Evidence for a second L chondrite impact in the Late Eocene: Preliminary results from the Wanapitei crater, Canada.
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Introduction: The Wanapitei impact structure (46°45´N; 80°45´W) is located 40 km NE of the city of Sudbury, Ontario, Canada. The 7 to 8 km in diameter crater is not exposed and lies completely within Lake Wanapitei [1]. The Wanapitei impact melt rocks contains about 1% of an extraterrestrial component and, based on Ni/Ir, Ni/Cr and Co/Cr ratios an L or LL chondrite projectile is advocated [2, 3, 4]. Two samples of impact-melt glass provide a K-Ar age of 37 ± 2 Ma [5]. Wanapitei crater is formed in the late Eocene, along with the two largest structures in the Cenozoic, the 100-km Popigai (35.7 ± 0.2 Ma) in northern Siberia and the 85-km Chesapeake Bay (35.5 ± 0.6 Ma) offshore Virginia. Enrichments in ^{3}He, detected in marine carbonates from the Massignano section in Italy, also characterizes the Late Eocene [6]. The possible higher impact rate and enhanced flux of interplanetary dust particles during that time are explained by either a comet shower caused by a perturbation of the Oort cloud [7] or an asteroid shower triggered by a major collision in the asteroid belt [8]. The latter interpretation is supported the identification of an L chondrite projectile for the Popigai crater [8].

Samples: To confirm the origin of the Wanapitei projectile, 10 samples of impact melt rock were analyzed for PGE by nickel sulfide fire assay combined with ICP-MS according to the procedure described in [8]. Siderophile elements (Ni, Co, Cr) were measured by ICP-MS. The samples were collected from glacial till, south of the Lake Wanapitei.

Results: In agreement with [2, 3, 4], the new data demonstrate the presence of an extraterrestrial component in the Wanapitei impact melt rocks (Fig. 1).

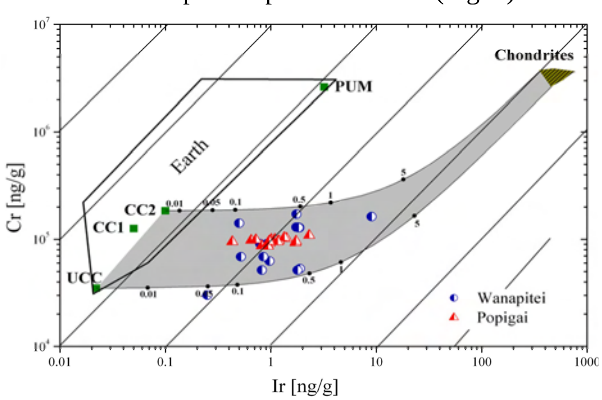

Fig 1. Log-log-plot of Cr vs. Ir concentrations of terrestrial lithologies compared to the composition of the Wanapitei and Popigai impact melt rocks. The gray field indicates the most likely mixing zones between chondritic projectiles and common terrestrial targets (described in detail by [9]). UCC = upper continental crust, CC = continental crust, PUM = primitive upper mantle.

The Cr and Ir values of Wanapitei and Popigai plot in the gray field representing the mixing "range" between upper continental crust and chondritic material.

Normalized to CI chondrite, the PGE compositions of the Wanapitei impact melt rocks display a flat elemental pattern, except for two samples enriched in Pt. The new analyses support the previous assumption of a chondritic projectile [2, 3, 4].

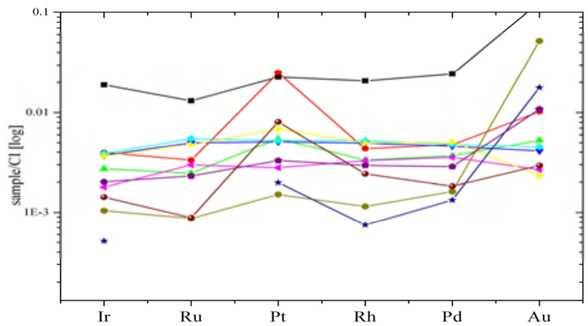

Fig. 2 CI norm. PGE and Au concentration in Wanapitei impact melt samples compared with data of [4] shown by gray stoppled lines.

