Ultra-high precision $^{40}Ar/^{39}Ar$ dating of impact events.

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Dating meteorite impact events is a challenging task, whether they occurred on Earth or on extraterrestrial bodies. Even more challenging is to obtain truly precise and accurate ages. Whereas $^{40}Ar/^{39}Ar$ results can be sometimes plagued by secondary geologic events (e.g., alteration on Earth; small subsequent impacts in space), they have the benefit to be able in most cases to directly date melt formation at the time of impact, and deliver precise and accurate results covering the entire geologic timescale, *provided* that proper plateau ages are obtained [1].

TERRESTRIAL IMPACTS: the number of impact events dated with a precision better than ± 2% is steadily, yet *very slowly*, growing. As of 2012, 18 impact structures were considered precisely dated [1], compared to 26 structures now. Recent additions include Araguhaina (254.7 ± 2.5 Ma; 2σ [2], then shifted to 262 ± 3 Ma [3] and 260.45 ± 0.67 Ma [4]), Lake St Martin (227.8 ± 0.9 Ma [5]), Dellen (140.82 ± 0.51 [6], Lappajärvi (76.20 ± 0.27 Ma [7], Clearwater 286.2 ± 2.2 Ma [8] and Paasselkä 231.0 ± 1.8 Ma [9]. Newly dated Quaternary impact events include the Australasian tektites (793 ± 14 ka; [10]) and Tenoumer (1.57 ± 0.14 Ma [11]), although their young ages make them harder to date with good precision. All these ages but one ([2,3]) have been obtained using the $^{40}Ar/^{39}Ar$ technique, albeit using a previous generation of machines. Recent developments in noble gas mass spectrometers have allowed a leap forward in terms of the analytical precision associated with $^{40}Ar/^{39}Ar$ ages. For example, we have obtained a weighted mean age of 14.808 ± 0.021 Ma for the Ries crater (compared to 14.85 ± 0.15 Ma [12]), and an age of 789 ± 3 ka (compared to 793 ± 14 ka [10]) measured on a series of Australasian tektites.

EXTRATERRESTRIAL: the ARGUS VI instrument allowed us to push toward increased precision, as well as much smaller sample quantity. For example, we have obtained an impact age of 2.3 ± 0.1 Ga for a 60 µm particle returned from Asteroid Itokawa by the Hayabusa spacecraft. In addition, we have obtained 9 impact ages with a weighted mean of 4500 ± 4 Ma from 9 individual components from three brecciated eucrites from Asteroid Vesta, suggesting a major impact at that time [cf. Kennedy et al., this workshop].

CONCLUSION: we will present a few cases showing the progress made in the $^{40}Ar/^{39}Ar$ dating of impact events, and what to expect in the coming years.

References: [1] Jourdan et al., Elements 2012; [2] Tohver et al., GCA 2012 ; [3] Erickson et al. Cont. Min. 2017; [4] Jourdan et al., unpublished; [5] Schmieder et al., EPSL 2014; [6] Mark et al., GLSP 2013; [7] Schmieder & Jourdan, GCA 2013; [8] Schmieder et al. GCA 2015; [9] Schwarz et al., MAPS 2015; [10] Schwarz et al., MAPS 2016; [11] Schultze et al. MAPS 2016. [12] Di Vincenzo & Skala GCA 2009.