PB-PB AGES OF CHONDRITIC PHOSPHATES. W.H. Schwarz[1], J. Hopp[1], T. Ludwig[1], A. Bouvier[2], M. Trieloff[1], N. Ma[2], H.-P. Gail[3], W. Neumann[1], [1]Institut für Geowissenschaften, Klaus-Tschira-Labor für Kosmochemie, Universität Heidelberg (Im Neuenheimer Feld 234-236, 69120 Heidelberg, Germany; winfried.schwarz@geow.uni-heidelberg.de). [2]Bayerisches Geoinstitut, Universität Bayreuth, Germany. [3]Institut für Theoretische Astrophysik, Zentrum für Astronomie (ZAH), Universität Heidelberg, Germany.

Introduction: Radiogenic isotope ages of chondrites provide constraints on the thermal histories of their parent bodies by determining the time when temperatures fall below distinct closure temperatures, e.g., for the Hf-W system at 1250 K, U/Pb-Pb ages of pyroxene at 1050 K, U/Pb-Pb ages of phosphates at 720 K, Ar-Ar of chondritic oligoclase feldspar at 550 K, or Pu fission track ages of merrillite at 390 K (e.g. [1-4]). While secondary ion mass spectrometry (SIMS) is routinely used for U/Pb-Pb dating of individual zircons, phosphates (being the major U bearing phase of chondrites) are more frequently dated by TIMS techniques (e.g., [2]) due to their respectively lower U and higher common Pb contents.

Samples and techniques: SIMS analyses were performed using the Cameca ims 1280-HR at University of Heidelberg (HIP). For U-Pb cross calibrations, we used Madagascar apatite (MAD; 485.0±1.7 Ma [5]), apatites from two anorthositic series from the Duluth Complex, Anorthosite Series (AS3; 1099±1 Ma) and Forest Center (FC1; 1094±34 Ma [5]) and Mount McClure apatite MMAp (523.5±1.5 Ma [5,6]).

For terrestrial apatite standards and preliminary chondritic apatite U-Pb-Pb measurements, we applied a ~10-50nA, 23 keV O^--primary ion beam with a diameter of 10-30 µm (10 µm pre-sputtering raster). Positive secondary ions were accelerated to 10 keV, nominal mass resolving power (MRP) was 5000 (reference peaks are $^{140}Ce^{40}Ca^{16}O_2$ or $^{40}Ca_2{}^{31}P^{16}O_4$, depending on the REE element abundance and appearance of isotopic interferences). The necessary U and Pb isotopes were measured in EM single collection mode using oxygen flooding to increase the Pb^+ yield. Each analysis comprised 20-30 cycles with a total integration time of 30-40min per analysis. Same conditions applied to Pb-Pb analyses of phosphates of Kernouvé and Estacado (H6), Allegan (H5), Blaubeuren (H4-5), acapulcoite Dhofar 125, Rumuruti and NWA 7514 (R), Tafassasset, NWA 12455, NWA 7317, NWA 11561 (CR6/7).

Results: Apatite standards were cross calibrated using MAD apatite as primary standard, yielding mean $^{206}Pb/^{238}U$ and concordia ages (Fig. 1) of 484.3±7.7 / 484.8±7.2 Ma (MAD), 1147±32 / 1138±25 Ma (AS3), 1071± 34 / 1071±18 Ma (FC1), 513±13 / 511±10 Ma (MMAp), with 2 sigma precisions of 1.6-3.2% these values are consistent with literature data [5,6]. ^{207}Pb-^{206}Pb ages could not be precisely evaluated due to the low ratio of radiogenic Pb to common Pb.

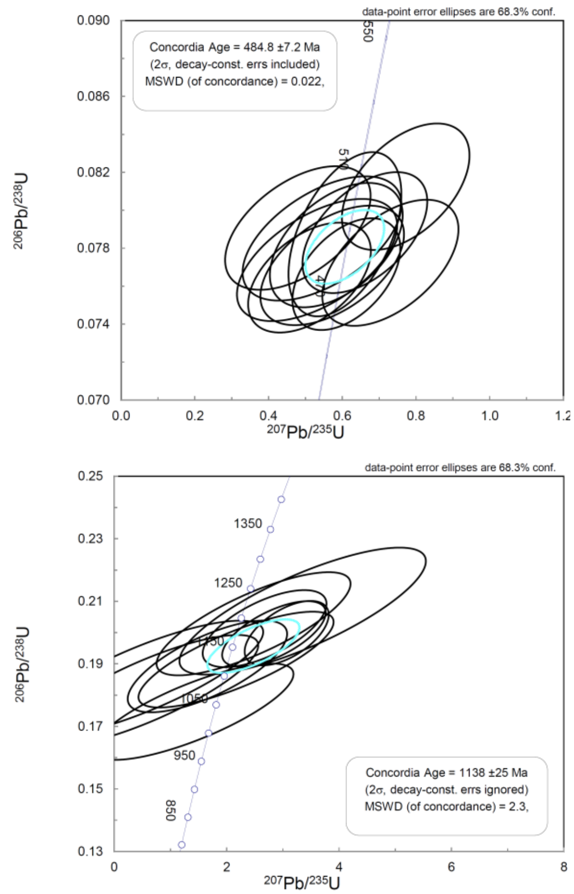

Fig. 1 Concordia plots of terrestrial apatite standards MAD (upper panel) and AS3 (lower panel). Error ellipses for individual grains (black) and average (blue).

For old chondritic phosphates with much higher proportions of radiogenic Pb, the situation concerning age errors is different: Here, $^{207}Pb/^{206}Pb$ ages are the most precise, followed by $^{207}Pb/^{235}U$ and $^{206}Pb/^{238}U$ ages. Hence, the discussion below focusses on $^{207}Pb/^{206}Pb$ ages only, which do not require standard calibrations.

