a slightly weathered iron meteorite except that much of the surface is studded with silicate material. A number of these silicate blebs are apparently single crystals, as cleavage surfaces can be recognized, and some, if not most, are orthopyroxenes. Thus, while a detailed description of the meteorite has not yet been made, the preliminary examination indicates a stony-iron meteorite with orthopyroxene (of the composition of diogenitic orthopyroxene) grains set in an iron matrix, somewhat

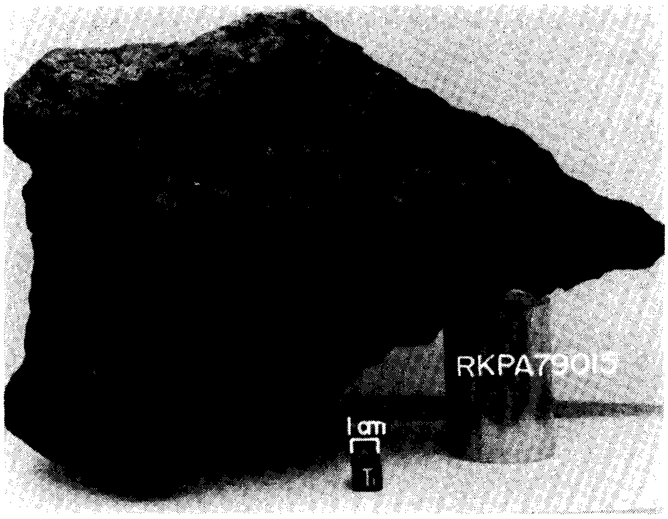


Fig. 26. RKPA79015–iron with silicate inclusions (10 kg). Note light colored silicate blebs on surface.

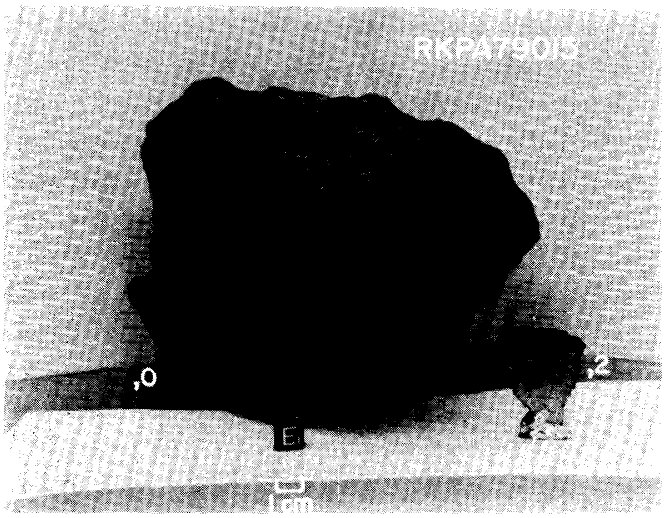


Fig. 27. RKPA79015. Showing slab cut from projecting corner. Note darker silicate material within the slab.

like a pallasite with a lower silicate to iron ratio and with orthopyroxene in place of olivine.

A slice (approximately 5 mm thick) was cut from a protruding portion of the meteorite to check that silicate material was also present in the interior (Fig. 27). The 4×2.5 cm slice is mostly kamacite with less abundant taenite. About ten percent of the slice consists of ellipsoidal to subangular inclusions of troilite, silicate, and troilite plus silicate. The silicate material has the composition of a magnesian orthopyroxene (around $Wo_2En_{73}Fs_{25}$): in some of the inclusions other silicates may be intergrown with the pyroxene. Chromite and schreibersite are also present. These findings are preliminary but are sufficient to indicate that RKPA79015 is probably unique and certainly demands further detailed study.

3. Conclusions

Detailed studies of the 1979 collection are just beginning. Preliminary examination of the returned samples has shown that the 1979 expedition opened up a new collection area that will be of major importance in future achondrite studies. The most exciting single aspect of the 1979 collection is undoubtedly the discovery of a new member of the shergottite group of meteorites. Sample EETA79001 is just under 8 kg and should thus provide ample material for detailed studies. It is unique in that it is made up of two distinct lithologies joined together along what may be the only known example of an undisturbed extraterrestrial igneous contact. The Elephant Moraine region has also provided other basaltic achondrite samples for study. The presence of polymict eucrites at the Elephant Moraine site that are similar to those at Allan Hills and at the Yamato site again raises the question as to why this particular type of achondrite, which is not common in the collections of known achondrites elesewhere in the world, is the most common type of achondrite in widely separated regions of Antarctica.

The 1979 collection also contains a unique iron meteorite with abundant silicate (orthopyroxene) inclusions and a large diogenite that appears to be texturally unique. We look forward to further collections from the Elephant Moraine region and from other parts of the Antarctic Continent.

Acknowledgments

We thank T. V. V. KING, C. SCHWARZ, D. BOGARD, J. ANNEXSTAD, S. FEICHT and E. STOCKTON for their help. Portions of this work were done while one of the authors (AMR) was a National Research Council-NASA Research Associate at the Johnson Space Center and a Visiting Scientist of the Lunar and Planetary Institute, which is operated by the Universities Space Research Association under Contract No. NASW-3389 with the National Aeronautics and Space Administration. This is LPI Contribution No. 436.

References

BINNS, R. W. (1967): Stony meteorites bearing maskelynite. Nature, **214**, 1111-1112.

CASSIDY, W. A., ANNEXSTAD, J. O., RANCITELLI, L. A. and BENDA, L. (1980): Results of the 1979-80 U.S. Antarctic meteorite expedition. Lunar and Planetary Science XI. Houston, Lunar Planet. Inst., 128.

KING, T. V. V., SCORE, R., SCHWARZ, C. M., REID, A. M. and MASON, B.H. (1980): Summary statistics of 1977 and 1978 Antarctic meteorite collections and a glimpse of the 1979 collection (abstract). Meteoritics, **15**, 315.

MCSWEEN, H. Y. and REID, A. M. (1981): Igneous layering in an achondritic meteorite (abstract). Abstracts of the 44th Annual Meeting of the Meteoritical Society, Bern.

MIYAMOTO, M., TAKEDA, H., YANAI, K. and HARAMURA, H. (1979): Mineralogical examination of the Allan Hills No. 5 meteorite. Mem. Natl Inst. Polar Res., Spec. Issue, **12**, 59-71.

NYQUIST, L. E., BOGARD, D. D., WOODEN, J. L., WIESMANN, H., SHIH, C.-Y. and BANSAL, B. M. (1979): Early differentiation, late magmatism, and recent bombardment on the shergottite parent planet (abstract). Meteoritics, **14**, 502.

REID, A. M. and SCHWARZ, C. M. (1980): Antarctic polymict eucrites (abstract). Meteoritics, **15**, 353.

TAKEDA, H., MIYAMOTO, M., YANAI, K. and HARAMURA, H. (1978): A preliminary mineralogical examination of the Yamato-74 achondrites. Mem. Natl Inst. Polar Res., Spec. Issue, **8**, 170–184.

TAKEDA, H., MIYAMOTO, M., ISHII, T., YANAI, K. and MATSUMOTO, Y. (1979): Mineralogical examination of the Yamato-75 achondrites and their layered crust model. Mem. Natl Inst. Polar Res., Spec. Issue, **12**, 82–108.

TAKEDA, H., MIYAMOTO, M. and ISHII, T. (1980): Comparison of basaltic clasts in lunar and eucrite polymict breccias. Proc. Lunar Planet Sci. Conf. 11th, 135–147.

(*Received February 23, 1981*)