15425 GREEN GLASS CLODS ST. 7 136.3 g

INTRODUCTION: 15425 is an extremely friable greenish clod (Fig. 1) in which the green material is the common Apollo 15 volcanic (pyroclastic) green glass. The sample is really a regolith clod with green glass concentrations varying considerably from place to place. Zones extremely rich in green glass are present and grade over short distances into fairly normal-looking regolith zones in which yellow and red glasses and lithic and mineral debris are common.

The clod is light-greenish gray, blocky, and subrounded. It was removed from the sample bag and processed as four pieces. The surface is smooth and too friable to have retained any patina or zap pits; the four pieces have disintegrated into several smaller pieces.

Two clods were collected from the north rim of Spur Crater and are labeled on lunar surface photographs and diagrams as 15425 and 15426 (Fig. 2). The samples were part of a small cluster of fragments each as much as 25 cm across, and were collected because of their green tint, similar to materials observed but not collected at St. 6A. No small crater is clearly related to the rock cluster. The CDR suggested that all the fragments in the cluster were part of a big fragment which broke when it hit (Bailey and Ulrich, 1975). They have generally been interpreted to be ejecta from a depth of perhaps 20 m beneath the surface (LSPET, 1972). The two clods were placed in the same bag and extracted as several pieces which were grouped in a now unknown manner and numbered 15425, 15426, and 15427, with fine material (<1 cm) residue numbered 15421 to 15424. According to data packs, it is likely that all three contain pieces of both of the original clods sampled, and all show variability in concentrations of green glass. Many studies have produced observations and conclusions without discriminating to which particular of the three samples specific data refers. Hence data from all three samples are most usefully considered together.

PETROLOGY: Macroscopically 15425 is fine-grained, with 95% of the material being a light greenish-gray or greenish brown, and with particle sizes less than 0.1 mm. The largest piece contains obvious rock clasts and does not have an exposure of light greenish-gray material. Matrices range from greenish to grayish in a patchy fashion, and the less green varieties, at first considered to be dust-coatings, are the dominant matrix. In general, the green zones appear as clasts (up to a cm or so) in the grayish-brown material. ,4, a piece originally about 15 g, consists of 70 to 80% of a very fine brown-gray matrix, 10% white clasts up to approximately 1 mm, 10% green glass, and less than 1% amber or brown glass. With the green material in the fine matrix, the total green material is 30 to 40%. ,2 (12 g)and ,5(16 g) appear to be very similar. Few pieces as big as 1 cm appear to be as rich in green glass as some subsamples of 15426 and 15427, although ,7(2 g) might have as much as 80% green glass.

