IRON OXIDES IN IRGHIZITES; D. D. Badjukov[1], F. Brandstaetter[2], T. L. Petrova[3], and G. Kurat[2], [1]Vernadsky Institute, Russian Academy of Sciences, Kosygin st., 19, Moscow 117975, Russia, [2]Naturhistorisches Museum, A-1014 Vienna, Austria, [3]Institute of Lithosphere, Russian Academy of Sciences, Moscow 109180, Russia.

Hematite-magnetite+/-ilmenite grains, aggregates, and clusters are occasionally present in irghizites (~0.01 %). It is likely that they represent shocked and thermally recrystallized hematite from the Zhamanshin target loess. Degrees of alteration range from texturally intact hematite grains with ilmenite exsolution lamellae over thermally decomposed single grains (now polycrystalline with various grain-sizes) to clusters of magnetite grains and needles in silicate glass. Local post-shock conditions varied, but fairly low peak temperatures (1700-1800 ^{o}C) are indicated by the survival of oxide grains.

Introduction: Aerodynamically shaped glasses (irghizites [1]) are found on the inner crater rim of the Zhamanshin crater, which is the only crater known to contain such glasses. Irghizites consist of Si-rich glass and generally have a diameter of less than one centimeter. They apparently were formed from loess-like sediments [2], but have an anomalously high Ir content and are also enriched in other siderophile elements relative to the target rocks [3]. These features suggest that the melt droplets originate from a location close to the projectile and that they were formed at an early stage of the Zhamanshin impact event. Relictic minerals can give information on the physical-chemical conditions during formation of the irghizites. Here we report on the occurrence and possible formation of rare Fe (+/-Ti) oxides in irghizites.

Results. A magnetic fraction separated from crushed irghizites consists of glass particles containing Fe (+/-Ti) oxides. The overall abundance of these oxides is about 0.01%. Particles were mounted in epoxy, polished, studied by optical microscopy and scanning electron microscopy, and analyzed with an electron microprobe. Oxide phases present are hematite, magnetite, and ilmenite. Most common are aggregates of magnetite grains containing irregularly shaped relictic hematite and variable amounts of glass - as inclusions and interstitially (Fig. 1). Textures range from *compact magnetite aggregates* with equigranular mosaic texture and rounded shapes (Fig. 1) to *magnetite clusters* with highly irregular shapes (Fig. 2). Much less common are texturally intact but thermally decomposed *hematite grains* with ilmenite exsolution lamellae (Fig. 3) and glass portions rich in needle-shaped *quench magnetite* (Fig. 4). Magnetite is mostly rich in Mg, Al, Si, and Ti (Table). Contents vary from inside the clusters (low) toward the contact with the glass (high). Hematite grains and relics are usually poor in minor elements, except for Ti (Table).

Table : Averaged composition of iron oxides from irghizites (EMPA). Numbers in parenthesis are standard deviations of the mean.

	Magnetite	Hematite	Ilmenite
FeO	78.67 (3.70)	80.28 (2.56)	55.79 (4.94)
MgO	4.66 (1.86)	1.52 (1.31)	1.94 (0.16)
MnO	0.31 (0.05)	0.37 (0.34)	0.32 (0.31)
Al_2O_3	4.49 (1.62)	1.94 (0.85)	1.56 (0.29)
TiO_2	1.93 (0.95)	4.90 (2.50)	32.09 (6.37)
SiO_2	1.34 (0.94)	0.64 (0.58)	1.15 (0.44)
Total	91.39	89.65	92.85

It should be noted that the totals of magnetite analyses are systematically low which could be due to a high content of Fe^{3+}. The glass has a constant silicious composition and only in a few cases there is a weak enrichment of the glass in Fe present at the contact to the iron oxids..

Discussion. It is likely that the oxides in irghizites are altered oxide minerals from the target rock. The transformation into aggregates could have taken place in two possible ways, via a melt or by recrystallization in the solid state. The ***minimum*** formation temperature of the irghizite melt should be about 1670 ^{o}C because of the presence of silica glass (lechatelierite) in micro-irghizites [4]. This temperature is close to the melting point of iron oxides [6]. The most common magnetite aggregates seem to have formed from a melt. Many have abundant interstitial glass and some have abundant glass inclusions in magnetite (Figs. 1,2). Furthermore, the magnetite composition varies with the distance from the contact to the glass and it is very different from that of the relictic (= original) hematite. The enrichments of the magnetite in Mg, Al, and Si as compared to hematite indicate a participation of the silicate melt in magnetite formation. The gradual increase of the contents of these elements in magnetite toward the contact with the glass indicates the involvement of a diffusion mechanism. The outermost magnetite grains of aggregates and clusters tend to develop crystal faces at the contact to the glass, indicating a possible crystallization from the silicate melt. The inner portions of the clusters, as well as the compact aggregates, have a low silicate/Fe-oxide ratio. If they formed from molten Fe oxide, it is surprising not

