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REPORT ON NUMBERED SPECIMEN 378, A PLATY FRAGMENT OF INDURATED TUFF WITH GROOVE-LIKE MARKINGS ON TWO SIDES

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PURPOSE: To examine specimen #378 using methods developed for the study of tephra (volcanic ash), specifically those that might help establish an approximate age for the tephra components, the fragment itself, and, most importantly, for the groove-like markings on the fragment surfaces.

STUDY PLAN:

Give the specimen a general examination with a binocular microscope.

Perform chemical test for allophane.

a. fresh tephra
b. area of reddish stain
c. tephra beneath clay skin
d. waxy clay skin
e. sandy matrix material

Examine specific components with a petrographic microscope

a. fresh tephra
b. tephra beneath clay skin
c. waxy clay skin
d. sandy matrix material

METHODS AND OBSERVATIONS: See attached.

RESULTS AND CONCLUSIONS:

Specimen #378 is composed of weathered fragments of volcanic ash of dacitic composition. It apparently has been fired to a high temperature. The glass has almost completely devitrified and is clouded with small feldspar and opaque phenocrysts. It contains small clinopyroxene crystals (50 µm) that have been etched. It is enveloped in a thick, complex weathering rind composed of concentric zones rich in altered glass, allophane, and layered silicate clay. The groove-like markings occur beneath this weathering rind, and also beneath a reddish stain that may have been caused by firing. They are older than both rind and stain. A sandy matrix coats the weathering rind in some areas. It, too, is highly weathered. The only samples I have examined that show a comparable degree of weathering are samples from central Mexico dated at approximately 250,000 - 300,000 years.

Judging by the extent of weathering of the tephra components, the nature and thickness of the enveloping weathering rind, and the extent of weathering of the adhering sandy matrix, I would suggest that specimen #378 and the groove-like markings upon it are considerably older than 24,000 years and may be as old as 250,000 - 300,000 years.

Virginia Steen-McIntyre
October 15, 1982

GENERAL EXAMINATION

On October 13, specimen #378 was given a general examination for six hours using a Wild stereomicroscope (magnification range x6-x50) and a high-intensity, white-light source. The specimen, a pinkish-gray rock (7.5YR 6/1, dry) mottled with a patchy clay coating, rested on an orange plastic coverlid and was handled as little as possible. During this time, Polaroid photographs and 35mm color slides were taken for documentary purposes (Figure 1a,b), and rough-pencil traces were made of both obverse and reverse surfaces to help the reader visualize the areas of the specimen discussed below (Figure 2a,b).

The general examination was most encouraging. Although the specimen had been roughly handled before its potential importance was recognized, much of the original coating remains, even including areas of sandy matrix material in protected cavities (areas marked I in Figure 2). Whether the sandy matrix is identical to the matrix material from which the specimen was taken, or whether it coated the specimen earlier in its history could not be determined.

Beneath the sandy matrix and, more generally, adhering in patches to all sides of the specimen is a waxy clay coating, light brown to brown in color (7.5YR 6/4-5/4, dry). It is especially pronounced just above the sample identification number, where it forms platelets approximately 1 mm in diameter (area II, Figure 2b). These platelets seem to lie in shallow pits on the fragment surface. They form a protective coating between the fragment and the sandy matrix material. This waxy coating covers the grooved lines, especially on the obverse side of the specimen (Figure 1a; Figure 2, area III). It occurs on the broken surface that terminates the grooves on the reverse side of the specimen near the identification number (near area II, Figure 2b). I believe this material is a weathering product of the tephra itself, probably allophane.

Beneath the waxy clay occurs another coating or alteration product; a red-to-orange-colored stain on the gray surface of the rock. It shows up best on the sides of the specimen, where it appears to concentrate in zones of weakness (higher porosity?). Under x50 magnification, this stain is seen within some of the grooves as well as on either side of them (Figure 2, area IV). I saw no concentration of stain on the broken surface near area II (Figure 2b), or where the specimen had been deeply scratched during prior handling (Figure 2b, area V).

The general microscope examination would suggest the following sequence of events:

tuff fragment	---->	grooves made in some way	---->	weathering (red stain)	---->	corner broken off	---->	formation of waxy clay

(Sandy matrix added sometime after grooves were cut; waxy coating can form <u>in situ</u> beneath sandy matrix.)

