FLUIDIZED IMPACT EJECTA AND ASSOCIATED IMPACT MELT CHANNELS ON VENUS;
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Fluidized ejecta blankets (FEBs) of many impact craters are among many intriguing features being discovered in recent Magellan radar images of Venus. Most FEBs are associated with craters 30-65 km in diameter in the area 24°-29°S, 336°-341°. Large FEBs are shown in figure 1. The larger FEB occurs in a shallow valley having a regional gradient of about 200 m / 130 km (about 0.1°). The sharp, lobate distal edges of venusian FEBs are similar to many FEBs on Mars, where subsurface water or ice is thought to contribute to fluidization [e.g., 1], although atmospheric interactions might also have a role [2]. An unusual characteristic of Venusian FEBs is the existence of sinuous channels originating on, cutting through, and continuing away from the fluidized ejecta blankets (termed "FEB-channels"). In figure 1 FEB-channels originate in a dendrite-like tributary pattern on the surface of an ejecta blanket, suggesting drainage of an interstitial liquid, probably an impact melt, from many parts of the ejecta. FEB-channels resemble terrestrial fluvial channels more than typical lava channels; they are sinuous and sometimes anastomosing, with eroded or streamlined "islands" in mid-channel. FEBs and FEB-channels cut plains units and deposited radar-bright material on their banks. In places the bank deposits apparently have been redeposited by wind, forming streaks. Back-scattering of FEBs are larger than surrounding plains and associated domes (5-10 km diameter), thus enhancing the visibility of domes in the channel areas.

Formation of FEBs apparently involves fluidization by impact shock melting of ejecta; FEB-channels seem to form by segregation and drainage of liquid from solid components of the ejecta. The dynamical behavior during emplacement of lunar impact melts, as seen in the morphologies of impact melt deposits of Orientale, Copernicus, Tsiolkovsky, and other large, fresh craters, seems qualitatively very unlike the behavior of venusian impact melts. Terrestrial and lunar impact melt generally is intermixed with large amounts of rock fragments, thus imparting an extremely high effective viscosity to the partially molten mixture. In contrast, we infer very low viscosities, possibly lower than 1 poise (2 orders-of-magnitude lower than basalt), for venusian impact melts in order to allow it to efficiently segregate and form fluvial-like FEB-channels. The origin of highly fluid outflow-channel-forming lavas elsewhere on Venus, although unrelated to impacts, may suggest a common genetic aspect [3]. We consider two general possibilities accounting for such low inferred viscosities: (1) high-temperature superliquidus or ultramafic silicate melts; (2) low-temperature nonsilicate compositions, perhaps sulfur or carbonatite. Figure 3 illustrates the viscosities of some candidate liquids.

Silicate impact melt? If FEB-channel-forming impact melts have silicate compositions, we infer either ultramafic compositions or extraordinary superheating. Ultramafic melt compositions would require impacts into mantle peridotite, komatiitic crust, or a shallow ultramafic magma chamber, as well as very high degrees of melting. Superheating would require heterogenous ejection of superheated liquefied ejecta and relatively cold solid ejecta, thus permitting rapid melt drainage of superheated liquid before thermal equilibration can occur. We note that high venusian ambient surface temperatures would encourage greater amounts of impact melting, but only by a few tens of percent. Higher impact velocities at Venus compared to Earth and Moon may better explain the sharp differences between ejecta on Venus and on the Moon, especially in conjunction with the ambient temperature effect.

Liquid sulfur? Sulfur lava flows on Earth are relatively rare and small, and form by melting of fumarolic sublimates. The plausibility of this impact melt type for Venus rests on a high abundance of S, especially in the form of sulfides, in the venusian crust (discussed further in [3]). Pyrrhotite ($Fe_{1-x}S$) may be an important crustal component on Venus, and would be among the first crustal phases to melt during mild heating. Liquid S containing a few percent FeS forms by decomposition of pyrrhotite at temperatures of about 1016 K [4], or lower if additional S-soluble components are present. Silicates would remain unmelted until a temperature about 200 K higher was attained. The viscosity of sulfur is less than 0.4 poise at venusian surface temperatures [5], about three orders of magnitude less than basalt. The density of liquid sulfur is about 1.64 g cm^{-3}, providing great buoyancy with respect to rock. Thus, liquid sulfur could drain out of an ejecta blanket in short order.

Carbonatite? Carbonate magmas locally form massive intrusions and volcanic constructs on Earth [6]. If carbonates constitute just a few percent of the venusian crust, partial remelting by impact shock-heating would yield carbonatite. The melting point of terrestrial carbonatite in the absence of water ranges to as low as 938 K at 1 kbar [7]. Thus, carbonatite can be generated at temperatures comparable to or much lower than basaltic lavas. Rheological data for carbonatite unfortunately do not exist to the best of our knowledge, but we infer from a variety of qualitative geological and experimental observations that these viscosities must be quite low compared to most lavas. The common explosive nature of carbonatite volcanism on Earth would be reduced on Venus by high surface atmospheric pressures.

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References. 1. Carr, M.H., et al., 1977, J. Geophys. Res. 82, 4055-4065. 2. Schultz, P.H., and D.E. Gault, 1984, Lun. Planet. Sci. XV, 732-733. 3. Kargel, J.S., G. Komatsu, J.S. Lewis, V.R. Baker, and R.G. Strom, 1991, ABSTRACT, this volume. 4. Lewis, J.S., 1982, Icarus 50, 103-114. 5. Bacon, R.F. and R. Fanelli, 1943, J. Am. Chem. Soc. 65, 639-648. 6. DuBois, C.G.B., 1963, Nature 197, 445-446. 7. Cooper, A.F. et al., 1975, Am. J. Sci. 275, 534-560.

