

A FURTHER INVESTIGATION OF THE EXCEPTIONAL ZIRCON AGGREGATE IN LUNAR THIN SECTION 73235,82. R.T. Pidgeon,¹ A.A. Nemchin,² C. Meyer,³

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Introduction: Smith *et al.* [1] described an exceptional zircon assemblage in thin section 82 from lunar breccia 73235 which, in transmitted light, resembles a cluster of pomegranate seeds, situated in a clast dominated by bytownite (Fig.1). They reported that high-contrast back-scattered electron (BSE) images of the zircon assemblage clearly show an overgrowth around most of the crystals. Most significantly these authors reported that the age of the rims of ca 4.18Ga is 120 million years younger than age of the interiors, dated at ca 4.31Ga. Smith *et al.* [1] concluded that ca 4.31 billion years ago a relatively large (500+micron) zircon crystallized within a clast of Ca rich plagioclase. The zircon was fractured into numerous smaller crystals and was subsequently overgrown by a second generation of zircon at approximately 4.18Ga.

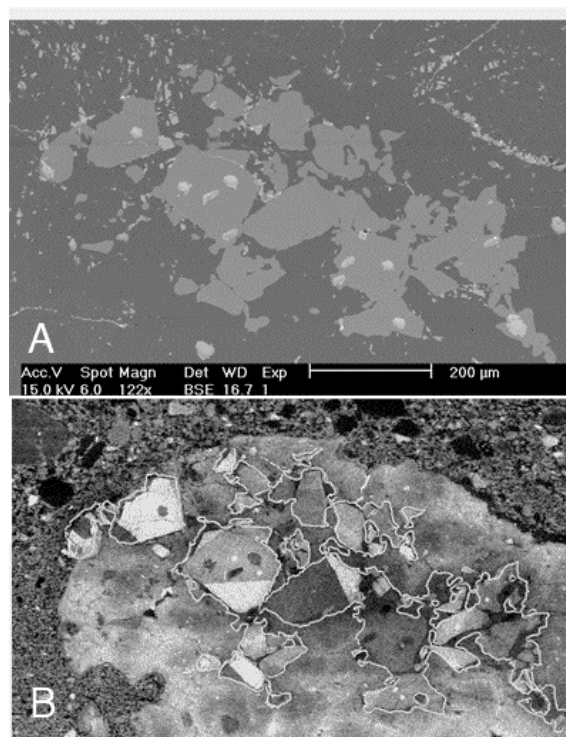


Fig.1 BSE image A shows the irregular shape of the zircon aggregate (light grey). White ellipses are SHRIMP analytical areas. The CL image of the same area (Fig.1B) shows the rounded outline of the light grey (CL) plagioclase-bearing host "clast". The zircon aggregate, seen on Fig.1A, is outlined on Fig.1B by an artificial white line.

The complex assemblage of zircons described by Smith *et al.* [1] (Fig.1) is unlike any other zircon occurrence known to the authors in terrestrial or lunar rocks and we report new SHRIMP analyses and cathodoluminescence (CL) imagery and speculate on the origin of the assemblage.

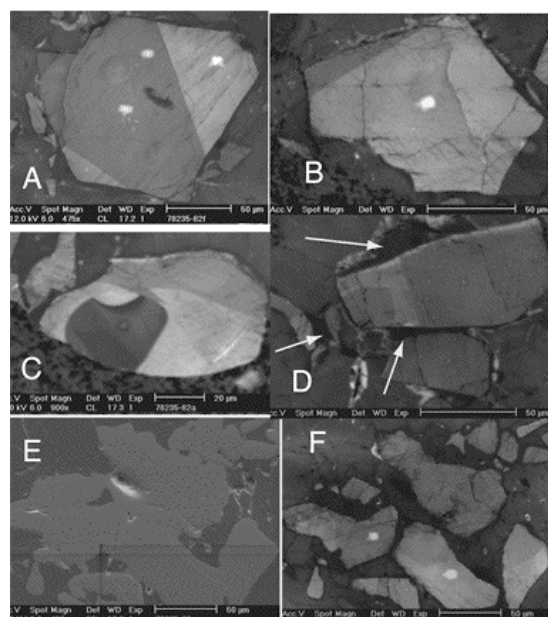


Fig.2 CL and SE imagery of selected grains and parts of the aggregate. Arrows (D) indicate areas of dark CL secondary zircon

