(F)RIGN ZIRCON CONFIRMS FRIGN ZIRCON.

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Introduction: The recognition that zircon can undergo a variety of transformations during shock deformation has resulted in a rapidly evolving state of understanding for how this mineral responds to the extreme thermodynamic changes generated during meteorite impact [1]. Among the pantheon of different shocked zircon textures, FRIGN zircon is the most unusual type of zircon known [2]; it is formed by initial transformation of zircon to reidite [3], and the subsequent reversion of reidite back to neoblastic zircon [1] at temperatures >1200 °C [4]. A key requirement to identify a given granular zircon as FRIGN is to demonstrate the presence of systematic disorientation relationships of approximately 90°/<110> among zircon neoblasts, which are crystallographically inherited from the zircon-reidite transformation. What is now recognized as FRIGN zircon was first described at Meteor Crater [5], Acraman [1], Ries [3], and in Australasian tektites [6], prior to formalization of the FRIGN acronym [2]. FRIGN zircon has been documented from 20 published sites, most recently at the Gosses Bluff impact structure [7], and has been demonstrated to be a useful geochronometer for dating impact events [eg, 8, 9].

FRIGN without reidite? Reidite is not predicted to be preserved in FRIGN zircon [2], given its thermal instability in impact melt rocks [4]. The absence of reidite in FRIGN zircon has led to a proposal that formation of FRIGN zircon does not involve transformations to reidite [10]. The alternative model to form FRIGN zircon involves wholesale melting of zircon at T >2700 °C based on the inferred presence of an 'yttria' rim on zircon and <100 nm zirconia inclusions in zircon neoblasts. Most critically, the model proposed by [10] does not involve formation of reidite; the systematic orientation relations among zircon neoblasts are attributed to 'synneusis'. Here we refute the model of [10] that claims FRIGN zircon forms by melting of zircon and without involvement of reidite. The non-FRIGN model is flawed for the following reasons: The T estimate of >2700 °C is based on an erroneous identification of yttria; the thermal metastability of zirconia polymorphs at grain sizes <100 nm is unaccounted for; zircon does not 'melt' (it dissociates); and no adequate explanation is given for systematic orientation relations among zircon neoblasts that is founded in crystallography.

FRIGN with reidite: (F)RIGN. Over the last year, multiple reports have been published of FRIGN zircon grains that contain preserved reidite [7, 11, 12, 13, 14]. All of these occurrences are in various impact melt rocks from the Gosses Bluff [7], Mistastin [11], Rochechouart [12], Haughton [13] and Ries [14] impact structures. The preservation of reidite in FRIGN zircon, here denoted as (F)RIGN, given evidence of both former and present reidite, provides incontrovertible evidence for the role of reidite in formation of FRIGN zircon. In these cases reidite has been effectively 'frozen in', and thus did not complete the transformation to neoblastic zircon. These examples include a variety of textural observations of the progressive recrystallization of reidite to neoblastic zircon. Examples from Haughton include reidite-bearing zircon grains in the same sample as fully FRIGN zircon grains, demonstrating a close spatial association [13]. Examples from Rochechouart include non-granular zircon grains dominated by reidite lamellae and reidite 'wedges' that contain fractures filled with granular zircon in FRIGN orientation [12]. Examples from Mistastin include grains with cores of coherent reidite that appear to have fully transformed to reidite; tendrils of granular zircon with FRIGN orientations encroach from the grain exterior, overprinting reidite [11]. Examples from Gosses Bluff include fully granular FRIGN zircon grains that contain scattered 'islands' of reidite domains throughout [7].

Summary: The FRIGN zircon model offers a phase-equilibria and crystallography-founded explanation for the systematic orientation relations among zircon neoblasts found in granular zircon from impact melt rocks. FRIGN zircon has thus far only been reported from impact settings, and has been described at 20 of the ~200 confirmed terrestrial impact sites (~10%). Recent descriptions of reidite preserved within FRIGN zircon, here termed (F)RIGN zircon, provide the critical 'missing link' for the FRIGN zircon model, and uniquely identifies the role of reidite in its formation.

References: [1] Timms N. E. et al. (2017) *Earth-Science Reviews* 165:185-202. [2] Cavosie A. J. et al. (2018) *Geology* 46:891-894. [3] Erickson T. M. et al. (2017) *Contributions to Mineralogy and Petrology* 172:6. [4] Kusaba K. et al. (1985) *Earth and Planetary Science Letters* 72:433-439. [5] Cavosie A. J. et al. (2016) *Geology* 44:703-706. [6] Cavosie A. J. et al. (2018) *Geology* 46:203-206. [7] Cousins V. et al. (2022) *Meteoritics & Planetary Science* this volume. [8] Kenny G. G. et al. (2019) *Geochimica et Cosmochimica Acta* 245:479-494. [9] Erickson T. M. et al. (2020) Nature Communications 11:300. [10] Kovaleva E. et al. (2021) *Earth and Planetary Science Letters* 565:116948. [11] Tolometti G. D. et al. (2022) *Earth and Planetary Science Letters* 584:117523. [12] Plan A. et al. (2021) *Meteoritics & Planetary Science* 56:1795-1828. [13] Erickson T. M. et al. (2021) *Geochimica et Cosmochimica Acta* 304:68-82. [14] Stadermann A. et al. (2022) *Lunar and Planetary Science Conference* Abstract #2028.