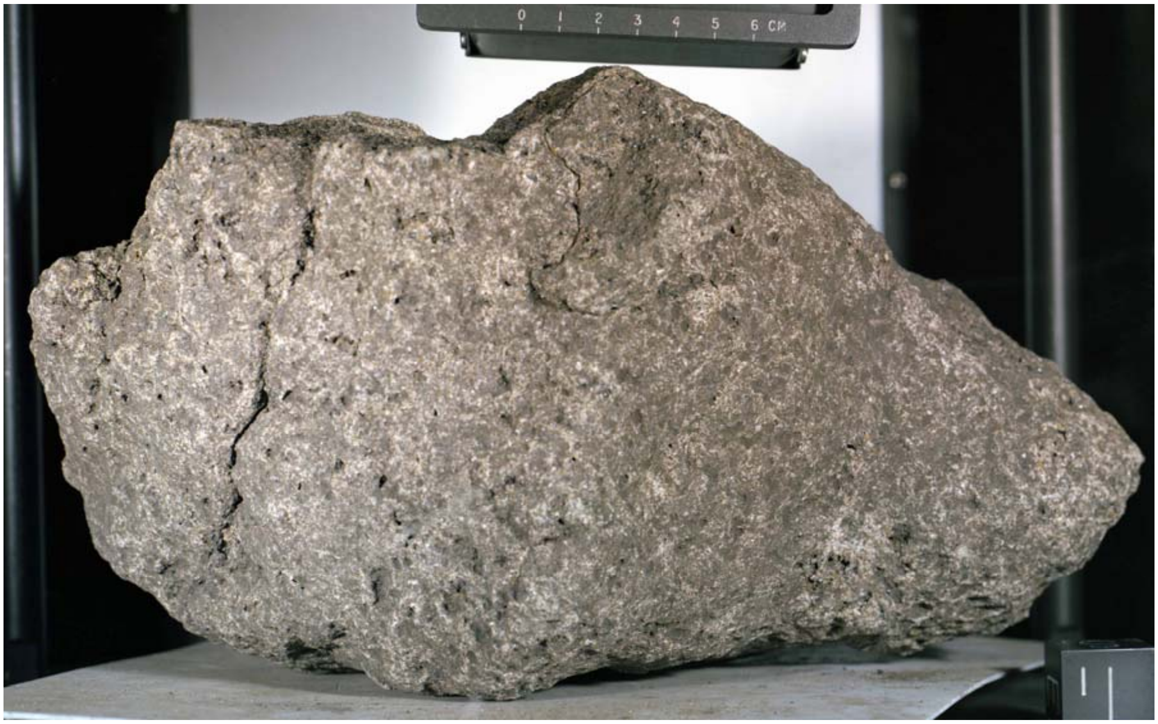


Figure 1. Four original pieces numbered 15425. S-71-43951

Nagle (1981) found that clods of 15425 were light colored with enough green glass to give a greenish tint, and all the pieces were friable. They showed differences in textural properties, in crystallization states, and in lithic association, and were all poorly sorted. Nagle (1981) drew comparisons with clods in core 15007 which are purer, with more unbroken spheres. 15425 was like 15427 in that numerous particles were crystallized; in 15426 there were more particles with quench crystallites, and the clods in core 15007 had more glassy spheres (however, these observations are probably more subsample specific than generalizations about the entire samples). Nagle's (1981) work on 15425 was on a thin section, but his designations of (,67) and (-7) are erroneous, as no such thin sections exist.

All the thin sections are from a single chip, and are of a porous regolith breccia. It contains abundant green glass, including partly crystallized varieties, in a fine-grained, dark brown matrix (Fig.3). Homogeneous volcanic yellow and red glass spheres, and heterogeneous yellow impact glasses are present. Lithic fragments include coarse highlands materials, including anorthositic and noritic fragments, as well as feldspathic impact melts and agglutinitic-looking glass. In some sections there are zones which are virtually entirely green glass, and these grade very sharply into more typical-looking regolith material. These zones appear to be essentially clasts in the remainder of the rock.

Butler et al. (1972) noted that chondrules (=green glass vitrophyres) are abundant in thin section 15425,16. Agrell et all. (1973) described glass from 15425, 15426, and 15427. All three contain green spheres, subordinate brown spheres, and other glasses of mare derivation. Agrell et al. (1973) listed an analysis of an evolved interstitial glass in an olivine chondrules (= green glass vitrophyre) in 15425, and noted four spheres isochemical with green glass spheres but with a granular crystalline mosaic texture. The average composition for five devitrified spheres is similar to general green glass analyses.

Delano (1979) analyzed clear green glasses in 15425, 15426, 15427, and 15318 with the microprobe for major elements and Ni, finding several different compositional groups; data for 15425 was not specified. Meyer et al. (1975) showed SEM photographs of a green glass sphere and its micromound surface texture from 15425,26. Butler and Meyer (1976) also showed a SEM photograph of a green sphere.

Delano (1980b) analyzed volcanic red glass (TiO_2 about 13.8 wt%) in 15425 as well as 15318, 15426, and 15427. Ni was in all cases below the detection limit of 50 ppm. He found three subgroups related by a prominent chemical trend. Experiments on this composition indicate that trend to originate from shallow (less than 5 kb) fractionation, and the most primitive glass to have originated at about 480 km depth.