The $^{207}Pb/^{206}Pb$ weighted mean ages (uncertainty: 1σ) of apatites from H6 Kernouvé (4517.9±7.1 Ma; n=6), H6 Estacado (4487.9± 6.2 Ma; n=11) and H5 Allegan (4556.8±13.4 Ma; n=5) agree well with TIMS values of 4522.5±1.4, 4491±8 and 4550.2±0.7 Ma [2] (TIMS uncertainties: 2σ), and are consistent with cooling curves constrained by radioisotope chronology and parent body modeling [1-3], see Fig. 2.

The mean Pb-Pb apatite age of the H4-5 breccia Blaubeuren (4530.3±6.4 Ma; n=12) is intermediate between H5 (4550 Ma - 4556 Ma [2]) and H6 ages (4491 Ma - 4523 Ma [2]). This points at secondary disturbances, maybe related to impact induced breccia formation, and needs to be further investigated by analysing lithologies of different petrologic type and/or additional isotopic dating.

Dhofar 125 apatite (4546.6±4.8 Ma; n=12) appears only slightly younger than the Pb-Pb TIMS age of Acapulco (4554.7±0.6 Ma), consistent with a generalized acapulcoite cooling curve [3], see Fig. 3.

In the case of Rumuruti, apatites generally displayed lower U contents. 21 analyses yielded a weighted mean of 4542.2±10.5 Ma, however, possible differences between different petrologic types still need to be investigated. Nevertheless, this age is in broad agreement with ^{40}Ar-^{39}Ar ages [7], and a new ^{53}Mn-^{53}Cr isochron age obtained by SIMS on olivine, implying early impact excavation and fast cooling of the Rumuruti breccia. We also obtained a weighted mean Pb-Pb age of 4534.8±8.8 Ma (n=6) for R5 NWA 7514 apatites ([U]≈2 ppm).

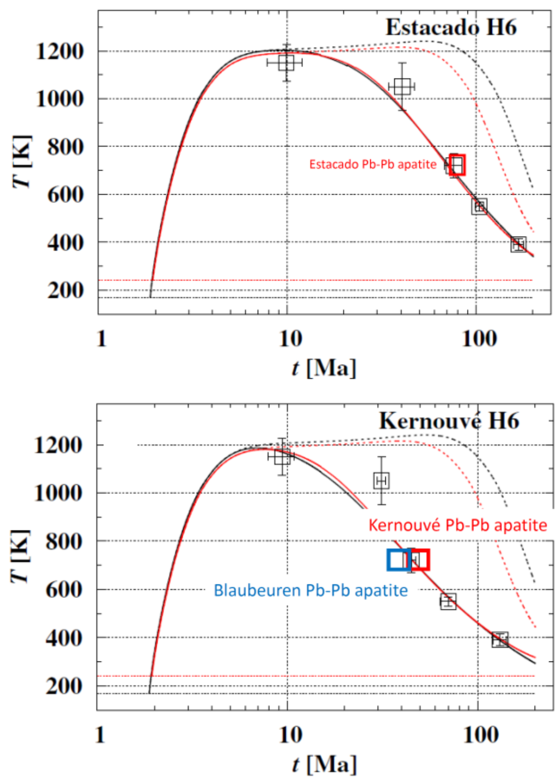

Fig. 2 Estacado (H6) and Kernouvé (H6) Pb-Pb apatite SIMS data agree with TIMS Pb-Pb data and are consistent with cooling curves constrained by Hf-W, Pb-Pb silicate, oligoclase Ar-Ar and ^{244}Pu fission track ages, in an optimized model of the H6 parent body [4]. Blaubeuren (H4-5) displays faster cooling than type H6.

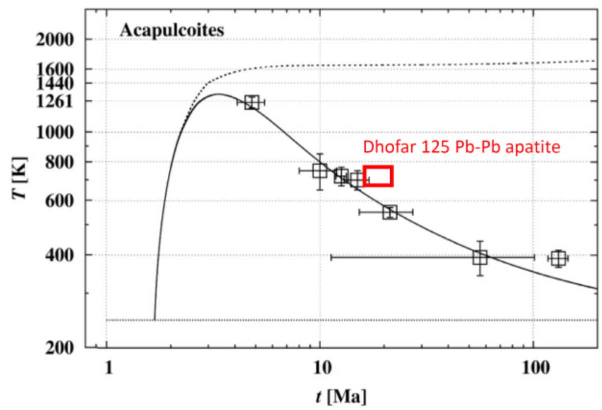

Fig. 3 Dhofar 125 Pb-Pb apatite SIMS data are consistent with the average acapulcoite cooling curve constrained by Hf-W, I-Xe feldspar/phosphate, oligoclase Ar-Ar and ^{244}Pu fission track ages, in an optimized model of the A-L parent body [3].

Finally, we measured Pb-Pb ages on merrillites ([U] ≈ 2-11 ppm) of Tafassasset classified as an ungrouped achondrite with affinities to CR chondrites based on O-Cr isotopic anomalies [8]. We find an average age of 4548.7±8.1 Ma (n=7) which is younger than its Hf-W, Mn-Cr, Al-Mg and Pb-Pb model ages ranging from 2 to 5 My after CAIs [8, 9]. We obtained precise Pb-Pb ages of merrillites for three CR6/7 chondrites NWA 12455 at 4558.4±2.5 Ma (n=16), NWA 7317 at 4560.1±2.9 Ma (n=10), and NWA 11561 at 4561.0±2.9 Ma (n=21) which may share a common and protracted thermal evolution history with Tafassasset.

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