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Shock-metamorphosed zircons from the Jack Hills metaconglomerate in the Narryer Gneiss Complex, Western Australia

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An intense flux of extraterrestrial bodies into inner solar system during ca. 3.8-4.1, called as Late Heavy Bombardment (LHB), has been hypothesized originally from studies of the Moon. Extraterrestrial impacts by meteoritic bodies and comets on the early Earth play a significant role for the initial state of crustal, atmospheric and biological evolution. Considering the planetary size, the Earth should have suffered approximately 20 times the impact flux compared to the Moon. Ancient terrestrial evidence of impact in the early Earth is, however, scarcely preserved due to surface erosion, sedimentary burial and tectonic destruction. To date, the oldest impact structure on the Earth is the 2.02 Ga Vredefort Dome, South Africa, and another oldest evidence of impact is 3.47-3.24 Ga spherule layers in the Barberton Greenstone Belt, South Africa. The impact chronology from these spherule layers suggest that the impact flux was significantly higher 3.5 Ga than today, but there are no terrestrial evidence of impact prior 3.5 Ga.

Geological information during Hadean era (before 4.0 Ga) can be deduced from detrital zircons as old as 4.4 Ga preserved in metasedimentary rocks at Jack Hills in the Narryer Gneiss Complex, Western Australia. Previous studies have reported that the Jack Hills metasedimentary rocks contain detrital zircons with ages continuously spanning from ca. 3.0 up to 4.4 Ga, but evidence of impact, such as shock-metamorphosed minerals, have not been confirmed. In the study we first report shock-metamorphosed detrital zircons from the Jack Hills metaconglomerate, in the Narryer Gneiss complex, Western Australia. A total of 8993 detrital zircons were investigated for the surface and internal structure using a scanning electron microscope and optical microscope with/without acid treatment, and four types of shock-metamorphosed zircons were currently identified; (1) curvi-planar (non-planar) feature (n = 6), (2) multiple sets of planar feature (n = 7), (3) partly granular (polycrystalline) texture (n = 2), and (4) fully granular texture (n = 10). Of these four, multiple sets of planar feature are proved for diagnostic evidence for impact origin, and now observed as annealed (decorated) planar feature, probably due to post-impact thermal heating or regional metamorphic overprint. Coarse polycrystalline zircon represents several micro-meter sized crystallites in a glassy $ZrSiO_4$ matrix that may resulted from shock-induced amorphization and subsequent recrystallization. This grain shows abundant micro-vesicles and tiny $ThSiO_4$ phase suggesting incipient melting and degassing.

Shock-metamorphosed zircons are often utilized for impact-dating due to their partly or completely Pb-loss (age resetting). Therefore, impact age determinations on shock-metamorphosed detrital zircons from the Jack Hills metaconglomerate would provide significant clues not only for the deciphering the impact history on the early Earth but also for the verifying LHB hypothesis.