IRON OXIDES IN IRGHIZITES: BADJUKOV D. D. et al.

to see any sign of turbulent mixing. All mixing documented by the glass inclusions in magnetite apparently took place via diffusion. In contrast, clear evidence for local dissolution of Fe oxides in the silicate melt is provided by the rare quench magnetites (Fig. 4). The presence of intact relictic hematite and intact rounded shapes (relictic abrasional shapes) and the equigranular texture of the magnetite clusters indicate highly variable local post-shock conditions. The survival of some grains, the rather mild alteration of many others, and the absence of large-scale mixing of Fe oxide and silicate melts indicate rather mild shock conditions during formation. However, most original hematite was destroyed and reduced to magnetite (or an oxidized variety) according to the local redox conditions and some oxide was dissolved in the silicate melt and re-precipitated as magnetite. Reprecipitation of hematite, of course, was inhibited by the very high O_2 fugacity required, because the magnetite stability at such high temperatures already requires a minimum O_2 fugacity of 10^{-6} bar. Taking into account a very short time of heating, we can conclude that the temperature was not higher than 1700-1800 ^oC. This post-shock temperature range corresponds to relatively low shock pressures that can be related either to strong attenuation of the shock wave front or to a relatively low velocity of the Zhamanshin projectile.

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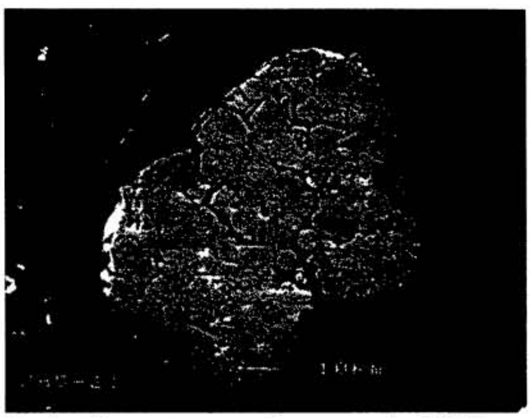

Fig.1 : Compact magnetite aggregate; BSE image.

Fig. 2: agreggate cluster of magnetite with relic hematite (light grey); BSE image.

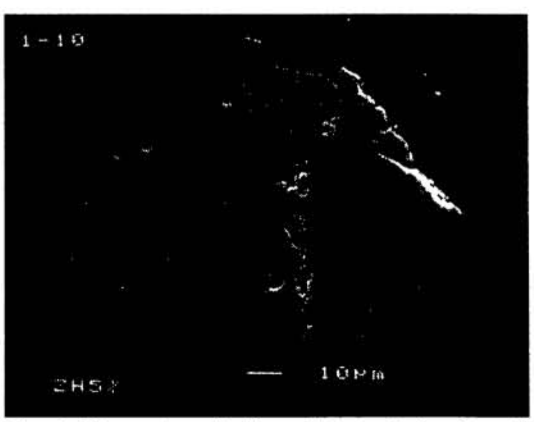

Fig. 3: Hematite with ilmenite exsolution lamellae; BSE image.

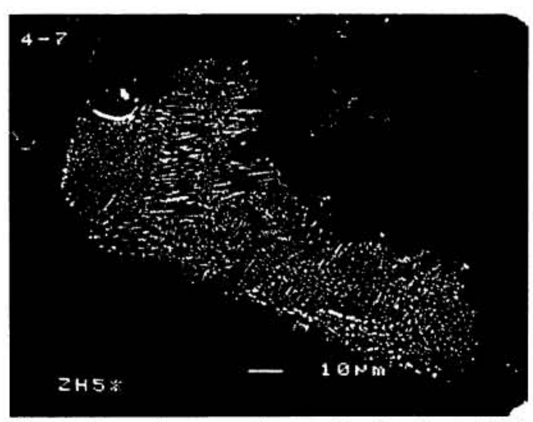

Fig. 4: Quench magnetite needles in glass; BSE image.