

## **Appendix II**

### **Description of Detrital Zircon Populations**

#### **Appendix to Chapter 6**

##### **Description of Zircon Grains**

Zircon populations and the physical characteristics of zircons that were separated from siliciclastic units of the Wolkberg Group and Transvaal Supergroup are described here in this appendix.

##### **· Schelem Formation (Figs 6.13 and 6.16)**

There are 3 concordant zircons (20, 23 and 47) in the 2850-2880 range. Zircon 20 is 175micron in length, subrounded but of low sphericity, and oscillatory zoned. Zircon 23 is 102micron in length, rounded and zoned. Zircon 47 is 395micron in length, subrounded and unzoned. The size and texture of these zircons vary significantly, possibly indicating that first as well as later order zircons are present.

There are 8 concordant zircons (1, 37, 39, 43, 50, 51, 52 and 55) between 2900 and 2950Ma. Zircon 1 is 124micron in length, very angular to angular and zoned. Zircon 37 is 102micron in length, very angular and zoned. Zircon 39 is 153micron in length, angular and zoned. Zircon 43 is 158micron in length, rounded, and have a core and an unzoned rim. Zircon 50 is 282micron in length, well rounded and unzoned. Zircon 51 is 232micron in length, rounded and unzoned. Zircon 52 is 311 micron in length, subrounded and unzoned. Zircon 55 is 153 micron in length, rounded, equant and zoned. The zircons of this population vary in length from 102-311micron with an average length of 189micron, in texture from angular to well rounded and are both zoned and unzoned. The variance in all these characteristics suggest that primary as well as later order zircons are present, and also that zircons of the same age may be coming from different source areas.

There are four nearly concordant zircons (4, 17, 29, 34) in the population between 2970-3010Ma. Zircon 4 is 147micron in length, very angular and display a weak zoning. Zircon 17 is 113micron in length, subrounded and unzoned. Zircon 29 is 141micron in length, subangular and zoned. Zircon 34 is 107micron in length, rounded, almost equant and zoned. The zircons of this population vary in size between 107 and 147micron, are angular to rounded and zoned as well as unzoned. The variety in textures suggests that these zircons may have been derived from different source areas.

There are three nearly concordant zircons in the 3170-3230Ma range (40, 42 and 48). Zircon 40 is 90 micron in length, angular to subangular and unzoned. Zircon 42 is 130micron in length, rounded and appears oscillatory zoned. Zircon 48 is 232micron in length, displays the euhedral character of the original zircon crystal, and is oscillatory zoned. These zircons vary in length from 90-232micron and in texture from well rounded to almost euhedral, which indicates heterogeneity of source areas for these zircons, as well as primary and later cycle zircons.

The oldest grain 36.1 ( $3336\pm 8\text{Ma}$ ) is subrounded, equant and approximately 190micron in length. It displays a distinct igneous oscillatory zoning, and the analyses was towards the side of the zircon in the oscillatory zones.

· **Duitschland diamictite** (Figs 6.16 and 6.18)

A total of 72 zircon grains were analysed for the Duitschland diamictite. Of these zircon grains 55 were discordant. The zircons of the Duitschland diamictite are mostly between 60 and 129 micron in diameter, and usually angular to subrounded. The youngest zircon (21) is  $2424\pm 12\text{Ma}$ .

There are five significant zircon populations for the Duitschland Formation. These groups are present between 2420-2570Ma, 2670-2820Ma, 3020-3100Ma, 3170-3200Ma and 3380-3440Ma. The most significant population is present between 2420-2570Ma, where 37 zircons nearly concordant zircons are present. This population is dense, but there is a small gap of approximately 10Ma present between the youngest four zircons

and the rest of the population. These zircons vary in length from 64-132micron with an average length of 87micron. A few of the zircons within this population include zircons 2.1, 5.1, 8.1, 30.1, 31.1 and 43.1. Zircon 2.1 is 75 micron in length, subrounded and zoned. Zircon 5.1 is 71micron in length, subrounded and oscillatory zoned. Zircon 8.1 is 73micron in diameter, well rounded, equant and zoned. Zircon 30.1 is 64micron in length, angular and zoned. Zircon 31.1 is 70micron in length, well rounded and zoned. Zircon 43.1 is 69 micron in length, angular and zoned. The zircons within this population display a very consistent length of approximately 85micron, and is usually angular to sub rounded. The regularity in their physical characteristics may suggest that were derived from a single source area.