Delano (1980a) and Delano et al. (1981) analyzed yellow impact glasses (TiO_2 about 4.8%) in 15425, 15426, 15427, and 15318; chemical data for 15425 was not distinguished. The glasses form a compositional cluster, unlike other impact glasses and distinct from the volcanic yellow glass. About 90% are angular fragments, with schlieren and lithic clasts, not spherules. Delano et al. (1981) considered that the glasses were exotic to the Apollo 15 site and were derived from Eratosthenian-age lavas in Mare Imbrium. However, yellow impact glasses from 15426 and 15427 were dated as 3.35 b.y. old by Spangler and Delano (1984).

Fang et al. (1982) inferred glass cooling rates for 15425, which they describe as a weakly coherent breccia containing a modest fraction of interstitial glass. Their composition for 15425 has 51.14% SiO_2, and 6.66% MgO, is of unknown derivation, and is quite different from 15426 or other likely regolith breccia compositions. The inferred cooling rates necessary for glass formation are higher than can be obtained for radiation, hence, such glasses formed in separate bodies; the breccia formed by subsequent compaction which did not include heating above the liquidus. In view of the unusual composition used, the application of the results to 15425 is questionable.

Nagle (1982) stated erroneously that 15425 was a rake sample and from a crater bottom; in fact it is neither.

