Table 1. Composition of glasses formed by local fusion in shocked basalt 12057,14.

	(1)		(2)		(3)	
SiO_2	45.94		47.92		30.79	
TiO_2	1.08		1.60		16.52	
Al_2O_3	0.93		12.99		5.51	
FeO	36.67		22.05		34.61	
MgO	2.83		2.35		0.26	
MnO	0.41		0.25		0.28	
CaO	10.06		11.73		7.68	
Na_2O	0.00		0.10		0.18	
K_2O	0.00		0.25		0.35	
TOTAL	97.92		98.24		96.18	
CIPW norm						
quartz	0.19		4.05		0.18	
orthoclase	0.00	2.73	0.59	41.74	2.07	16.96
albite	0.00		4.15		1.52	
anorthite	2.54		32.95		13.19	
diopside	41.59		22.03		22.15	
enstatite	4.95	93.15	4.33	54.70	0.44	47.84
ferrosilite	46.61		28.34		25.25	
ilmenite	2.05		3.04		31.38	

(1) Greenish-brown glass, shock area I; (2) Green glass, shock area II; (3) Dark brown glass, shock area III.

Within three small areas (I, II, III), about 1 mm^2 each, local stress concentrations resulted in stronger shock effects (Fig. 3). In the center of these areas local fusion produced glasses the compositions of which are shown in Table 1. None of these glasses corresponds to the bulk composition of the rock. Area I shows concentric zones of diminishing pressure (decreasing shock metamorphism) around the central melt; the innermost zone contains diaplectic plagioclase glass. In an outer zone the plagioclase is partially isotropic (lamellae parallel to (010) and irregular isotropization), and passes gradually into birefringent plagioclase. Tridymite grains within this zone show planar features parallel to a hexagonal prism. Diaplectic plagioclase glass and partially isotropic plagioclase occur also around the central melts of areas II and III.

All three areas of high stress concentrations are situated adjacent to large ilmenite crystals. Apparently, shock waves of high peak pressures were produced by reflection at the grain boundaries of ilmenite which has the highest impedance of all constituents.

Glasses Produced by Shock Melting

The most conspicuous constituents of Apollo 11 and Apollo 12 soils and breccias are glasses of various morphology, color, and composition. A minor amount of glasses is of volcanic origin. They contain euhedral phenocrysts of olivine and other minerals, and they shall not be considered here. The majority of glasses are produced by shock. Most of them are of polymineralic composition. Monomineralic glasses are almost exclusively represented by diaplectic plagioclase glasses formed in the solid state. Monomineralic glasses formed by shock fusion are extremely rare.

Morphological types

According to morphology and texture the shock-fused polymineralic glasses may be classified into the following groups: *angular fragments* occur in soils as well as in breccias and range in size from less than 1 μm up to several mm (see Tables 6 and 7). *Regular forms of revolution* are minor constituents of soils and breccias, ranging in shape from spherules to ellipsoids, cylinders, dumbbells, and teardrops. We observed such bodies in the size fractions between 0.3 μm and about 2 mm. They are twice as abundant in Apollo 11 than in Apollo 12 samples (see Tables 6, 7, and 8).

Angular fragments and regular bodies are either homogeneous or heterogeneous. The latter show flow structures, schlieren, vesicles, and inclusions of unshocked or shocked mineral and rock fragments. They have a wide range of colors (colorless, green, yellow, orange, brown, red, violet, nearly opaque) and refractive indices which increase with increasing $FeO + TiO_2$ (Fig. 4) and decreasing $SiO_2 + Al_2O_3$. The majority of fragments and regular bodies contain minute metallic spherules or minute euhedral opaque crystals. Both types of glasses are sometimes partly or completely devitrified. Apollo 12 glasses show distinctly higher degrees of devitrification than Apollo 11 glasses.

In Apollo 12 samples glass fragments and few regular bodies of a characteristic beige-brown to maroon-brown color occur which were not found in Apollo 11 soils and breccias. These glasses show flow structures and are commonly rich in schlieren, vesicles, and mineral inclusions which are mostly shocked. All of them contain devitrification products, some of which were formed in the immobile matrix, mostly as spherulites, others at higher temperatures within the flowing melt. Most typical of the latter are small lath-like microlites with skeletal terminations, arranged in flow lines.

Glassy agglomerates are major constituents of soils and breccias. Their shapes are very irregular, mostly similar to slags or cinders. They consist of highly vesiculated glass, including and cementing together mineral and rock fragments. The glass is of yellow to dark brown color and commonly contains abundant minute metallic spherules. It is similar to the glassy coatings and the matrix glass of breccias. Distinction between glassy agglomerates and angular glass fragments becomes increasingly

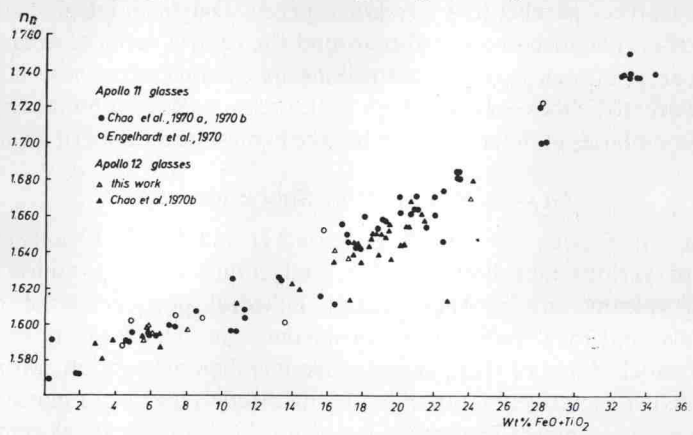

Fig. 4. Apollo 11 and Apollo 12 glasses: Refractive index versus $FeO + TiO_2$ content.