Chapter 2
General Geological Setting
and Overview of Available Age Data

2.1 Introduction

It has been suggested that the siliciclastic sediments of the late Archean to late Paleoproterozoic sedimentary sequences preserved on the Kaapvaal craton have been derived from the craton itself or the Limpopo metamorphic belt (i.e. Visser, 1969; Button, 1973, Barton et al., 1989). It is, therefore, important for this zircon provenance study to give an overview of radiometric ages currently available for different igneous lithologies on the Kaapvaal craton and in the Limpopo belt. The age of different volcanic units within the sedimentary sequences are also important. If the age of volcanism corresponds to the age of a specific metamorphic event, it may be suspected that detrital zircons of similar age to the metamorphic event may be found in the basin that are of similar age as the metamorphic event. For example, if the ca 2.65Ga Limpopo belt was a source area to and reason for the development of the sedimentary basin that accommodated the ca 2.6-.27Ga Wolkberg Group, then a large population of 2.6-2.7Ga detrital zircons may be expected to be present within the Wolkberg Group.

2.2 Kaapvaal Craton

Radiometric ages suggest that the Kaapvaal craton of South Africa formed and stabilized between 3.7 and 3.0Ga ago, making it one of the oldest reasonably sized (ca. $1.2\times10^{6}km^{2}$) examples of an ancient continental fragment (De Wit et al., 1992). The basement of the Kaapvaal craton consists of a mosaic of sub domains that have been welded together by processes that may have been similar to those of modern day plate tectonics (De Wit et al., 1992)(Fig 2.1).

The nucleus of the Kaapvaal craton consists of at least three well-defined tectono-stratigraphic terrains namely the Ancient Gneiss (3644±4Ma, Kröner and Compston, 1988), southern Barberton greenstone, and the northern Barberton greenstone terrains

(3450-3250Ma, Kamo and Davis, 1994; Armstrong et al., 1990, Kröner et al., 1996, Byerly et al., 1996). The boundaries between these terrains are all considered to be tectonic (De Wit and Roering, 1990; De Wit, 1991). Apart from the Barberton Greenstone Belt, several other granite-greenstone terrains are preserved on the Kaapvaal Craton (Brandl and De Wit, 1997)(Fig 2.1).

The western part of the Kaapvaal Craton is of Neoarchean age, compared to a Mesoarchean age for its eastern part (De Wit et al., 1992)(Fig 2.1). At around 3.1Ga, amalgamation of granite-greenstone terrains terminated and the $>0.5\times10^6$km^2 Kaapvaal Craton stabilized (De Wit et al., 1992; Brandl and De Wit, 1997 in De Wit and Ashwal, 1997), immediately prior to the deposition of the first cratonic sedimentary cover sequences.

2.3 Cover Sequences

The Witwatersrand and correlative Pongola Supergroups (Beukes and Cairncross, 1991) are the oldest sedimentary cover sequences preserved on the Kaapvaal craton (Figs 2.2 and 2.3). A marked erosional surface is developed at the base of the Witwatersrand-Pongola Supergroup. Sedimentary patterns displayed by the Pongola and Witwatersrand successions suggest cyclic sea level fluctuation, and basin subsidence typical of thermal subsidence basins (Beukes and Nelson, 1995). The presence of banded iron formation, shale, quartzite, diamictites and conglomerate indicate that the Witwatersrand-Pongola Supergroups were deposited in a wide spectrum of depositional environments, ranging from deep shelf to fluvial. Sediment input into the Witwatersrand-Pongola basin was mostly from the west, suggesting that the Kraaipan greenstone belt may have been a source (Fig 2.1). Detrital zircon ages for quartzites within the Witwatersrand Supergroup suggest that the siliciclastic material was derived from source areas of middle to late Archean age (Barton et al., 1989; Robb et al., 1990), most probably the basement rocks of the Kaapvaal craton itself. Deposition of the Witwatersrand Supergroup lasted approximately 260Ma, between 3100Ma (Dominion Group, Armstrong et al., 1990) and 2837Ma (pretectonic quartz porphyry sill, Gutzmer et al., 1999)(Fig 2.2).

