MORPHOLOGICAL VARIABILITY OF FeNi ‘SPHERULES’ AND VESICLES IN WABAR GLASS (SAUDI ARABIA) – A CASE FOR DYNAMIC METEORITE MELT-TARGET MELT-GAS INTERACTION.

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Introduction: The ~300-year-old Wabar meteorite craters, three craters 11 m, 64 m, and 116 m in diameter, respectively, that were struck by a IIIA iron meteorite in the Rub' Al-Khali desert (SE Saudi Arabia; crater field roughly at 21°30' N, 50°28' E) count among the youngest terrestrial impact structures. Impact melt lithologies at the Wabar impact site comprise predominantly small aerodynamically shaped glass spheres, droplets, and dumbbells, as well as larger and more coherent glassy impact melt rocks in Fe-poor (bright), Fe-rich (dark), and mixed bright-dark (‘marble-like’, sometimes bluish) varieties known as ‘Wabar glass’ [1-7] (Fig. 1). Shock metamorphic features in the Wabar glass (e.g., shocked and molten quartz, ballen cristobalite, or molten feldspar) are well documented [4;8;9]. The geochemical composition of the Wabar glass is highly siliceous (~87-94 wt% SiO_2) [4]. Metallic FeNi spheres (‘spherules’ [10-12]), similar to those observed in Henbury impact glass (Australia) and the Monturaqui impactite (Chile), are representative of the notable meteoritic contamination in the massive Wabar impactites [4;5;10-12].

FeNi Spheres (‘Spherules’) in Wabar Glass: Compositionally, the metallic FeNi spheres in the Wabar glass, generally up to ~100 µm in diameter, show a distinct heterogeneity with respect to Fe, Ni, and Co contents; previous studies listed variable values of ~89-36 wt% Fe, ~8-64 wt% Ni, and ~0.5-2.7 wt% Co in the FeNi spheres [12] (however, recent microprobe measurements also yielded Ni contents of up to ~90 wt%, comparable to the Henbury and Monturaqui spheres [12]). Morphologically, the FeNi spheres usually show undisturbed round shapes, either as isolated spheres within the impact glass or as spheres associated with fluidal schlieren-like traces of microspheres of the same FeNi material (Fig. 2A). A notable amount of predominantly small FeNi spheres ~1 µm in average diameter is commonly adhered to the internal surface of vesicles in the Wabar glass (Fig. 2A+B). In some cases, FeNi spheres are coated by an iron-rich and nickel-poor silicatic glass phase of meshed appearance (~57-62 wt% Fe_2O_3; ~31-34 wt% SiO_2; ~3-5 wt% CaO; ~1-3 wt% Al_2O_3; <1 wt% NiO; Fig. 2C). Some spheres contain inclusions of sulfides (Fig. 3C) or display surficial embayments. FeNi spheres that occur at vesicle boundaries sometimes display marks of flattening within the gas bubble; in turn, vesicles in contact to FeNi spheres also show signs of marginal penetration and compressive deformation (Fig. 2D). Moreover, three apparently cubic FeNi microcrystallites ~1 µm in size could be observed within an agglomerate of small-sized FeNi spheres in a vesicle.

Discussion and Suggestions: In addition to the highly variable contents of Fe and Ni in the metallic Wabar spheres, which was explained by the early fractionation of the Wabar meteorite upon impactor decompression [5;12] and the selective oxidation during melting and dissemination of the meteoritic melt droplets [4;10-12], the morphological variability of the FeNi spheres and vesicles might provide further clues to the rheologic and degassing behavior of the hot Wabar impact melt. FeNi spheres with schlieren-like traces of microspheres (Fig. 2A) and microspheres adhered to internal vesicle surfaces (Fig. 2B) indicate a liquid state of the impact melt during the incorporation and movement of the spheres. Likewise, the FeNi sphere-vesicle interaction - i.e., the compressional flattening of FeNi spheres by gas pressure at vesicle-melt interfaces along with the deformation of the vesicles by indentation (Fig. 2D) - suggests a highly dynamic liquid state of the whole impact melt system, maybe as an emulsion of meteorite melt in the degassing target melt. This also points to the influence of high temperature, high volatile content, high gas pressure, lowered viscosity, and differential surface tension effects within the poorly homogenized Wabar impact melt (see [4;12]).