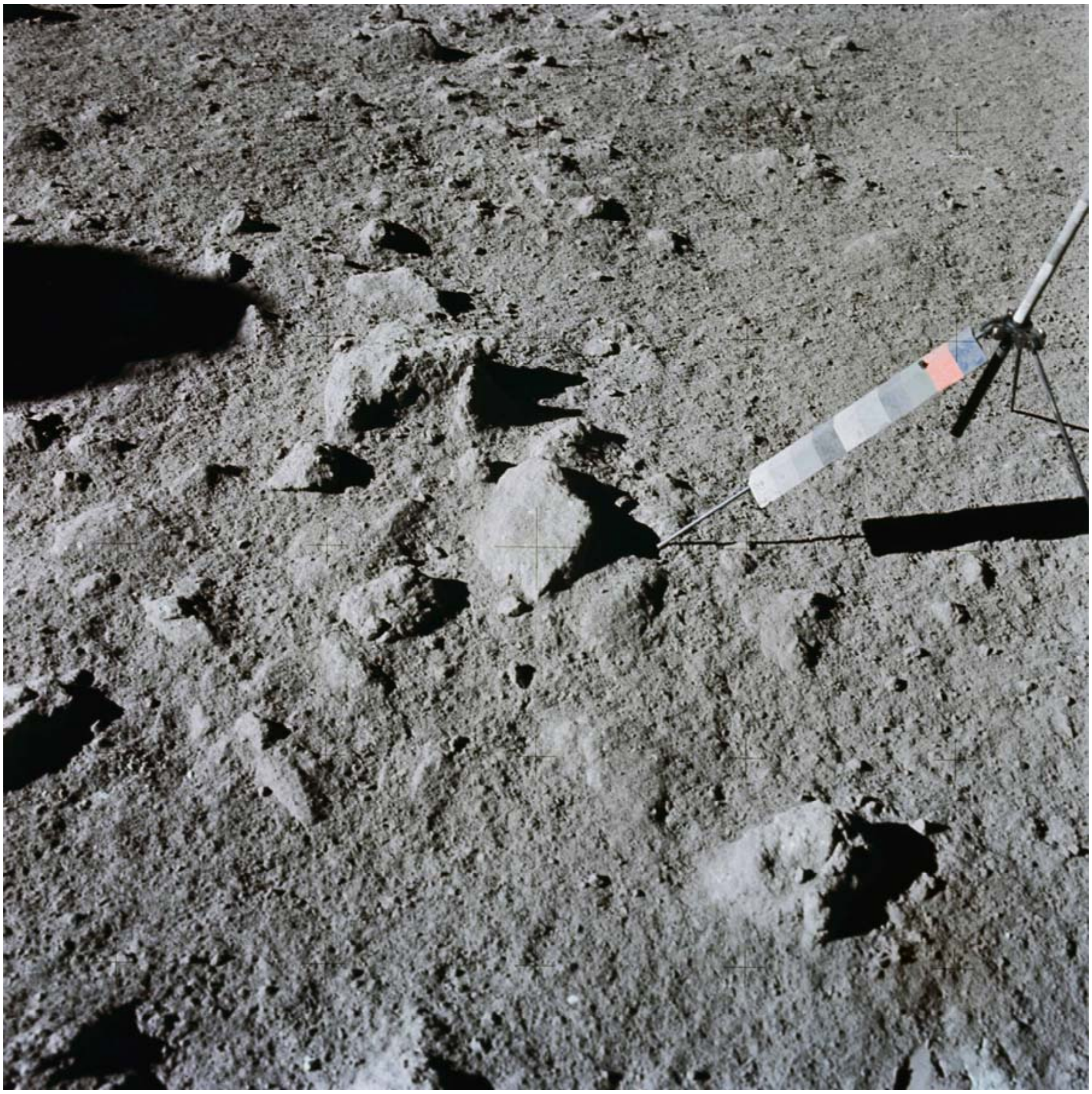


Fig. 2a

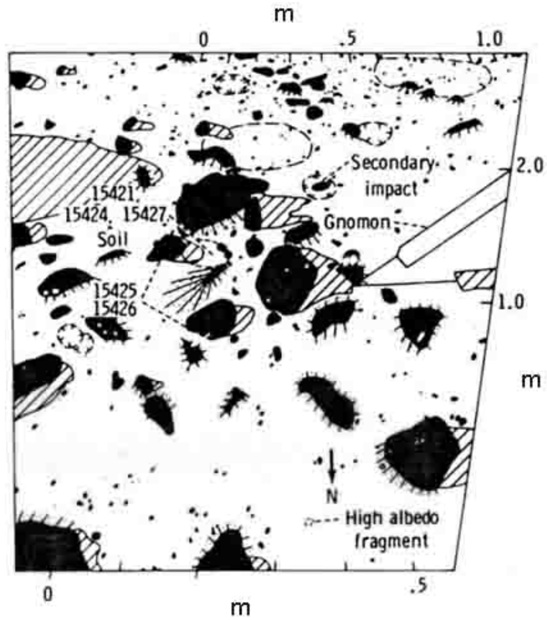


Fig. 2b

Figure 2. Presampling environment of samples 15421-15427
a) surface photograph AS15-86-11666, b) sketch map.

CHEMISTRY: No bulk analysis for 15425 has been reported; analyses of individual glasses are included in the reports above. Chemical studies of the surfaces of glasses in 15425 were made by Meyer et al. (1975), Butler and Meyer (1976), Butler (1978), and Cirlin and Housley (1979). Meyer et al. (1975) found that of 50 handpicked droplets studied in 15425,26, only one had large Zn and Pb signals (ion microprobe) and surficial micromounds; SEM-EDX data showed that Zn and S were present in the micromounds but not in the underlying glass. Hence the surficial micromound film is a major site for volatile species. Meyer et al. (1975) consequently deduced a cogenetic origin for the spheres and the surficial volatiles, consistent with a lava fountaining mechanism. The surface Pb has no corresponding U and Th, i.e., it is unsupported. Butler and Meyer (1976) found that S was the most abundant element in the surface coat of the green spheres. 96% of all spheres showed detectable S; for other elements the proportions are: Zn, 79%; Cl, 51%; K, 16%; Cu, 42%; Ni, 17%; and P, 8%. A Zn vs. S plot shows that the ratio is varied from grain to grain (Fig. 4), but is constant for an individual grain (Fig. 5). Butler (1978) showed an SEM photograph and a Zn intensity map of a green droplet in 15425,26. Four brown glass droplets (= yellow volcanic glass) with S and Zn coats were also found, with nearly identical compositions (TiO_2 about 3.6%). Cirlin and Housley (1979) used a scanning Auger microprobe to investigate the surface of green and brown (= yellow volcanic) glasses in 15425, providing data for Zn/S. The volatiles in the outer few atomic layers vary considerably from one droplet to another, but the variation in individual droplets is much smaller. The Zn/S ratio deviates from 1, indicating that the carrier is not merely a ZnS phase. No K was observed in any of the five green glasses, whereas three brown (= yellow volcanic) glasses did show K.