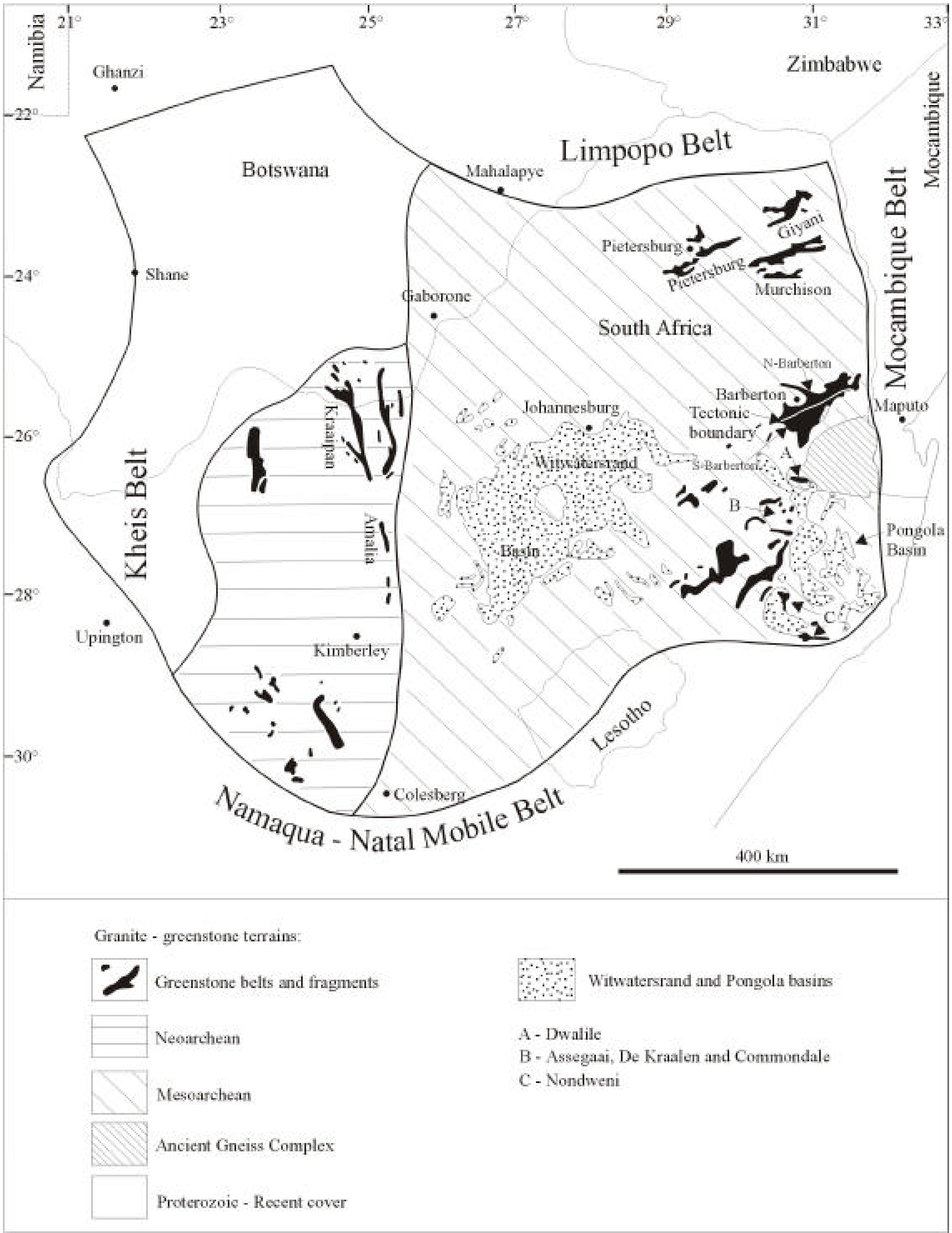

Figure 2.1 Important tectonic components of the Archean Kaapvaal craton (modified after Brandl and De Wit, 1997).