There are 10 nearly concordant zircons (13.1, 14.1, 17.1, 25.1, 35.1, 48.1, 53.1, 56.1, 66.1 and 68.1) in the 2670-2810Ma population. This is the second most significant population in the Duitschland Formation. This population is densely populated by 6 analyses between 2770-2810Ma. Zircon 35.1 is 104micron in length, still display the original euhedral form of the zircon crystal and zoned. Zircon 53.1 is 142micron in length, displays its original elongated euhedral shape and is oscillatory zoned. Zircon 66.1 is 87micron in length, subangular and zoned. Zircon 68.1 is 98micron in length, subangular and zoned. The average length of the grains is 97micron. Most of the grains are very angular or still display their euhedral shape. Although relatively small, at least some of the grains may be first order derived based on their primary euhedral shape.

There are three concordant zircon grains (4.1, 28.1, 58.1) in the 3020-3100Ma range. Zircon 4.1 is 103micron in length, oscillatory zoned and rounded. Zircon 28.1 is 53micron in length, angular and zoned. Zircon 58.1 is 86micron in length, subrounded and zoned.

There are two concordant zircons (1.1, 36.1) in the 3170-3200Ma age range.

The oldest population (3380-3410Ma) contains two nearly concordant zircons. The oldest zircon (65.1) is  $3416 \pm 10$ Ma. It is 108micron in length, rounded and zoned, probably a second cycle zircon.

· **Timeball Hill Formation** (Figs 6.16 and 6.20)

A total of 43 zircon grains were analysed for the quartzite in the Timeball Hill Formation. Of these grains 25 were nearly concordant.  $^{207}\text{Pb}/^{206}\text{Pb}$  ages define four populations for the detrital zircons of the Timeball Hill Formation. These populations are present between 2320-2430Ma, 2450-2560Ma, 2570-2640Ma and 2740-2930Ma.

There are four nearly concordant grains (7.1, 24.1, 27.1 and 28.1) in the range 2320-2430Ma. The youngest zircon (7.1,  $2324 \pm 17$ Ma) is 122micron in diameter, rounded and zoned. Zircon 24.1 is 116micron in diameter, subrounded, of low sphericity and unzoned. Zircon 27.1 is 104micron in length, subangular and zoned. Zircon 28.1 is 122micron in length, rounded to well rounded and zoned. Although there is not a significant variation in the size of these zircons, they display textural features that vary from subangular to rounded and unzoned to zoned.

There are thirteen concordant zircon grains (2.1, 3.1, 9.1, 13.1, 14.1, 15.1, 22.1, 23.1, 29.1, 33.1, 35.1, 43.1) in the 2450-2560Ma population. The length of the zircons varies between 91-146micron with an average length of 113micron. The zircons are rounded to well rounded, but display both unzoned and zoned internal patterns. Zircon 2.1 is 98micron in length, rounded, equant and zoned. Zircon 3.1 is 98 micron in diameter, rounded and zoned. Zircon 9.1 is 134micron in length, rounded and zoned. Zircon 14.1 is 116micron in length, rounded, of medium sphericity and unzoned in texture. Zircon 15.1 is 122 micron in length, well rounded and zoned. Zircon 22.1 is 110micron in length, subrounded to rounded and zoned. It displays a euhedral core. Zircon 23.1 is 98micron in length, well rounded of medium sphericity and unzoned. Zircon 29.1 is 116 micron in length, well rounded, spherical and unzoned. Zircon 33.1 is 134micron in length, well rounded, of low sphericity and zoned. Zircon 35.1 is 122micron in length,

subangular to subrounded and unzoned. Zircon 43.1 is 146micron in diameter, well rounded and unzoned.

There are two (36.1, 42.1) nearly concordant zircons in the 2570-2640Ma range. Zircon 36.1 is 79micron in length, subrounded and zoned. Zircon 42.1 is 61 micron in length, rounded and zoned.

There are five (10.1, 11.1, 20.1, 26.1, 39.1) concordant zircons in the 2730-2920Ma range. They vary in length between 79-128micron and have an average length of 97micron. Zircon 10.1 is 104micron in length, rounded and unzoned. Zircon 20.1 is 128micron in length, rounded and zoned. Zircon 26.1 is 91micron in length, subrounded and unzoned. Zircon 39.1 is 85micron in length, rounded and zoned. Zircon 11.1 is 79micron in length, zoned and rounded.

The oldest concordant zircon is grain 21.1 (3614±5). It is 104micron in length, subangular to rounded and unzoned.