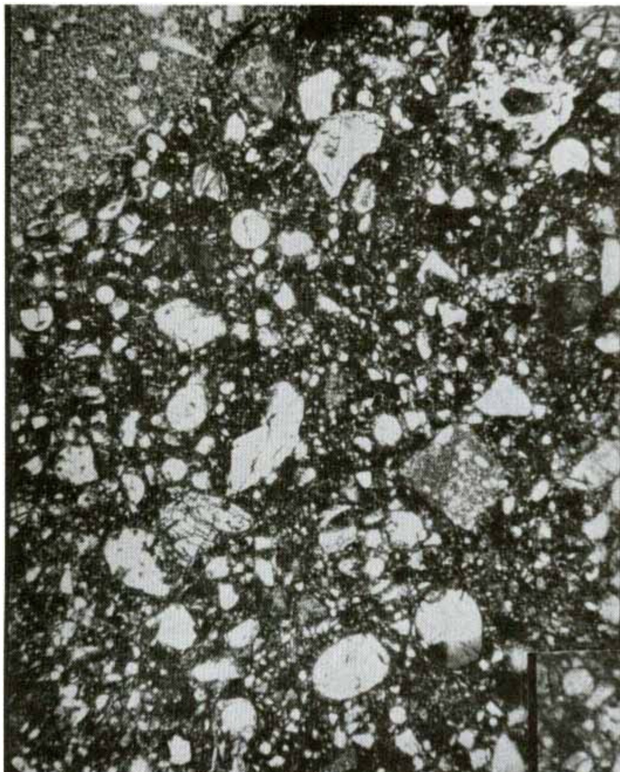


Fig. 3a

Fig. 3b

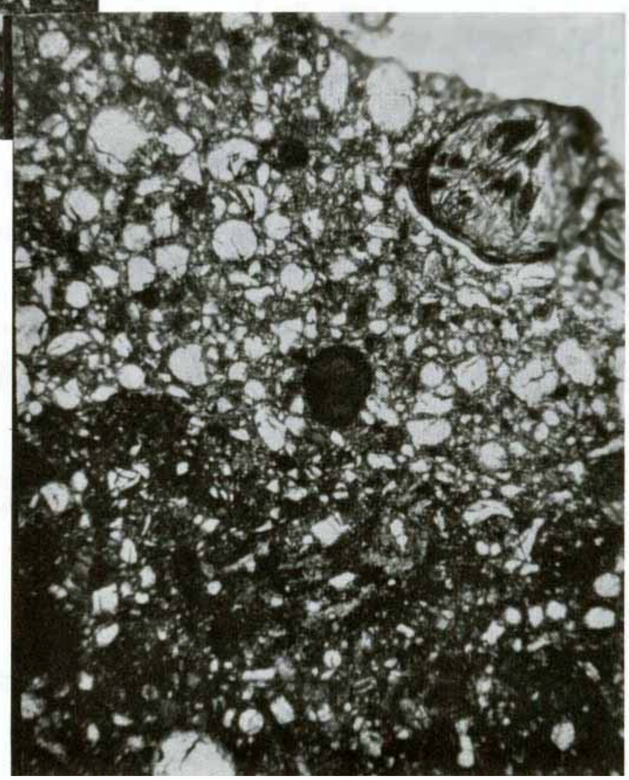


Figure 3. Photomicrographs of 15425,10. Transmitted light. Widths about 2 mm.
a) typical friable regolith, with glass and lithic clasts;
b) shows zone at top which is a pure green glass and its partly crystallized products.

