A possible impact origin for the 1.6 Ga Wernecke Breccias in northern Yukon, Canada. J. Verbaas*[1], D.J. Thorkelson[1]. [1]Simon Fraser University, Department of Earth Sciences, 8888 University drive, Burnaby, British Columbia, Canada, *Corresponding author: jacobverbaas@gmail.com

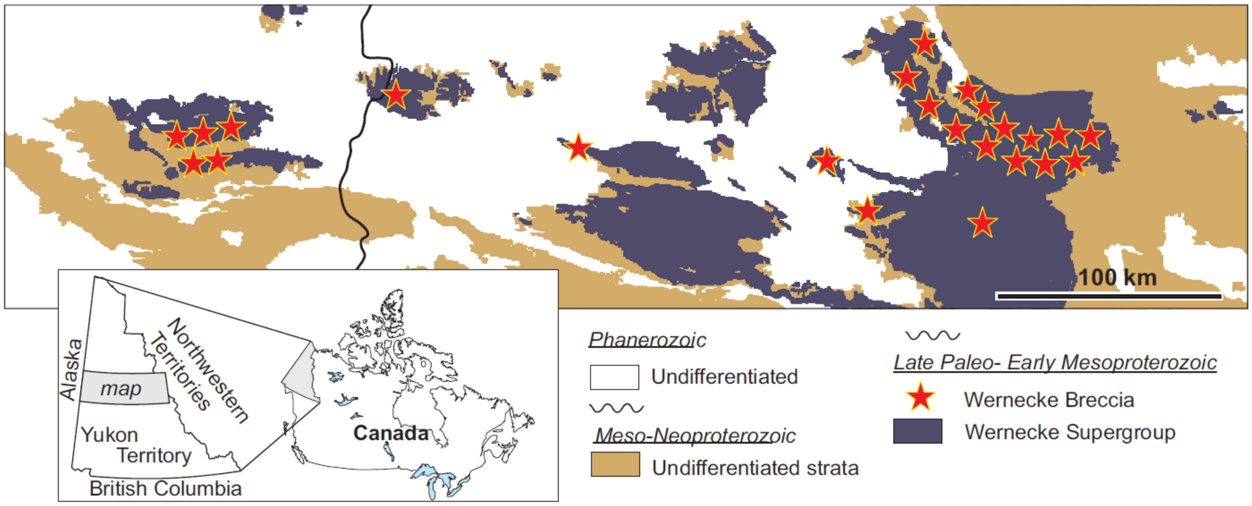

Fig 1; Map showing the extent and distribution of Wernecke Breccia zones

Introduction: The Wernecke Breccias are large, widespread zones of "hydothermal" breccia in northern Yukon, Canada [Fig. 1]. Here, we consider the possibility that these breccias were generated by an impact with a large meteor at the beginning of the Mesoproterozoic. The breccias consist of angular clasts surrounded by a matrix of hematite, quartz and other minerals. The clasts commonly range in size from 0.5-50 cm, but include megaclasts with lengths up to hundreds of metres [Fig. 2]. Many of the clasts are preserved at depths of several km beneath their points of origin, indicating significant downward travel of clasts within the breccias.

The breccias occur in zones that range in size from tens to thousands of metres. They crop out in curvilinear arrays over an area of over 300 x 150 km [1]. Many but not all of the zones are connected by faults. The breccia zones and the adjacent wallrock were clearly affected by hydrothermal activity, as indicated by the mineralogy of the matrix and numerous iron oxide-copper-gold mineral occurrences that lie within the breccias and adjacent wallrock. However, the cause of the hydrothermal activity, the relationship between the hydrothermal fluids and initial rock fragmentation, and the process of megaclast foundering, all remain enigmatic. No igneous activity of the same age, which could be invoked as a source of heat and fluid activity, has been identified, despite excellent exposure and numerous geological studies. We know of no modern or ancient analogues for a breccia-megaclast system of this size.

The breccias formed in a convergent setting at the beginning of the Mesoproterozoic (1599 Ma; U-Pb titanite) [2]. The convergent margin was located on the northwestern edge (in current coordinates) of the ancestral core of North America (Laurentia). At the time of breccia formation, the convergent margin consisted of crystalline basement of Laurentia overlain by folded and metamorphosed sedimentary strata (Wernecke Supergroup), and capped by an obducted volcano-plutonic terrane (Bonnetia). The continental margin was overlain by a succession of unlithified sediments, possibly on the floor of a shallow sea or lake [Fig. 3].

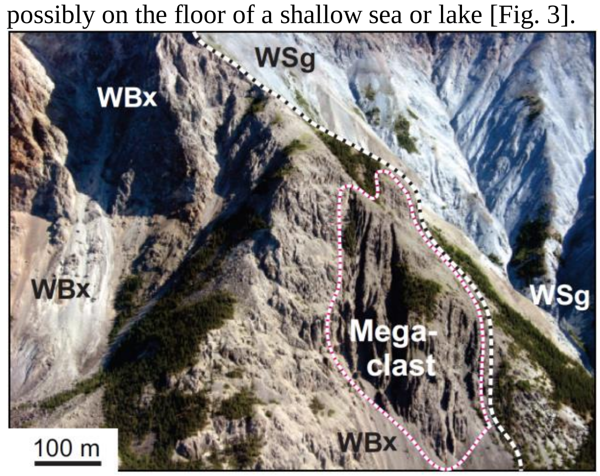

Fig. 2; Megaclasts in the Wernecke Breccia (WBx). The host rock is greenschist-grade metasedimentary rock of the Wernecke Supergroup (WSg).