· **Hekpoort Formation** (Figs 6.16 and 6.24)

The sample for the Hekpoort lava was taken from a 40cm thick volcanoclastic quartzite bed in zone 3 of the Hekpoort Formation, as defined by Coetzee (2001). This unit is crossbedded and display upward coarsening successions on a centimetre scale. It consists almost entirely of medium to fine grained angular quartz grains. A total of 49 zircon grains was analysed for this layer within the Hekpoort lava. Of these zircons 25 grains were nearly concordant. The size of the zircons ranges between 100 and 150 micron. The shape of the zircons varies between elongated and euhedral (Hek 1.1 and Hek 4.1) to rounded (Hek 6.1). All of the zircons have been rounded to varying degrees. Zoning is present in most of the zircons (Hek 1.1). Five significant populations of zircons are defined by  $^{207}\text{Pb}/^{206}\text{Pb}$  ages between 2230-2250Ma, 2270-2450Ma, 2500-2520Ma, 2560-2650Ma and 2860-2890Ma.

Four concordant zircons (2.1, 11.1, 24.1 and 41.1) are present in the 2230-2250Ma range. The length of these zircons varies from 80-140 micron with an average length of 110 micron. The zircons are euhedral to very angular and zoned. Zircon 2.1 is an euhedral zircon that is approximately 70micron in length and zoned. It was analysed on the side of the grain in a zonated area. Zircon 11.1 is a very angular zonated zircon grain. It was analysed towards the side of the grain. Zircon 24.1 is a angular splinter of a euhedral zircon that is approximately 80 micron in length. The zircon is oscillatory zoned. It was analysed near its core. Zircon 41.1 is a euhedral zircon that is approximately 100micron in length. This zircon displays oscillatory zoning and it was analysed towards the side in oscillatory zoning.

There are 12 (1.1, 5.1, 14.1, 16.1, 26.1, 27.1, 28.1, 34.1, 37.1, 46.1, 47.1 and 49.1) nearly concordant grains in the 2270-2450Ma population. These zircons vary in length from 74-113 micron with an average length of 83micron. The texture of the zircons vary from almost euhedral to subrounded. Zircon 1.1 is 113micron in length, and although slightly rounded still displays its original euhedral crystal shape. Zircon 5.1 is 74micron in length, subrounded and zoned. Zircon 14.1 is 99micron in length, angular to subangular, and zoned. Zircon 16.1 is 78micron in length, very angular and appears zoned. Zircon 26.1 is 74micron in length, subangular and zoned. Zircon 27.1 is 95micron in length, subrounded, equant and zoned. Zircon 28.1 is 86micron in length, subangular and zoned. Zircon 34.1 is 95micron in length, rounded and zoned. Zircon 37.1 is 87 micron in length, subangular to subrounded and zoned. Zircon 46.1 is 97micron in length, euhedral, and zoned. Zircon 47.1 is 95micron in length, subrounded, and displays a core and rim structure. The analyses was in the core of the zircon. Zircon 49.1 is 86micron in length, euhedral and not zonated. The analysis was towards the apex of the zircon.

There are three (3.1, 13.1, 42.1) nearly concordant grains in the 2500-2520 population. The length of the zircons varies from 88-101 micron with an average length of 95 micron. The zircons are angular to well rounded and zoned. Zircon 3.1 is 95micron in length, well rounded and zoned. Zircon 13.1 is 101micron in length, angular and displays oscillatory zoning. Zircon 42.1 is 88micron in length, subrounded and zoned.

There are two (23.1, 32.1) concordant zircons in the ill defined 2560-2650Ma population. Zircon 23.1 is 47micron in length, subangular to subrounded. Zircon 32.1 is 101 micron in length, subrounded and zoned.

Four nearly concordant zircon grains (6.1, 7.1, 21.1 and 38.1) define the oldest population between 2860-2890Ma. The zircons vary in length from 100-120micron with an average length of 110micron. Texturally they vary from euhedral to rounded. All of these zircons are zoned. Zircon 6.1 is a rounded grain that is approximately 100micron in length. It appears to be oscillary zoned. The analyses was near the centre of the zircon. Zircon 7.1 is an elongated euhedral grain approximately 120micron in length. It was analysed towards the side of the zircon. Zircon 21.1 is a rounded approximately 100micron detrital grain that appears to have a core and a rim. The analyses are in the core of the grain. Zircon 38.1 is a subrounded grain, approximately 120micron in length. The analyses was in the centre of the zircon.

· **Daspoort Formation** (Figs 6.16 and 6.26)

A total of 50 zircon grains were analysed for the Daspoort quartzite. Of these only 15 were less than 10% discordant. Based on  $^{207}\text{Pb}/^{206}\text{Pb}$  radiometric ages five detrital zircon populations are defined for the Daspoort Formation. These populations are present between 2225-2250Ma, 2260-2280Ma, 2360-2420Ma, 2770-2800Ma and 2860-2910Ma. The Daspoort zircons that were analysed range in size from 40 – 170micron. All of the grains have been rounded to some extent.