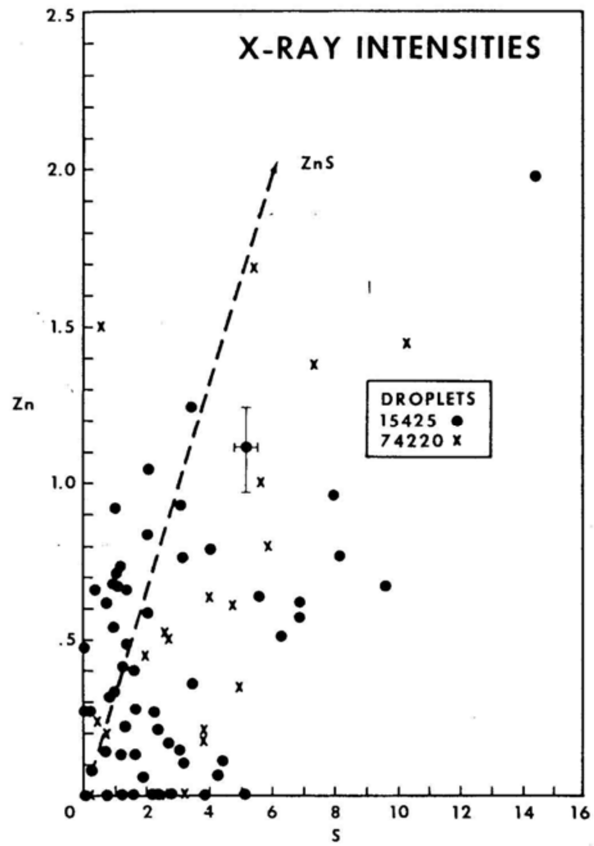


Figure 4. Zn vs. S x-ray intensities for 20x20 micron areas on green glass droplets from 15425,26 (Butler and Meyer, 1976).

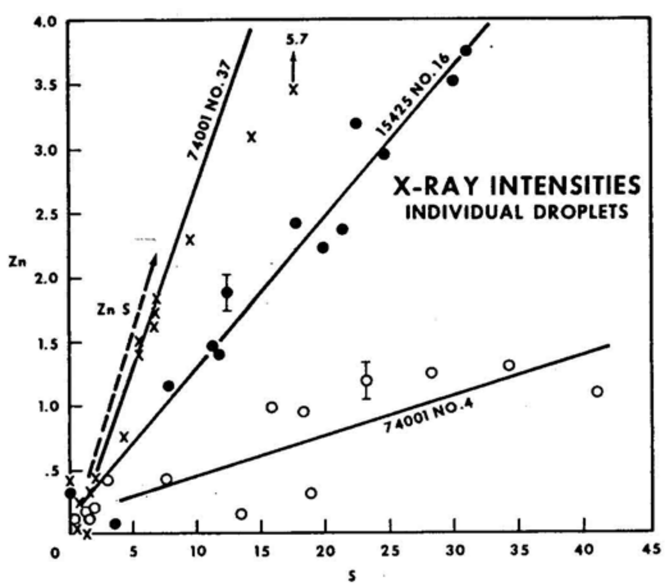
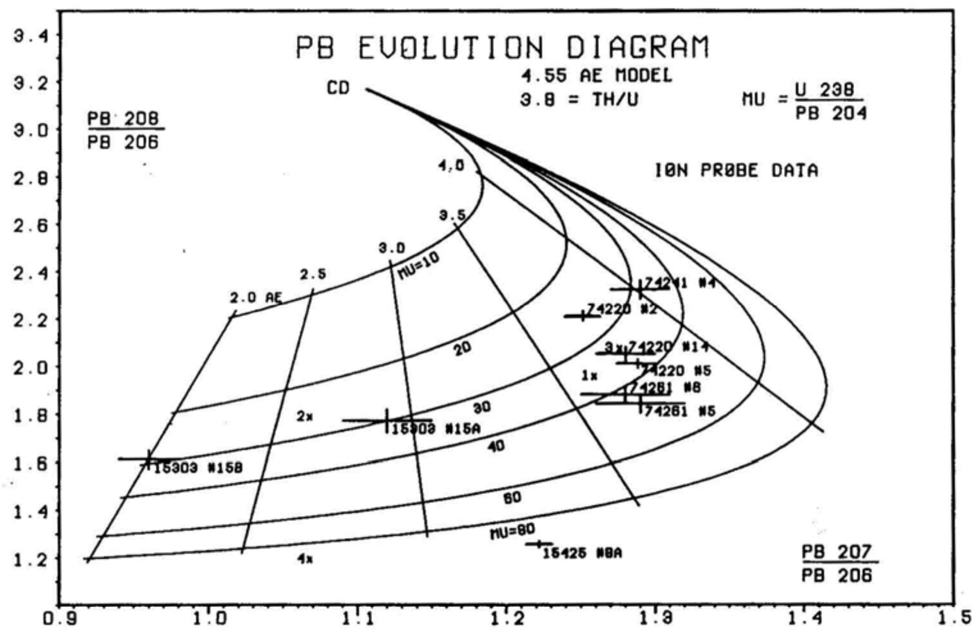


