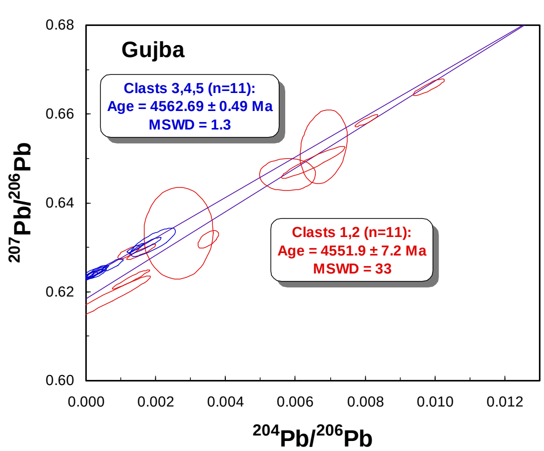
YOUNG PB-ISOTOPIC AGES OF CHONDRULES IN CB CARBONACEOUS CHONDRITES. Yuri Amelin[1] and Alexander N. Krot[2], [1]Geology Department, University of Toronto, and Geological Survey of Canada, 601 Booth St., Ottawa, ON, Canada, K1A 0E8, yamelin@nrcan.gc.ca, [2]Hawai‘i Institute of Geophysics and Planetology, SOEST, University of Hawai‘i at Manoa, Honolulu, HI 96822, USA, sasha@higp.hawaii.edu.

Introduction: CB (Bencubbin-type) carbonaceous chondrites differ in many ways from more familiar CV and CO carbonaceous chondrites and from ordinary chondrites [1-8]. CB chondrites are very rich in Fe-Ni metal (50-70 vol%) and contain magnesian silicates mainly as angular to sub-rounded clasts (or chondrules) with barred olivine (BO) or cryptocrystalline (CC) textures. Both metal and silicates appear to have formed by condensation. The sizes of silicate clasts vary greatly between the two subgroups of CB chondrites: large (up to one cm) in CB_a chondrites, and typically to <<1 mm in CB_b chondrites. The compositional and mineralogical differences between these subgroups and between the CBs and other types of chondrites suggest different environment and possibly different timing of chondrule formation [4, 5, 7, 8].

In order to constrain the timing of chondrule–forming processes in CBs and understand genetic relationship between their subgroups, we have determined Pb-isotopic ages of silicate material from the CB_a chondrite Gujba and CB_b chondrite Hammadah al Hamra 237 (HH237 hereafter).

Pb-isotopic results for Gujba: Five silicate clasts having BO textures extracted from Gujba were characterized by SEM and EPMA [8]. Each clast was coarsely crushed, and three or more fragments devoid of visible terrestrial weathering effects from each clast were washed in distilled acetone, followed either by repeated ultrasonic agitation in 2M HCl and 1M HBr or by heating in 7M HNO_3 and 6M HCl. Fractions containing 50-300 pg of Pb were analyzed using a two-step static multicollector procedure on a Triton TI mass spectrometer at the Geological Survey of Canada. The results are summarized in the isochron diagram below:



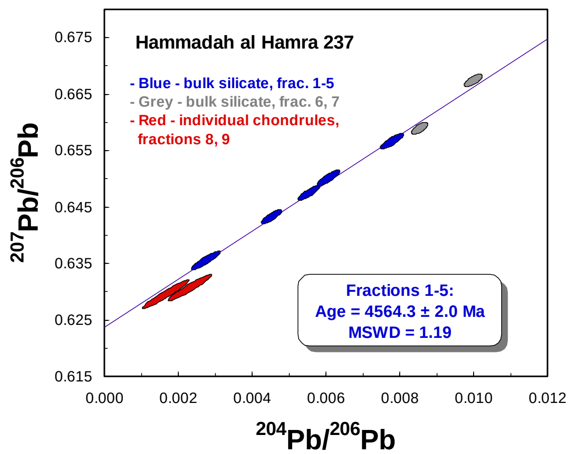
Fragments from silicate clasts 3, 4 and 5 produced highly radiogenic Pb-isotopic analyses with measured $^{206}Pb/^{204}Pb$ ratios of 307-2602 (four out of 11 analyses yielded $^{206}Pb/^{204}Pb>1000$). The common Pb content in most of these fractions is close to analytical blank, therefore the influence of common Pb heterogeneity on the age calculation is very small. Isochron regression of these data yielded an age of 4562.7±0.5 Ma (MSWD=1.3), which we consider the best estimate for the timing of formation of the Gujba silicate clasts.

Eleven fractions from the clasts 1 and 2 produce a scattered array, which yields an errorchron date of 4551.9±7.2 Ma (MSWD=33). One fraction from the clast 1 plot on the isochron defined by clasts 3, 4 and 5, whereas all the other analyses plot below that isochron. The $^{207}Pb/^{206}Pb$ ratios in highly radiogenic analyses from the clasts 1 and 2 are dispersed as much as less in radiogenic analyses. This dispersion thus cannot be explained entirely by common Pb heterogeneity. It indicates variable ancient loss of radiogenic Pb from clasts 1 and 2, which can be a result of shock metamorphism experienced by Gujba [9]. The consistency of radiogenic $^{207}Pb/^{206}Pb$ between the fragments of clasts 3, 4 and 5, on the other hand, strongly suggests single-stage evolution without noticeable influence from the secondary processes, because there are many factors (e.g., grain size, mineral composition, fracturing) that make shock- or alteration-related Pb-loss vary, but there is no process known to stabilize the degree of secondary Pb-loss.