Soft sediment textures: Recently, clasts exhibiting soft sediment deformation textures within the Wernecke Breccia were investigated. These soft sediment textures developed as the result of unconsolidated sediments foundering and flowing into the Wernecke Breccia zones during brecciation. The textures are direct evidence for breaching of the surface by the breccia zones [3].

Wernecke Breccia genesis: A model that can explain all features of the Wernecke Breccias needs to comply to the following conditions. First, it must accommodate the formation of clasts of up to hundreds of meters in size and their foundering into the breccia zones for several kilometres. Second, it must account for soft sediments being able to descend into the breccia zones and for these sediments to remain ductile until they came to rest deep within the crust. Third, the model must be able to explain the distribution of the breccia zones over a very large area [Fig. 1] in the absence of concurrent igneous activity.

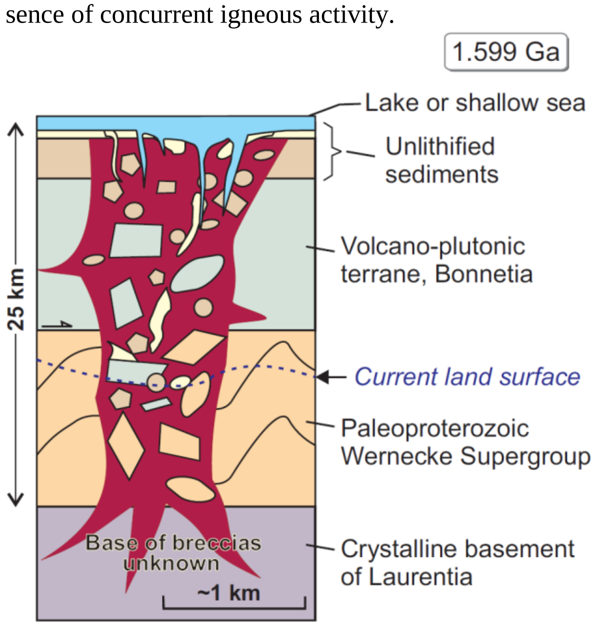

Fig. 3; Crustal column during brecciation. Soft sediments and rocks of Bonnetia foundered to the level of the Wernecke Supergroup. Note current erosion level.

Rapid brecciation: The occurrence of megaclasts and of clasts exhibiting soft sediment textures, both of which foundered several kilometres into the Wernecke Breccia zones is hard to explain by a geological process that occurs at tectonic speeds and low strain rates. Rather, in order to sustain enough open space for megaclasts to founder into the breccia zones, and in order to keep ductile sediments from lithifying at depths of several km, a large amount of energy must have been introduced into the crust in a short amount of time.

Sustaining open space: Field relations, mineralogy and geochemical studies indicate that the current exposures of the breccia zones developed at depths of 3-9 km, and have since been exposed by erosion.[4,5]. The lithostatic pressures at these depths would have been between 81 and 243 MPa, making it difficult for the breccia megaclasts to move large distances – certainly not on the order of kilometres. Importantly, faulting as a mechanism of transport is unlikely because fault fabrics are absent in the great majority of the breccia zones. These constraints point to significant but short-lived open space at the time of fragmentation. Specifically, we appeal to conduits up to hundreds of meters across that extended from the middle crust to the surface and were sites of transient open space .

As shown in Fig. 4, the Wernecke Breccias contain a range of clast types – igneous, sedimentary, metamorphic and soft-sediment. The Wernecke Breccias may be deeper and larger verions of polymictic clastic-matrix breccias described for the Slate Island impact structure. In this impact structure, clasts from different crustal levels mixed in tabular zones of up to one hundred metres across [6].

Possible impact scenarios: An impact, or several impacts could transfer enough energy into the Earth to rupture the crust, develop short-lived open space, and allow foundering of large clasts for several kilometres. In one scenario, all of the zones of the Wernecke Breccia were generated in ring fractures by a single, very large impactor. In another, the breccias were generated by a train of impacts related to a bolide that disintegrated upon entering Earth's atmosphere. In the single-impact case, the impactor must have been very large, given the broad distribution of the breccia zones [Fig. 1]. In the disintegrating bolide case, each Wernecke Breccia zone may have been formed by a separate impact. No sites of impact have been confirmed, and their identification may be hampered by both depth of erosion and widespread younger sedimentary cover. No direct evidence for an impact, such as shock metamorphism, shatter cones or pseudotachylite, has been identified, although their absence may be related to depth of erosion.

References:

[1] Thorkelson, D.J. et al. (2005) *Can. J. Earth Sci., 42, 1045-1071,*. [2] Furlanetto, F. et al., (2013) *Prec. Res. 224, 512-528.* [3] Verbaas, J. (2014) *Yukon Expl. and Geol.*; [4] Hunt, J.A., et al. (2011) *Can. J. Earth Sci. 48: 1425-1445*. [5] Nielsen A.B. et al. (2013) *Prec. Res., 238, 78-91.* [6] Dressler and Sharpton (1997) *Tectonophysics 275, 285-311*