There are two (17.1, 39.1) nearly concordant grains that occupy the 2225-2250Ma age range. Zircon 17.1 is an elongated euhedral grain that is approximately 110micron in length and 42micron in width. The zircon appears massive but contains a fluid inclusion. The analysis was however away from the fluid inclusion towards the apex of the zircon grain.

There are three (5.1, 8.1, 38.1) nearly concordant grains in the 2260-2280Ma population. Zircon 5.1 is a subrounded zircon grain that is approximately 85micron in length. It appears to be a relict of the apex of a zircon crystal and oscillatory zoned. Zircon 8.1 is a subrounded grain, approximately 110micron in length. It appears unzoned. Zircon 38.1 is a subangular to subrounded approximately equant grain that is approximately 65micron in diameter. It displays zoning and was analysed towards the edge of the grain.

There are 5 (2.1, 7.1, 16.1, 46.1 and 48.1) concordant grains in the 2360-2420Ma population. Zircon 2.1 is a subrounded grain that is 135micron in length and zoned. Zircon 7.1 is subrounded, 81micron in length and zoned. Zircon 16.1 is well rounded, 100micron in length and zoned. Zircon 46.1 is angular, 127micron in length and not zoned. Zircon 48.1 is subrounded, 69micron in length and unzoned.

There are two (44.1, 49.1) nearly concordant grains in the 2770-2800Ma population. Zircon 44.1 is 85micron in length, subrounded and zoned. Zircon 49.1 is 85 micron in length, rounded and unzoned.

There are three (1.1, 4.1, 37.1) concordant grains in the oldest 2860-2910 population. Zircon 1.1 is 88micron in length, angular and zoned. Zircon 4.1 is 108micron in length, rounded and zoned. Zircon 37.1 is 69micron in length, subrounded and zoned.

· **Magaliesberg Formation** (Figs 6.16 and 6.30)

29 zircon grains were analysed from the Magaliesberg quartzite. Of these grains 19 grains were nearly concordant. The zircons of the Magaliesberg quartzite that was analysed are in the range of 60-215micron and mostly subrounded to well rounded. Two significant detrital zircon populations are defined by  $^{207}\text{Pb}/^{206}\text{Pb}$  ages for the Magaliesberg Formation. These populations are present from 2200-2220Ma and 2230-2270Ma.



There are two (15.1, 27.1) nearly concordant zircons present in the 2200-2220Ma population. Zircon 15.1 is 111micron in length, well rounded, spherical and oscillatory zoned. Zircon 27.1 is 113 micron in length, rounded, and unzoned.

There are 13 (1.1, 2.1, 5.1, 7.1, 10.1, 12.1, 13.1, 17.1, 18.1, 21.1, 22.1, 24.1, 29.1) nearly concordant zircon grains in the 2230-2270Ma population. Zircon 1.1 is 133micron in length, subrounded to rounded, and zoned. Zircon 2.1 is 98 micron in length, subrounded, of medium sphericity and zoned. Zircon 5.1 is 81micron in length, rounded, spherical and zoned. Zircon 7.1 is 163micron in length, subrounded to rounded, of low sphericity and zoned. Zircon 10.1 is 130 micron in length, rounded, spherical and massive. Zircon 12.1 is 113micron in length, subangular to subrounded and not zoned. Zircon 13.1 is  $\pm 70$  micron in length, subrounded and zoned. Zircon 17.1 is 124micron in length, subrounded and not zoned. Zircon 18.1 is  $\pm 90$  micron in length, subrounded, and has an unzoned appearance. Zircon 21.1 is 143micron in length, rounded and zoned. Zircon 22.1 is 86 micron in length, subrounded to rounded and not zoned. Zircon 24.1 is 215micron in length, almost euhedral, elongated and oscillatory zoned. Zircon 29.1 is 85 micron in length, subrounded to rounded, with an unzoned internal texture.



Zircon 25.1 ( $2874 \pm 6$ Ma) is the oldest concordant grain. It is 190micron in length, subrounded to rounded, of low sphericity and oscillatory zoned.

## **Appendix to Chapter 7**

### **Swaershoek Formation (Figs 7.6 and 7.9)**

There are 6 nearly concordant zircons in the 2050-2070Ma population. Zircon 12.1 is rounded but of low sphericity, 195  $\mu\text{m}$  in length and zoned. Zircon 17.1 is oscillatory zoned, euhedral and 180 $\mu\text{m}$  in length. Zircon 19.1 is euhedral, 165 $\mu\text{m}$  in length and zoned. Zircon 22.1 is 285 $\mu\text{m}$  in length, euhedral, elongated and oscillatory zoned. Zircon 36.1 is rounded, slightly elongated and zoned. Zircon 40.1 is 180 $\mu\text{m}$  in length, elongated rounded and zoned.