Pb-isotopic results for HH237: Three methods were used for separation of silicate fractions from HH237. Fractions 1-5 were separated by dissolution of metal from a coarsely crushed bulk meteorite in ~2M HCl during 48 hours, with subsequent removal of remaining metal and other magnetic material by a hand magnet and hand-picking under a binocular microscope. Fractions 6 and 7 were separated from more finely crushed meteorite material by a hand magnet. In addition, two large individual chondrules (8 and 9) were extracted from a polished meteorite slab using dental tools.

Each silicate fraction was cleaned by sequential leaching in hot 7M HNO_3 and 6M HCl. The HNO_3 and HCl were collected separately and analyzed for Pb isotopes along with the residues. Leaching residues contain relatively radiogenic Pb with measured $^{206}Pb/^{204}Pb$ ratios between 97-405. The first (HNO_3) leachates contain almost entirely “modern” common

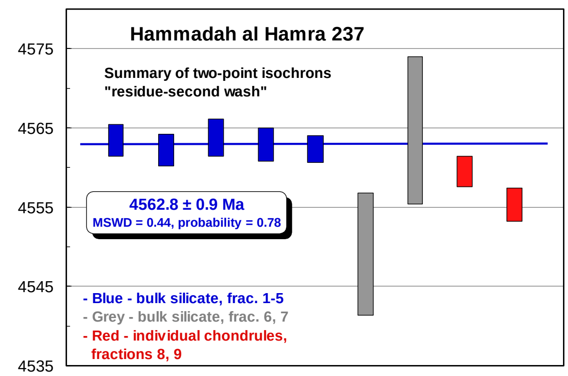
Pb ($^{206}Pb/^{204}Pb$ between 16.9-22.8), whereas the second (HCl) leachates contain a mixture of common Pb and radiogenic Pb ($^{206}Pb/^{204}Pb$ between 30-85). The Pb isochron results for the residues are shown in the isochron diagram below:



An isochron regression for five fractions extracted by metal dissolution (blue symbols) yields the age of 4564.3±2.0 Ma (MSWD=1.19). Although this regression has no scatter exceeding analytical errors, the precision of the age is compromised by extrapolation of the error envelope from moderately radiogenic Pb-isotopic data to the y-axis.

Two bulk silicate fractions extracted by magnetic susceptibility (6 and 7, grey symbols) yielded slightly less radiogenic Pb analyses. The analyses of individual chondrules (8 and 9, red symbols) yielded more radiogenic Pb, but lower $^{207}Pb/^{206}Pb$ ratios, which are inconsistent with the isochron for the fractions extracted by metal dissolution. This pattern can be explained if the HH237 silicates are pervasively affected by a secondary process, possibly similar to the process that influenced the Gujba clasts 1 and 2 (i.e., shock metamorphism [10]). Minerals produced or modified by shock metamorphism have lost their earliest accumulation of radiogenic Pb, and their presence forces the $^{207}Pb/^{206}Pb$ ratios down. It is possible that these minerals were converted to an acid-soluble form by a prolonged (48 hours) contact with HCl during metal dissolution, whereas a shorter (several hours) hot-acid washing alone does not dissolve them completely.

Determination of precise and accurate Pb-isotopic age in the presence multiple common Pb components and secondary alteration effects is difficult. Since the fractions extracted by metal dissolution appear to contain no secondary material, we can try to improve precision by considering two-point and three-point leachate-residue isochrons for individual fractions. This approach is based on the assumption that one of the common Pb components is more acid-soluble than the other. In this case, the more soluble component is removed by the first leaching step, whereas the second leachate and the residue would contain only the second, relatively insoluble common Pb component. The two-point isochrons for "residue-second wash" pairs for individual fractions would then give accurate and consistent dates, even if the isotopic composition of the second common Pb component varies between the fractions, and regressing all residue and second wash data together may not produce a valid isochron. If our assumption is wrong, then the two-point isochron dates would be scattered. A summary of two-point isochron dates:



shows that all the two-point isochrons for "residue-second wash" pairs for fractions 1-5 give consistent results. Their weighted average of 4562.8±0.9 Ma (MSWD=0.44) is our current best estimate for the timing of formation of the HH237 silicates. This result is consistent with the less precise Pb-Pb isochron dates for the fraction 1-5 residues, and with the combined isochron date for the fraction 1-5 residues (above) and second washes (4564.1±4.2 Ma, MSWD=7.5).

Conclusion: Our results establish simultaneous (and therefore probably co-genetic) origin of both subgroups of CB chondrites, and confirm young age of CB chondrites relative to primitive ordinary and CV chondrites.

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References: [1] Weisberg M. K. et al. (2001) *MAPS, 36*, 401-418. [2] Meibom A. et al. (2001) *JGR, 106*, 32,797-32,801. [3] Campbell A. J. et al. (2001) *GCA, 65*, 163-180. [4] Krot A. N. et al. (2001) *Science, 291*, 1776-1779. [5] Campbell A. J. et al. (2002) *GCA, 66*, 647-660. [6] Krot A. N. et al. (2002) *MAPS, 37*, 1451-1490. [7] Rubin A. E. et al. (2003) *GCA, 67*, 3283-3298. [8] Krot A. N. et al. (2004) *MAPS, 39*, A56. [9] Weisberg M. K. and Kimura M. (2004) *LPSC, XXXV*, #1559. [10] Meibom A. et al. (2005) *MAPS, 40*, in press.