The grooves in question were undoubtedly made before the waxy clay coating was formed. They were probably made before most reddish stain was precipitated. I have seen a similar type of weathering sequence (volcanic glass - red stain - waxy clay) in samples of dacitic pumice from Mexico dated 600,000 ± 340,000 years (Steen-McIntyre <u>et al.</u>, 1981, p. 11,15). I have not seen appreciable clay coatings on dacite pumice samples younger than <u>ca</u> 30,000 years, collected from well drained, temperate sites. I cannot recall examining dated samples of pumiceous dacite in the <u>ca</u> 30,000 - 200,000 year range.

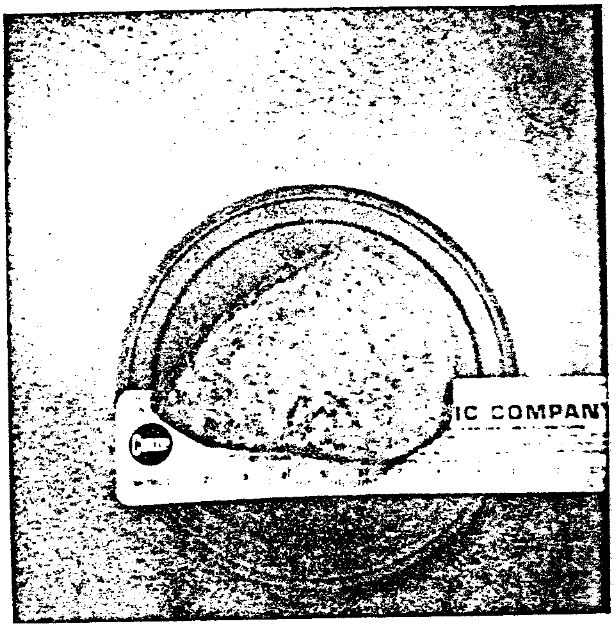


FIGURE 1A

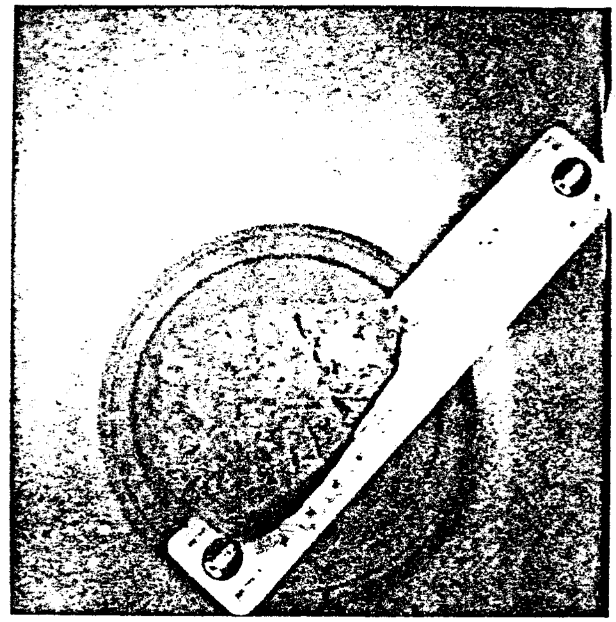


FIGURE 1B

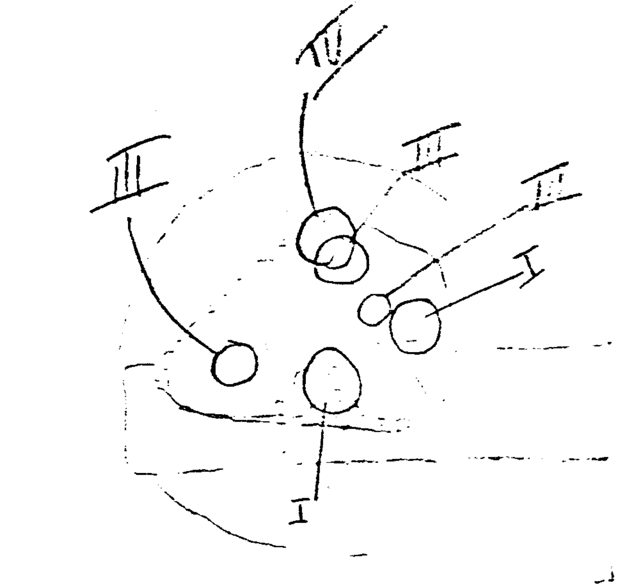


FIGURE 2A

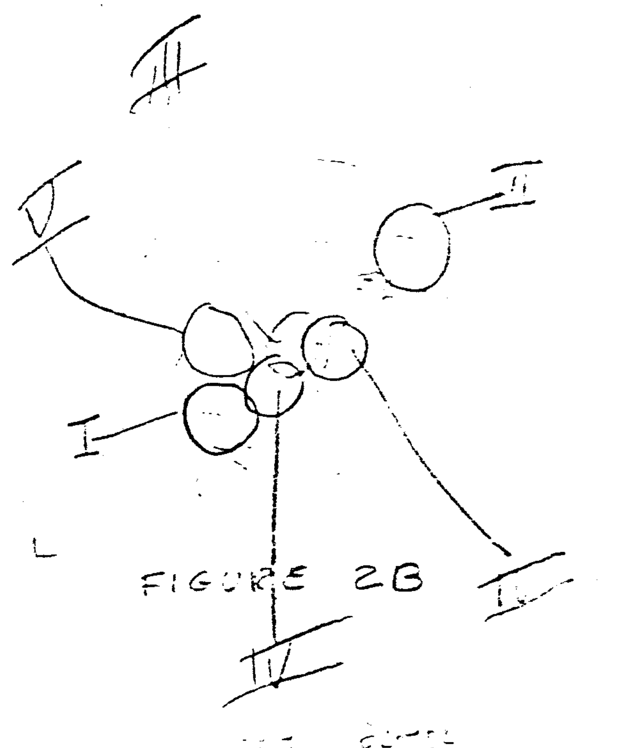


FIGURE 2B

ALLOPHANE TEST

Allophane is one of the first weathering products to form from fresh volcanic glass. Its presence, as well as that of layered silicate clays that form from this intermediate material, can thus give some indication of the age of a specimen.

