Advance Report on "Acid" Xenoliths from Surtsey

by

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In the course of the Surtsey eruption a number of xenoliths have been ejected. This report deals solely with the "acid" xenoliths collected by numerous scientists that have visited Surtsey, and it is a pleasure to acknowledge our debt to all those who have contributed to the collection, especially Jens Tómasson, Jón Jónsson and Dr. Finnur Gudmundsson, who supplied very valuable material. Work is still in progress on this study, and the author would be most grateful for any additions to the present acid xenolith collection.

The great majority of the acid xenoliths were collected from volcanic ash just after the explosive phase ceased, but in addition the late Tómas Tryggvason collected an excellent specimen of an acid xenolith enclosed in lava on Surtsey. The latest acid xenoliths were gathered by Dr. Finnur Gudmundsson on the beach of Surtsey from amongst drifting pumice from Syrtlingur on June 3rd, 1965, and these xenoliths were almost certainly brought up by the Syrtlingur eruption.

The acid xenoliths collected are sub-rounded to spherical, and range in size from 2 cm to 10 cm in diameter. They are invariably coated with a veneer of dark-brown to black basaltic glass, and are therefore easily overlooked in the tephra. Microscopically the acid xenoliths are divisible in two:

(a) dense, chalky-white or light-grey and fine grained xenoliths;

(b) coarse grained, yellowish xenoliths of granitic or granophyric texture.

The first mentioned group is by far the more abundant, whereas only 2 samples of granitic xenoliths are available to the author. But, as will be shown later, the xenoliths from Syrtlingur are closely allied to and derived from the granitic xenoliths.

Dense fine grained xenoliths.

These xenoliths are very similar as a group, consisting of an entirely crystalline mass, generally partly "sphaerulitic" and with a felty mass of fine crystals or microlites 0.05 - 0.1 mm in length. Most of the minerals present are too small to permit identification by the optical microscope, but an x-ray diffraction study of these is in progress. Tridymite is an ubiquitous constituent in the dense, fine grained xenoliths, in small "nests" of twinned, wedge-shaped crystals of very low birefringence and low refractive index.

Cordierite is certainly present in one xenolith and possibly in some others. Cordierite has been identified by x-ray diffraction methods in specimen No. 1162 where it occurs as small rectangular crystals of good habit, optically positive, $2V_{\gamma}$ 80-88°. Very fine plagioclase needles and laths are the chief constituents in the sphaerulitic patches.

Other minerals are not identified so far.

TABLE I

Dense, fine grained acid xenolith from Surtsey:

SiO_2	60.80	Norm:	
Al_2O_3	21.97	Qz	18.70
Fe_2O_3	0.26	Or	2.05
FeO	0.76	Ab	26.65
MnO	0.01	An	46.60
MgO	0.29	Wo	3.78
CaO	11.16	En	0.82
Na_2O	2.92	Fs	1.00
K_2O	0.34	Mt	0.30
H_2O^+ / H_2O^-	1.20	Ap	0.11
TiO_2	-		
P_2O_5	0.04		
	99.75%	Analyst: H. Sigurdsson	

Granitic and granophyric xenoliths.

Only two good samples of this type are available. Specimen No. 1165 is a grey rock fragment, 1-2 mm in grain size, showing granitic texture with rare granophyric intergrowth around some of the plagioclase laths. Plagioclase, quartz and alkali feldspar are the chief minerals. The twinned plagioclase has $2V_\gamma$ 68-75°, and a universal stage determination indicates the composition Ab_{88} (low temp. series). Both microcline and orthoclase are present, the latter in graphic intergrowths with quartz. Zircon is a common accessory.

The xenolith is coated by a thin veneer of colourless glass, n = 1.495, formed by the fusion of feldspar and quartz. Glass is also present within the xenolith, as a thin vesicular film between all the mineral grains in the rock. At the time of eruption the granite xenolith had already been partially fused by the enclosing basic magma, but the resulting liquid became quenched to glass on ejection from the crater.

Xenolith No. 1166 is of granitic texture, grey coloured and medium grained, consisting of plagioclase and orthoclase with subordinate quartz. Plagioclase, determined on the U-stage, has $2V_\gamma$ 63-68^o, and an optic orientation indicating Ab_{75}. Refractive index on β is 1.546 (Ab_{72}). The alkali feldspar is orthoclase, and the combined values of refractive index (β = 1.531) and extinction angle indicate Or_{50} Ab_{40} An_{10}.

In the core of the xenolith little melting has occurred, except of an unknown ferromagnesian mineral, leaving dark-brown patches of glass. In the outer part vesicular glass separates the individual minerals, which grades into an entirely glassy envelope in the outermost zone.

Some of the feldspars in this xenolith have not undergone simple melting at once, but instead individual feldspar grains have reverted to an aggregate of minute high-temperature minerals, which mimick the optical orientation of the parent feldspar so that twinning may be preserved and the entire aggregate remain in optical continuity.

The mineral composition of these aggregates is as yet unknown. The outermost glass of the xenolith is colourless, n = 1.498 and the boundary between the acid glass and the enclosing basaltic glass is quite sharp.

Specimen No. 511 was amongst those collected from Syrtlingur ash, and consists of a very frothy, vesicular light-grey glass. No crystals are present except for accessory zircon. Refractive index of this glass is n = 1.495. It is believed that this specimen represents the complete fusion of a granitic xenolith, such as those described above.

Discussion.

The material here represented indicates the presence of granitic rocks at depth below Surtsey, as well as acid rocks of unknown texture, represented by the dense, fine grained xenoliths. The granitic xenoliths have undergone varying degrees of fusion, brought about by the fluxing action of volatiles from the basic magma as well as the mutual fluxing of quartz and feldspar within the xenolith at the high temperature available in the magma (1170^{o}C).

Attention is drawn to the absence of hybridisation between the granitic liquid and the basalt magma; even basaltic olivine crystals enclosed within acid glass are devoid of corrosion or reaction features.

The dense, fine grained xenoliths are consistently crystalline and never contain glass. They are believed to be the pyrometamorphic product of a rock, possibly of an original sedimentary nature or an igneous rock of a very unusual composition (e.g. an igneous cumulate), now completely recrystallized. The oxides SiO_2, Al_2O_3 and CaO constitute 94% of the dense, fine grained xenolith. Their composition is therefore amenable to a study in the system $CaO-Al_2O_3-SiO_2$ (Rankin and Wright, Am. J. Sci., 39, 1915, p. 25). The xenolith falls on the binary eutectic anorthite - mullite, very close to the ternary eutectic point tridymite - mullite - anorthite, whose liquidus temperature is 1345^{o}C. The absence of glass in the dense, fine grained xenoliths is therefore readily accounted for, as the magma certainly never reached the extreme temperatures required to melt material of this composition.

The work in progress on acid xenoliths from Surtsey is part of a wide-embracing study on acid xenoliths collected from a range of volcanic rocks from all parts of Iceland. Among these are specimens collected from Tertiary basalts, Pleistocene palagonite tuffs as well as recent lavas and cinder cones. It is possible that this material may have a bearing on the enigmatic - and fashionable - question of the nature and composition of the Icelandic crust.