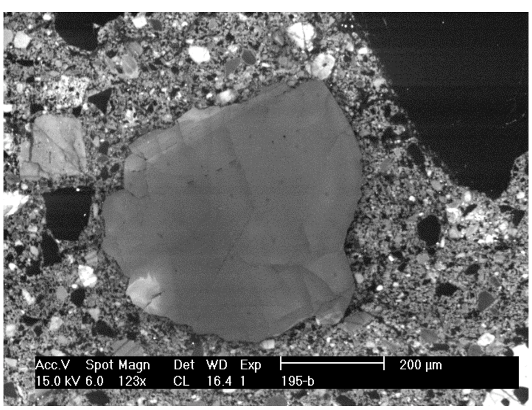
EVENTS IN THE LIFE OF THE OLDEST ZIRCON ON THE MOON: A COMBINED SIMS, CL, EBSD AND RAMAN STUDY. R. T. Pidgeon[1a], A. A. Nemchin[1], M. Grange[1], N.Timms[1], [1]Department of Applied Geology, Curtin University, Kent Street, Bentley, WA 6102, Australia ([a] r.pidgeon @curtin.edu.au)

Introduction: Zircon has been identified in a number of KREEP-rich breccias in lunar samples. Precise U-Pb isotopic analyses of these grains began in the 1980's, with the development of the SHRIMP ion microprobe [1,2] and zircon U-Pb geochronological research since this time has revealed a complex history of lunar magmatism beginning at c 4.42 Ga, the age of the oldest zircon on the moon [3] and ending at c. 3.9 Ga, the age of the later heavy bombardment [4]. An important question that needs to be resolved is whether magmatic events dated by zircon are impact related or represent endogenic lunar igneous activity. In most cases information is not available to resolve this issue but where SHRIMP U-Pb measurements are made on skeletal zircons that crystallized in cooling impact induced melt the zircon age clearly dates an impact event. A second possibility for dating an impact is by investigating the U-Pb age pattern in a zircon that has been disturbed by one or more impacts. This is less straightforward and to unravel the history of such grains it is necessary to apply a combination of optical and cathodoluminescence (CL) imagery, electron backscattered diffraction (EBSD) and Raman spectroscopy besides SIMS U-Pb measurements. In this contribution we describe results using these techniques on the oldest lunar zircon found so far [3]. This c. 4.42 Ga grain from the matrix of Apollo 17 breccia sample 72215,195 contains evidence of its igneous origin and also of one or more later impact events.

The c. 4.42 Ga lunar zircon: The location of this zircon in the breccia matrix is shown in the following CL image. The grain is a broken fragment , about



500µm in diameter, with an equidimensional, rounded form suggesting mechanical abrasion during transport. The main body of the grain has a uniformly low CL intensity and grey-pink birefringence indicating extreme radiation damage. Exceptions are a small bright (CL) patch on the left side of the grain and a bright linear sliver along the top. The grain does not have PDFs or other structures indicative of severe impact.

SHRIMP U-Pb measurements: A total of 41 SHRIMP U-Pb isotopic measurements were made on this grain. The $^{207}Pb/^{206}Pb$ ages vary within the grain from 4.42 Ga in two areas in the centre to 4.35 Ga in areas of bright CL. The inhomogeneous age distribution is attributed to an impact event at c. 4.35 Ga. The reduction in $^{207}Pb/^{206}Pb$ age is due to the progressive and incomplete removal of radiogenic Pb from the zircon, despite the grain having little radiation damage. Whereas it would appear at first sight that only Pb has been lost from the grain it can be demonstrated from a plot of $^{207}Pb/^{206}Pb$ age versus U and Th that some loss of these elements has also occurred in areas of bright CL.

EBSD and Raman measurements: EBSD, optical birefringence and Raman intensity maps and the distribution of U and Th, show an identical pattern delineating the distribution of radiation damage in the grain. A comparison of this pattern with the Pb-Pb age distribution shows that these are not the same indicating that Pb loss occurred independently of the distribution of U and Th and the radiation damage at c. 4.35 Ga. The Raman width data confirm the highly radiation damaged structure of the zircon. By comparison with Raman data from unannealed zircon grains it is evident that radiation damage in the c. 4.42 Ga grain has been annealed by a later event.

History of the c. 4.42 Ga zircon: A combined SIMS, CL, EBSD, Raman and optical investigation has revealed a complex history for the grain from initial crystallization at c. 4.42 Ga, severe chemical disturbance at c. 4.35Ga and a number of impact and transport events culminating in final deposition and annealing at c. 3.8 Ga.

References: [1] Compston W. et al. (1984) *JGR*, 89, B525-B534. [2] Pidgeon R.T. et al. (2010) *Precam. Res*., 44-49. [3] Nemchin A.A. et al. (2009) *Nature Geosc.,*2, 133-136. [4] Nemchin A.A. et al. (2008) *Geochim. Cosmochim. Acta*. 72, 668-689.