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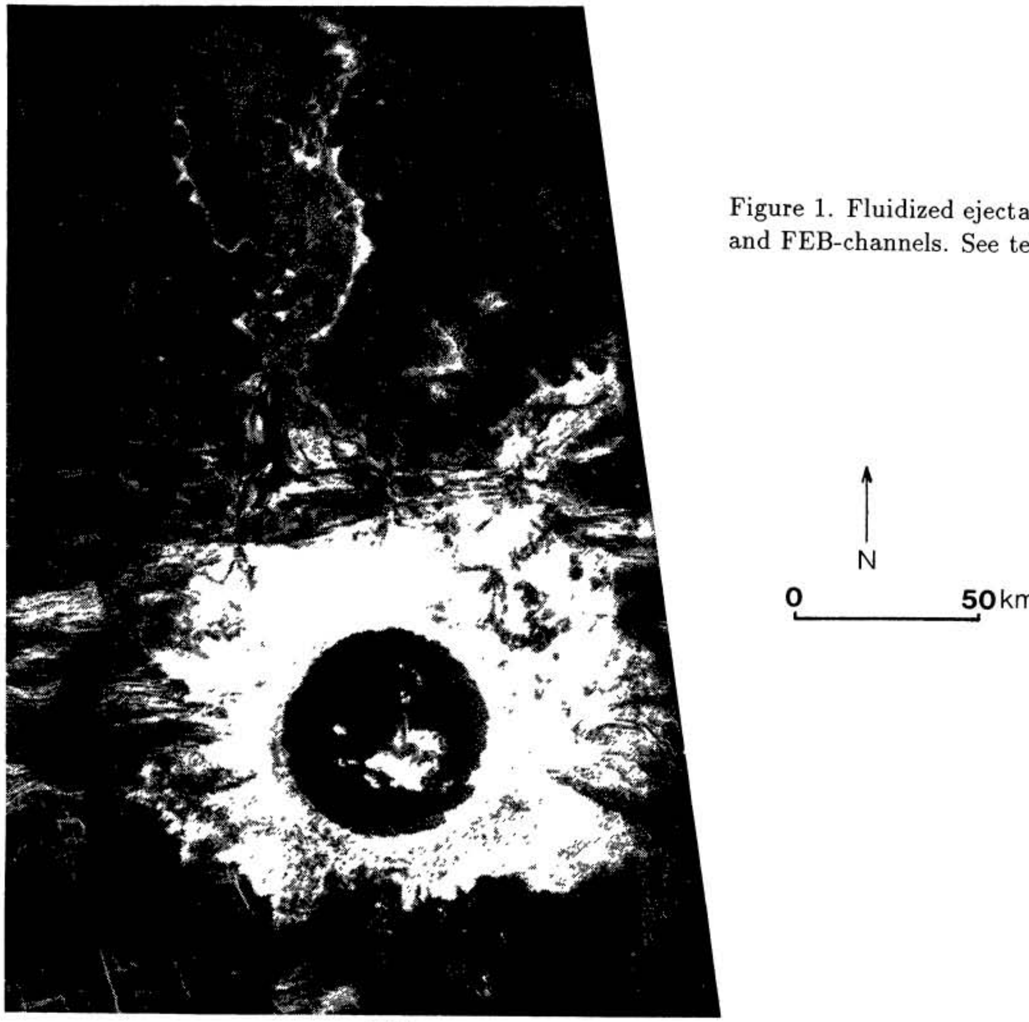

Figure 1. Fluidized ejecta blankets (FEBs) and FEB-channels. See text for the detail.

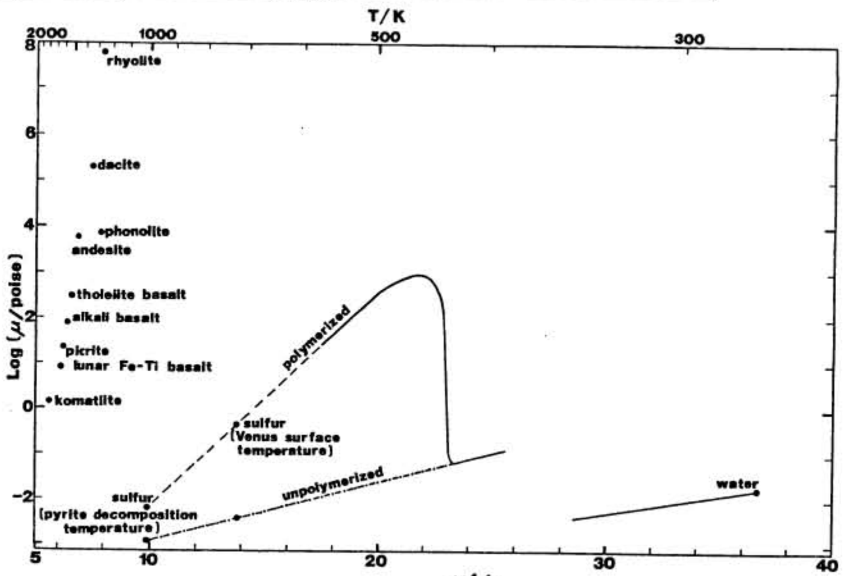

Figure 2. Viscosities of anhydrous silicate liquids at their respective liquidus temperatures, sulfur, and water.