Samples of tephra components, waxy clay, and matrix material were checked for allophane content using the rapid field method developed by Fieldes and Perrott (1966). For this test, minute samples of sediment are placed on phenolphthalein indicator paper and flooded with a drop of saturated NaF solution. Samples containing appreciable allophane quickly turn the indicator paper red. A pink color indicates intermediate allophane activity. Where little allophane is present, no color is developed. The method works well for subsoils low in alkali that contain no free $CaCO_3$.

Small samples for the allophane test were collected from the following areas of specimen #378:

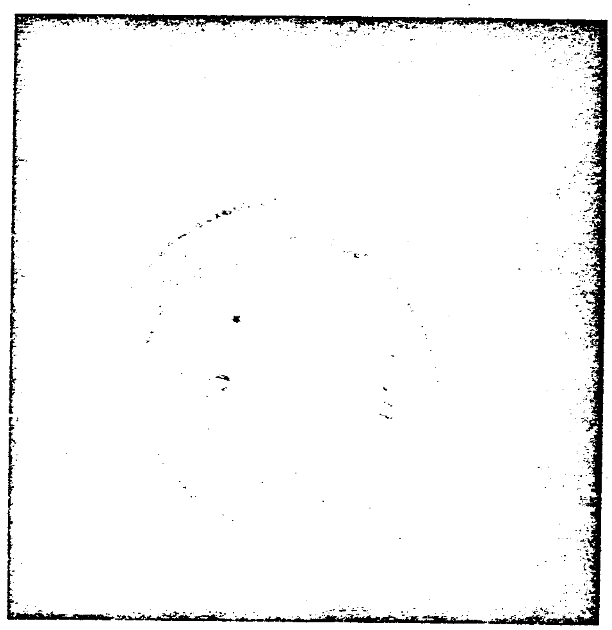
a) sandy matrix Area I, Figure 2b. Material scraped off with the point of a brass safety-pin and transferred with a dissecting forceps.
b) waxy clay Area II, Figure 2b. A small flake of clay was lifted from the surface of the specimen with dissecting forceps. It was 0.5 mm thick.
c) tephra directly beneath clay skin Same as (b). Area scraped with a pair of blunt-nosed forceps and the scrapings transferred with dissecting forceps.
d) red-stained area Side of specimen, in small veinlet. Veinlet scraped with a brass pin and scrapings transferred with dissecting forceps.
e) fresh tephra Area V, Figure 2b. Deepest part of groove scraped with brass pin. Scrapings transferred with dissecting forceps.