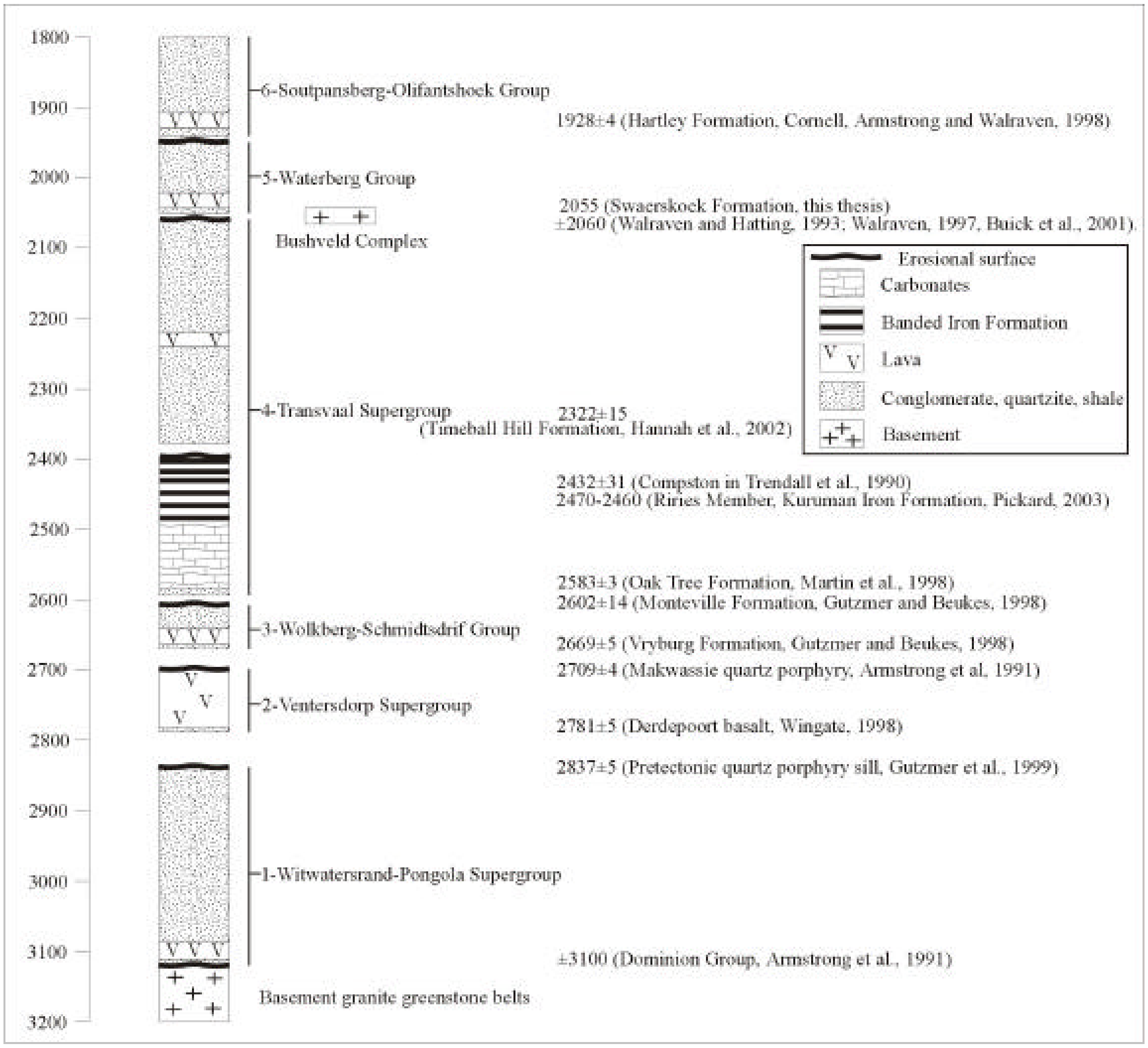

Figure 2.2 Archean to Paleoproterozoic sedimentary cover sequences on the Kaapvaal craton.