There are 11 nearly concordant zircons in the 2075-2150Ma population. Zircon 3.1 is 195 $\mu\text{m}$  in length, well rounded, of medium sphericity and unzoned. Zircon 5.1 is well rounded, equant, unzoned and 110 $\mu\text{m}$  in length. Zircon 6.1 is well rounded, 122 $\mu\text{m}$  in length, equant and unzoned. Zircon 8.1 is oscillatory zoned, well-rounded and 180 $\mu\text{m}$  in length. Zircon 10.1 is 145 $\mu\text{m}$  in length rounded and zoned. Zircon 13.1 is well-rounded, unzoned and 145 $\mu\text{m}$  in length. Zircon 16.1 is 145 $\mu\text{m}$  in length, subangular and unzoned. Zircon 24.1 is zoned, subrounded to rounded and 120 $\mu\text{m}$  in length. It seems to have a core that is slightly rounded, and was analysed in its core. Zircon 29.1 is rounded, equant, unzoned and 110 $\mu\text{m}$  in length. Zircon 32.1 is 180  $\mu\text{m}$  in length, subangular and unzoned. Zircon 34.1 is well rounded, equant, unzoned and 195 $\mu\text{m}$  in length.

### **Sandriversberg Formation (Figs 7.9 and 7.11)**

There are 6 nearly concordant grains in the 1990-2025Ma population. Zircon 8.1 is 330 $\mu\text{m}$  in length, rounded but of low sphericity and oscillatory zoning. Zircon 10.1 is the youngest grain and described above. Zircon 25.1 is 128 $\mu\text{m}$  in diameter, well rounded and zoned. Zircon 26.1 is of low sphericity, subrounded, zoned and 213 $\mu\text{m}$  in length. Zircon 28.1 is 170 $\mu\text{m}$  in length, rounded to subrounded, equant and oscillatory zoned. Zircon 43.1 is 183 $\mu\text{m}$  in length, rounded and zoned. The grain has an euhedral core but was analysed in oscillatory zoning outside of the core.

There are 8 nearly concordant grains in the 2025-2075Ma population. Zircon 9.1 is well-rounded, zoned and 146 $\mu$ m in diameter. Zircon 11.1 is well rounded, equant, displays an unzoned texture and is 189 $\mu$ m in length. Zircon 12.1 is angular, equant, zoned and 91 $\mu$ m in length. Zircon 21.1 is 195 $\mu$ m in length, well rounded but of low sphericity and unzoned. Zircon 23.1 is rounded, unzoned and 232 $\mu$ m in length. Zircon 32.1 is well rounded, 146 $\mu$ m in length and unzoned. Zircon 38.1 is subrounded to rounded, unzoned and 170 $\mu$ m in length. Zircon 44.1 displays a primary euhedral crystal shape and is 152 $\mu$ m in length. It has a rounded core, but the grain was analysed in the apex of the grain, outside of the core.

There are 8 nearly concordant grains in the 2075-2150Ma population. Zircon 4.1 is well rounded, equant, unzoned and 116 $\mu$ m in length. Zircon 18.1 is rounded, almost spherical, 122 $\mu$ m in length and zoned. Zircon 27.1 is well rounded but of low sphericity, 323 $\mu$ m in length, and zoned. Zircon 30.1 is oscillatory zoned, 256 $\mu$ m in length, rounded but of low sphericity. It has a core that appears to be euhedral, but was analysed towards the margin of the grain in oscillatory zoning. Zircon 31.1 is rounded, almost equant, 165 $\mu$ m in length, and zoned. Zircon 34.1 is equant, well rounded, unzoned and 122 $\mu$ m in length. Zircon 40.1 is rounded, oscillatory zoned and 171 $\mu$ m in length. Zircon 42.1 is rounded but of low sphericity, zoned and 152 $\mu$ m in length.

There are 3 nearly concordant grains in the 2670-2720Ma population. The oldest grain analysed (7.1) is part of this population; it is 250 $\mu$ m in length, well rounded but of low sphericity and zoned and yielded a  $^{207}\text{Pb}/^{206}\text{Pb}$  age of 2715 $\pm$ 9Ma. Zircon 39.1 is 232 $\mu$ m in length, well rounded but of low sphericity and oscillatory zoned. It has an euhedral core, but was analysed towards the margin of the zircon in oscillatory zoning. Zircon 41.1 is rounded, equant, unzoned and 134 $\mu$ m in length.