Figure 5. Zn vs. S x-ray intensities for spots on an individual green glass sphere from 15425,26 (Butler and Meyer, 1976).

RADIOGENIC ISOTOPES AND GEOCHRONOLOGY: The only radiogenic isotope study for 15425 is for Pb isotopes in the surficial volatile coat of green glasses by Meyer et al. (1975). Isotopic ratios were determined for individual spheres and the data are probably not diluted by any Pb component supported by U or Th inside the glass; the surficial Pb has apparently been unsupported by U or Th. Only one data point from 15425 was used. Because the ratios of the isotopes to ^{204}Pb could not be determined as well as ^{206}Pb, the data were unconventionally plotted on a ^{208}Pb/^{206}Pb vs. ^{207}Pb/^{206}Pb diagram (Fig. 6). A constant lunar Th/U ratio of 3.8 was assumed. The data for 15425 agree in a general way with the age determined by Podosek and Huneke (1973), and is consistent with a model in which there was no differentiation in the source region from 4.53 to 3.4 b.y.; the surficial Pb evolved in a ^{204}Pb/^{238}U-rich source inside the Moon.

PROCESSING AND SUBDIVISIONS: The initial four pieces constituting 15425 soon disintegrated because of their friability into several smaller pieces which were stored as ,1 to ,8 (range 2 g - 77 g), and are probably now in even smaller pieces. ,8 was potted and produced all the thin sections (,10 to ,19). ,4 was subdivided for a few allocations (and is now 4.8 g), and a grain mount was also made from it. ,7, which was believed to be richer in green glass than most, gave birth to ,30 which was sieved and partly consumed.



Lead evolution diagram for unsupported lead in Apollo 15 green and Apollo 17 orange glass samples. Only the best ion probe data from Table 2 are plotted here. CD = isotope ratio for primordial lead as measured in Canyon Diablo troilite, μ = mu = today's ratio for ^{238}U/^{204}Pb for the source region. Point 1 is Silver's (1974b) value for the lead volatilized from 74220 at 600°C. Point 2 is Silver's (1974a) value for the bulk sample 74220. Point 3 is Silver's bulk value corrected for lead evolved from 3.5 b.y. to present. Point 4 is lead ratio measured for bulk sample of 15426 by Barnes *et al.* (1974). Growth curves for lead isotopes assuming a single-stage evolution in a reservoir with Th/U = 3.8 and variable ^{238}U/^{204}Pb. The new decay constants for U and Th were used (Tatsumoto *et al.*, 1972).

Figure 6. Pb evolution diagram for green and orange glass droplets (ion microprobe data) (Meyer et al., 1975).