Deposition of the Witwatersrand-Pongola succession was succeeded by the late Archean Ventersdorp Supergroup (Winter, 1976), which is the second oldest first order sequence stratigraphic unit deposited on the Kaapvaal craton (Fig 2.2). A prominent erosional surface is developed at the base of the Ventersdorp Supergroup, followed by the deposition of mostly lava, conglomerate, quartzite and shale. Unlike the Witwatersrand Supergroup, the Ventersdorp Supergroup is preserved extensively across the Kaavaal craton (Fig 2.3). Lavas of the Ventersdorp Supergroup were deposited in both terrestrial and sub-aqueous environments (Winter, 1976, Hall and Els, 2002), in an extensional tectonic regime (Hall and Els, 2002, Tinker et al., 2002). Radiometric ages of 2781±5Ma (Derdepoort lava, SHRIMP U-Pb zircon, Wingate, 1998) at the base of the succession and 2709±4Ma (SHRIMP U-Pb zircon, Armstrong et al., 1991) for the Makwassie quartz porphyry towards the central part of the Ventersdorp Supergroup have been obtained for the Ventersdorp Supergroup. Taking into account the deposition of the sediments of the upper Ventersdorp Supergroup, volcanism and sedimentation of the Ventersdorp Supergroup may have lasted more than 100Ma.

Neoarchean to early Paleoproterozoic sedimentary sequences that unconformably rest on the Ventersdorp Supergroup that precede chemical sediments of the Transvaal Supergroup include the Wolkberg Group (Bosch, 1992), the Buffelsfontein Group (Tyler, 1979) and the Schmidtsdrif Subgroup (Beukes, 1978). These were deposited after a period of erosion that followed the deposition of the Ventersdorp Supergroup (Fig 2.4). The above mentioned sedimentary sequences represent the third first order sedimentary sequence on the Kaapvaal craton. The Wolkberg Group is preserved on the north eastern side of the Kaapvaal craton and is composed mainly of siliciclastic and volcano-sedimentary rocks while the Schmidtsdrif Subgroup preserved on the south western side of the Kaapvaal craton is characterized by siliciclastic sediments capped by a sequence of platform carbonate rocks (Fig 2.4). Siliciclastic detritus for these successions was derived from the northeast (Button, 1973, Beukes, 1978), and it has been suggested that the Limpopo belt may have been a source area (Fig 2.5).

An erosional surface marked by conglomerate at the base of the Black Reef Formation erodes into the Wolkberg Group and preceed deposition of the 4th oldest first order sequence on the Kaapvaal craton, the Paleoproterozoic Transvaal Supergroup (Fig 2.4). Varying lithologies such as carbonates, banded iron formation, conglomerate, diamictite, quartzite and shale provide evidence of significant sea level fluctuations during the deposition of the Transvaal Supergroup (Fig 2.4). Paleocurrent studies suggest that most of the siliciclastic detritus was derived again from the northeast. Radiometric ages of 2583±3Ma have been obtained for the basal part of the Transvaal Supergroup, whilst its uppermost units were deposited at approximately 2060Ma, just prior to the intrusion of the Bushveld complex at ca. 2055-2062Ma (Buick et al., 2001; Walraven and Hattingh, 1993; Walraven, 1997)(Fig 2.2).