The descriptive term ‘spherule’ (i.e., describing round, spherical-shaped particles of variable origin) is widely used in the impact- and cosmogeological context to describe recrystallized melt and/or condensed vapor droplets that generally obtain their shape during the flight through a gas medium like air, such as cosmic spherules (e.g., [13]) or microtektites and microkrystites (e.g., [14-16]). The term FeNi 'spherules' in the Wabar impact glass - that obviously never experienced free flight [12] (as is probably also the case at Henbury and Monturaqui) – might be misleading, and it is suggested to prefer the denomination meteorite-melt FeNi 'spheres' or 'droplets' as earlier done by [4].

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References: [1] Philby H. St. J. B. (1933) *The Empty Quarter*. Henry Holt, N.Y., 432 pp. [2] See T. H. et al. (1988) LPSC 19:1053-1054. [3] Murali A. V. et al. (1988) LPSC 19 :815-816. [4] Hörz F. et al. (1989) *Proc. LPSC* 19:697-709. [5] Mittlefehldt D. W. et al. (1992) *Meteoritics* 27:361-370. [6] Basurah H. M. (2003) *Meteoritics Planet. Sci.* 38:155-156. [7] Prescott J. R. et al. (2004) *J. Geophys. Res.* 109:E01008, 8 p. [8] Schmieder M. et al. (2009) LPSC 40, abstr. #1020. [9] Gnos E. et al. (2009) *Meteoritics Planet. Sci*. 44:A79 (supplement and poster presented at the 72nd Annual MetSoc Meeting, July 13-18, 2009, Nancy, France). [10] Brett R. (1967) *Amer. Mineralogist* 52:721-733. [11] El Goresy A. et al. (1968) In: French B. M. and Short N. M. (eds.) *Shock Metamorphism of Natural Materials*, Mono Book Corp., Baltimore, p. 531–554. [12] Gibbons R. V. et al. (1976) *Proc. LPSC* 7:863-880. [13] Taylor S. et al. (2000) *Meteoritics Planet. Sci*. 35:651-666. [14] Glass B. P. and Burns C. A. (1988) *Proc. LPSC* 18:455-458. [15] Simonson B. M. and Glass B. P. (2004) *Annu. Rev. Earth Planet. Sci*. 32:329-361. [16] Smit J. et al. (1992) *Proc. LPSC* 22:87-100.

Fig. 1: Polished section of marble-like bluish Wabar glass with impact-metamorphosed sandstone (white clasts) and numerous blasen and schlieren. Sample width ~5 cm.

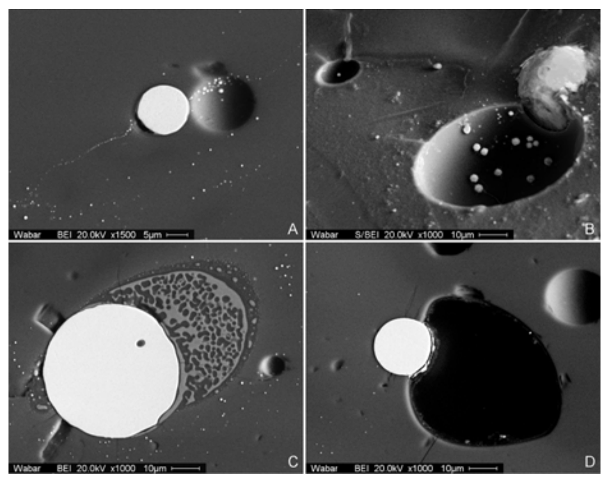

Fig. 2: Backscattered electron images of FeNi spheres in Wabar glass (obtained from sample shown in Fig. 1); A: undisturbed spherical-shaped FeNi sphere with schlieren-like trace of FeNi microspheres (left of large sphere) and microspheres adhered to a gas vesicle (right of large sphere); B: large sphere at vesicle interface (right) and FeNi microspheres at the internal surface of a vesicle (backscattered electron image merged with secondary electron image); C: FeNi sphere coated with Fe-Ca-Al-rich silicatic glass of meshed appearance (light grey) and sulfide inclusion (dark spot within sphere); D: FeNi sphere partially flattened at vesicle interface; also note the indentation-deformed vesicle.