The results of the allophane test for the above samples are given in Table 1. The interpretation of the data seems clear. Specimen #378 is covered by a complex weathering rind formed by the breakdown and transformation of fresh volcanic glass through a weathered glass rich in allophane to a waxy silicate clay that still shows some allophane characteristics. The fact that this waxy clay tends to form platelets that curl at the edges suggests a 2:1 expanding lattice clay of the montmorillonite group. Clearly this clay, which covers the grooves on the specimen, was not introduced from without; the sandy matrix which covers it gives no allophane reaction. Rather, it is an end-product of a sequence of chemical reactions that probably has been in operation for a considerable length of time.

TABLE 1
REACTION OF MATERIALS TO ALLOPHANE TEST

Material	NaF Reaction First Drop	 Second Drop*	Allophane?
Sandy matrix	no change	no change	no
Waxy clay	no change	pink	some
Tephra under clay	red	pink	yes
Red-stained area	no change	pink	some
Fresh tephra	no change	no change	no

*After ca 30 minutes.



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*After _ca_ 30 minutes.

PETROGRAPHIC EXAMINATION

Additional samples from areas I, II, and V (sandy matrix; waxy clay, tephra beneath clay skin, fresh tephra) were examined with a Leitz petrographic microscope (magnification range x160-x320) and a white light illumination source. Five duplicate reference slides of four mounts each were first prepared using Preservaslide, an epoxy resin with refractive index (n) approximately 1.52. In addition, several samples of "fresh" tephra were mounted in a series of refractive index oils in order to determine (n) of the volcanic glass shards.

The reference slides and oil mounts described above were examined briefly. The results are given below:

a) sandy matrix Under x320 magnification, the sandy matrix material appears to be considerably weathered. Most fragments are of clay or clay-coated feldspar and rock fragments. I did note one cloudy green amphibole fragment, but no pyroxenes. It is possible that the pyroxenes have been completely weathered away.
b) waxy clay The clay fragments appear reddish-brown in transmitted light. They are birefringent, and have n slightly greater than the mounting medium (1.52). I noted a few, small, shaggy clinopyroxene fragments. They had been almost eaten away.
c) tephra directly beneath clay skin This sample is a mixture of fine, glassy dust and clay. Much of the glass is cloudy and light tan in color, probably due to an allophane coat. Small (ca 50 µm) shaggy pyroxenes observed (clinopyroxene + opaques; possible orthopyroxene).
d) red-stained area Not examined.
e) fresh tephra Under x320 magnification, the fragments appear anything but fresh. They break down readily into glassy dust with patchy birefringence, and small opaques. The refractive index of the glass is approximately 1.52, but it is difficult to be more accurate because the glass is full of microlites. It is in the process of devitrification. Etched, small clinopyroxene fragments noted. Sample too weathered to attempt an approximate date using the tephra hydration method.

The petrographic character of the tephra components, waxy clay coat, and sandy matrix material suggest considerable age. The only samples I have examined that show a comparable degree of weathering were samples dated 250,000 - 300,000 years from the Valsequillo region, central Mexico. In this region occur several dated layers of dacitic ash. Of these layers, those younger than approximately 20,000 years contain fresh pyroxene crystals and clear glass shards. It is only at approximately 22,000 - 24,000 years that orthopyroxene crystals begin to show signs of etching and the glass begins to cloud. The clinopyroxene and amphibole crystals still look fresh (Steen-McIntyre, 1981, p. 58). The samples from specimen #378 are all highly weathered by comparison. This suggests an age for them considerably greater than 24,000 years.

10/15/82 Upon further reflection on the appearance of the "fresh tephra" samples under the petrographic microscope, it seems highly probable that the rock has been fired to a high temperature, and that it is actually a piece of ceramic. The devitrification of the glass shards and their powdery nature, the small (50 µm) clinopyroxene grains (pigionite?), and the large number of small opaques all would suggest this. If this view is correct, then the reddish stain covering the groove-like markings and the red-yellow veinlets on the side of the fragment may have had different origins; the one caused by high heat, the other by weathering. The fact that the specimen has been fired would not alter my estimate as to its age. Etched pyroxenes and thick clay weathering rinds form only after much time has passed. I would suggest a competent ceramist be allowed to examine the sample.

REFERENCES

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