The projectile identification is obtained by the linear regression method described in [8]. The linear correlation of Rh/Ir and Pd/Ir is show in Fig. 3 a, b. The correlation allows the determination of the projectile elemental ratio. The identification of the projectile is carried out by comparing the ratios with those obtained for different types of chondrites [10].

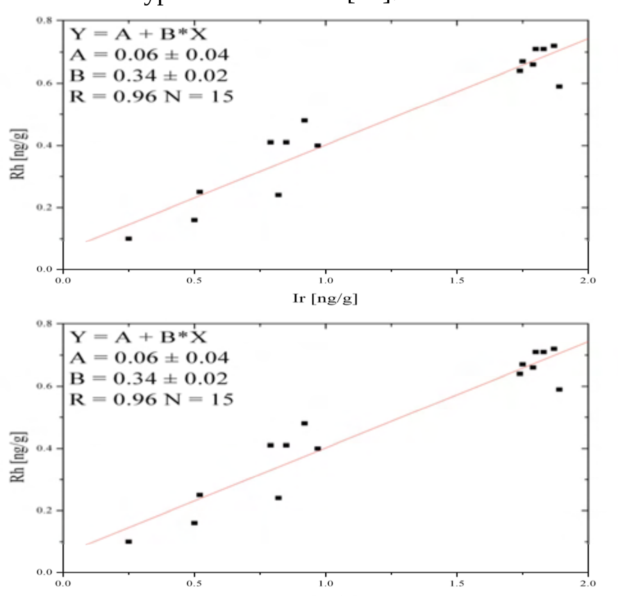

Fig. 3 a and b. Regression analyses of Rh and Pd vs Ir of the impact melt of Wanapitei. B represents the projectile elemental ratio.

The identification of the Wanapitei projectile is shown in Fig. 4. The elemental ratios of the Wanapitei projectile are almost identical to those previously obtained from the Popigai crater [8], and plot close to the field of the L-chondrite. The close similarity between the Wanapitei and Popigai projectiles indicates that they probably share the same origin in the asteroid belt.

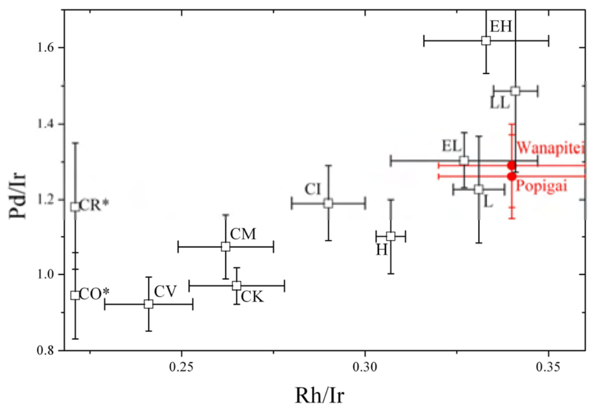

Fig. 4 *Comparison of the PGE "projectile elemental ratios" of the impact melt rocks of Wanapitei and Popigai with those of different types of chondrites calculated from the database of [10]. The error bars represents one standard deviation. (*Rh/Ir elemental ratio unknown).*

Discussion and Conclusion: In addition to Popigai, Chesapeake Bay and Wanapitei, the Mistastin and Haughton [11] craters also formed during the Late Eocene (Fig. 5). So far two craters, Popigai and Wanapitei were formed by the same type of projectile, an L chondrite, supporting the hypothesis that a major disruption of the L parent body triggered an asteroid shower in the Late Eocene.