Structure of the aggregate: The CL image shows that the aggregate consists of zircon fragments that are subdivided into domains or zones, which vary in U and Th and CL from one zone to another (Fig.1) but, within any one zone, the CL (Fig.2 A,B,C and D) and concentrations of U and Th are uniform. These are the earliest features evident in the fragments and are interpreted as primary zones. Individual fragments, including the zones, are crossed by sets of fine, approximately parallel fractures (e.g. Fig. 2A). These do not resemble the distinct planar structures found in a number of shocked zircons [3], but, we agree with Smith *et al.* [1], that these are probably related to shock. In addition, birefringence images of some fragments show fine parallel lines which can be interpreted as shock induced planar deformation features. Surrounding the zoned primary grains are areas of

zircon, shown by arrows on Fig.2D, which show no CL response. This dark CL zircon has a sharp but irregular, crosscutting boundary with the primary fragments and encloses some small fragments entirely. This is shown on Fig.2E and F which are a SE image (E) and a CL image (F) of the same area of the aggregate. As shown on Fig.2F, the secondary zircon forms around fractured grains that have been relatively displaced one against another, as indicated by the non-continuity of zones in the individual fragments. The zircon fragments are irregular in size and outline and the overall texture appears more like a crushed aggregate set randomly in cement (Fig.2F).

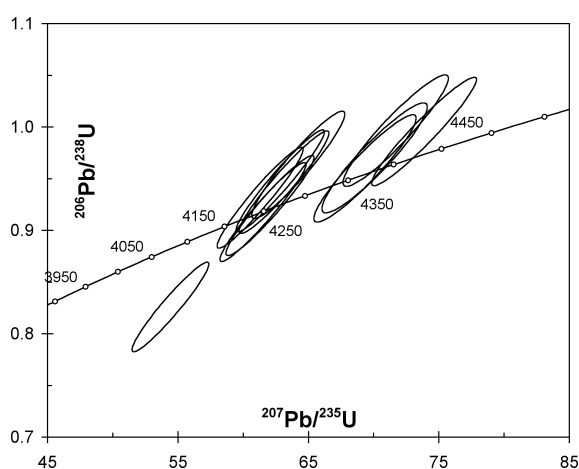


Fig.3 Concordia showing Curtin SHRIMP U-Pb data for the primary (4.31Ga) and secondary (4.18Ga) zircon.

Curtin SHRIMP data: Curtin SHRIMP U-Pb results, shown on the concordia plot (Fig.3), confirm the two ages of 4.31Ga for primary zircon fragments and 4.18Ga for the surrounding secondary zircon “cement” previously reported by Smith *et al.* [1].

The primary zircon has a consistent initial Th/U ratio of 0.21 to 0.35. The secondary zircon has a similar Th concentration to the primary zircon but has a distinctly higher and non systematic U concentration. Space limitations prevent discussion of other chemical signatures of the aggregate reported by [1], REE determined by [2] and oxygen isotopes and REE determined by ourselves.

Origin of the zircon aggregate: Our observations that the zircon aggregate represents a multitude of shattered fragments of primary zircon contained within a matrix of secondary zircon differs from the explanation by Smith *et al.* [1] that the secondary zircon forms as overgrowths on shattered fragments of original zircon. A closer analogy for the structure

of the aggregate is that of a micro-scale pseudotachylite. [3,4]. Pseudotachylite is considered a common shock phenomenon [3,4] and one explanation for the observed aggregate is that a large zircon experienced an intense shock resulting in fracturing of the zircon followed by partial melting, which in turn was followed by rapid solidification to form secondary zircon glass, resulting in the observed apparent fracture-filled structure. Volatilization loss of Pb accompanied flash melting and U, from melted high U parts, or from a source external to the zircon, was disseminated throughout the molten zircon.

Under this model the age of 4.31Ga for the zircon fragments dates the initial crystallization of the zircon in an anorthositic magma and the age of 4.18Ga for the matrix zircon dates the major impact responsible for the microscale “pseudotachylite” zircon structure. The shock associated with the ejection of the rock during the Imbrium impact at ca 3.85Ga has not been registered by the zircon U-Pb systems.

References : [1] Smith J.M., *et al.* (1986). *LPS XVII*, 805-806. [2] Ireland T.R. and Wlotzka F. (1992) *Earth&Planet.Sci Letts*, 109,1-10. [3] Reimold W.F. (1995) *Earth-Sci. Rev.*,39,247-265. [4] French B.M. (1989) *Traces of Catastrophe*, LPI Contribution No 954.