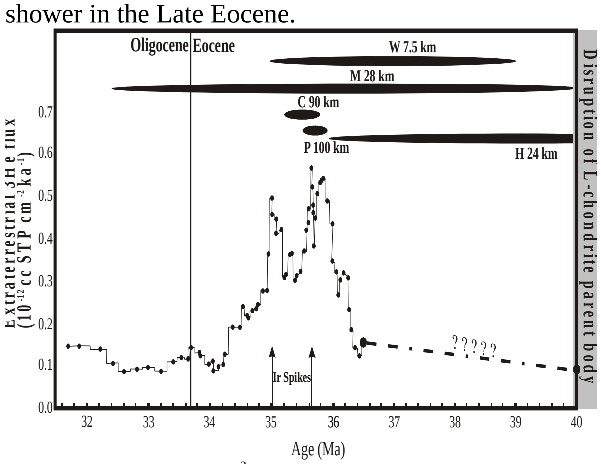

Fig. 5. Time correlation of ^{3}He and Ir enrichment in the sediments of Massignano, Italy [6] and impact craters, the size of the ellipses represents the error on the crater's ages, W = Wanapitei, M = Mistastin, C = Chesapeake Bay, P = Popigai, H = Haughton re-dated by [11]. Major collision in the L parent body is shown at 40 Ma. There is no ^{3}He data for the time between 40 Ma and 36.5 Ma.

The scenario of disruption of an asteroid with L chondrite composition is also compatible with the cosmic-ray exposure ages of L chondrite meteorites (Fig. 6).

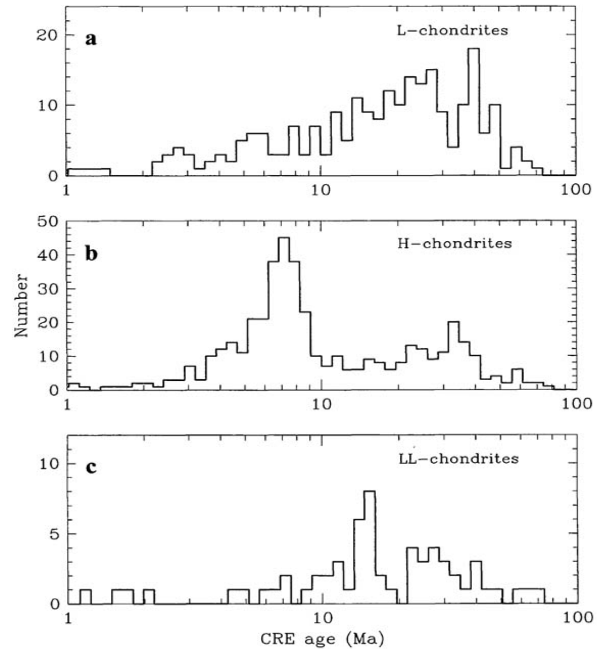

Fig: 6. Number of meteorites vs. cosmic-ray exposure age for ordinary chondrites, diagram from [12].

L chondrites meteorites appear to record a major event ~ 40 Ma ago, which is followed by an exponential decay due to dynamical half-life (Fig. 6 a) [12, 13]. This possible collision would be followed by an interval during which fragments were sent to an Earth crossing orbit, resulting in a coeval increase of the impact rate and ^{3}He delivery. The resulting asteroid shower may have lasted ~ 2.5 million years, as indicated by the spread of the ^{3}He anomaly in the Massignano sediments (Fig. 5). Identification of the projectiles responsible for the formation of the Chesapeake Bay, Mistastin and Haughton craters, and more precise dating of other impact structures with possible Late Eocene age, such as Logoisk (42.3 ± 1.1 Ma) may or may not confirm the hypothesis of a major L chondrite shower originating in the asteroid belt, some 37 million years ago.

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Ref: [1] Dence & Popelar (1972) Geol. Assoc. Can., Sp. Pap. **10**, 117-124. [2] Winzer et al. (1976) GCA **40**, 51-57. [3] Wolf et al. (1980) GCA **44**, 1105-1022. [4] Evans et al. (1993) GCA **57**, 3737-3748. [5] Grieve & Ber (1994) Meteoritics **29**, 621-631. [6] Farley et al. (1998) Science **280**, 1250-1253. [7] Tagle & Claeys (2004) Science **305**, 492 [8] Tagle & Claeys 2005 GCA **69**, 2877-2889. [9] Tagle & Hecht (subm.) MAPS [10] Tagle (2004) PhD. Humbold Univ. Berlin; [11] Sherlock et al. (in press) MAPS [12] Morbidelli & Gladmand (1998) MAPS **33**, 999-1016 [13] Marti & Graf (1992) Annu. Rev. Earth Planet. Sci. **20**, 221-43.