The base of the Waterberg Group is marked by an erosional unconformity (Fig 2.4). It erodes, amongst others, into the volcanic rocks of the Bushveld Complex. The Waterberg Group is composed mostly of conglomerate, quartzite and shale, with minor volcanic rocks. Paleocurrent directions suggest that sediments were derived mostly from a source area towards the northeast of the Waterberg Group outcrop area. A quartz porthyritic lava near the base of the Waterberg Group has a radiometric age of 2055Ma (this study), suggesting that deposition of this 5th oldest first order sequence on the Kaapvaal craton commenced soon after the intrusion of the Bushveld complex (Fig 2.2).

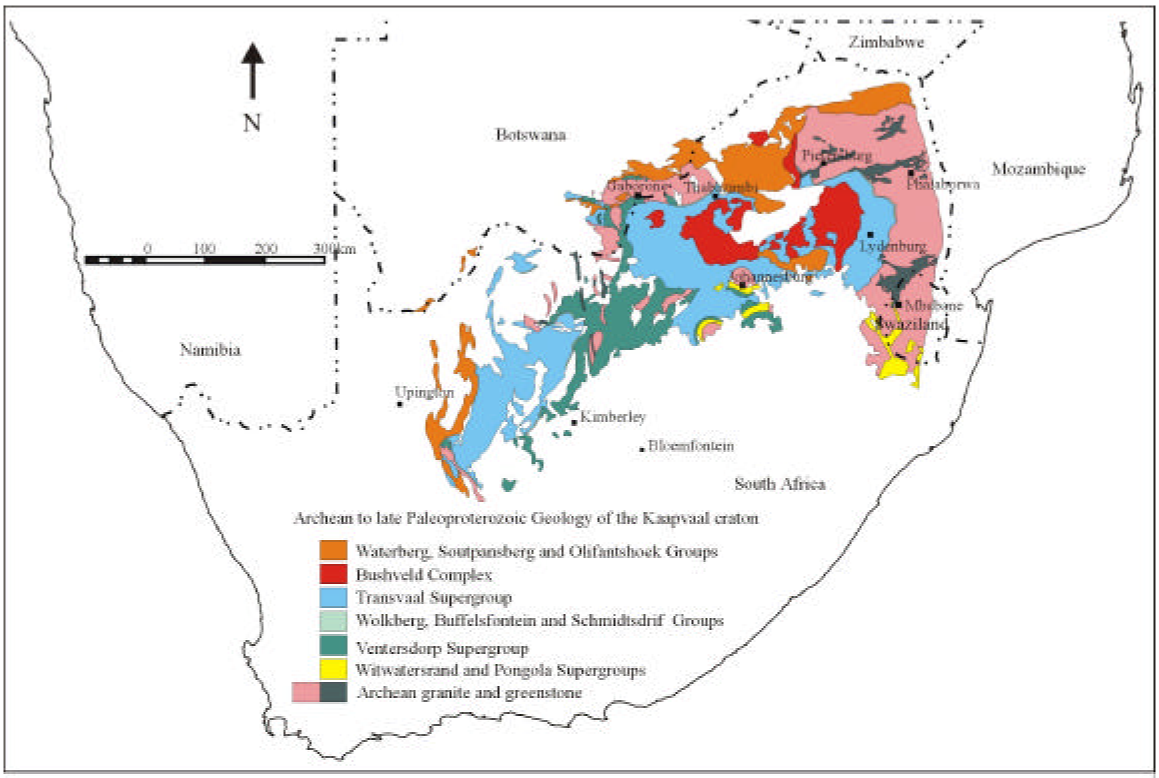

Figure 2.3 Archean to late Paleoproterozoic geology of the Kaapvaal craton. Modified from Cairncross (2004).

The Soutpansberg Group is the oldest succession that covers both the Limpopo belt and the Kaapvaal craton (6th oldest first order sedimentary sequence on the craton) (Fig 2.2). A significant erosional unconformity is present at the base of the Soutpansberg Group and possible lateral equivalents that are preserved in several outcrop areas (Fig 2.4).

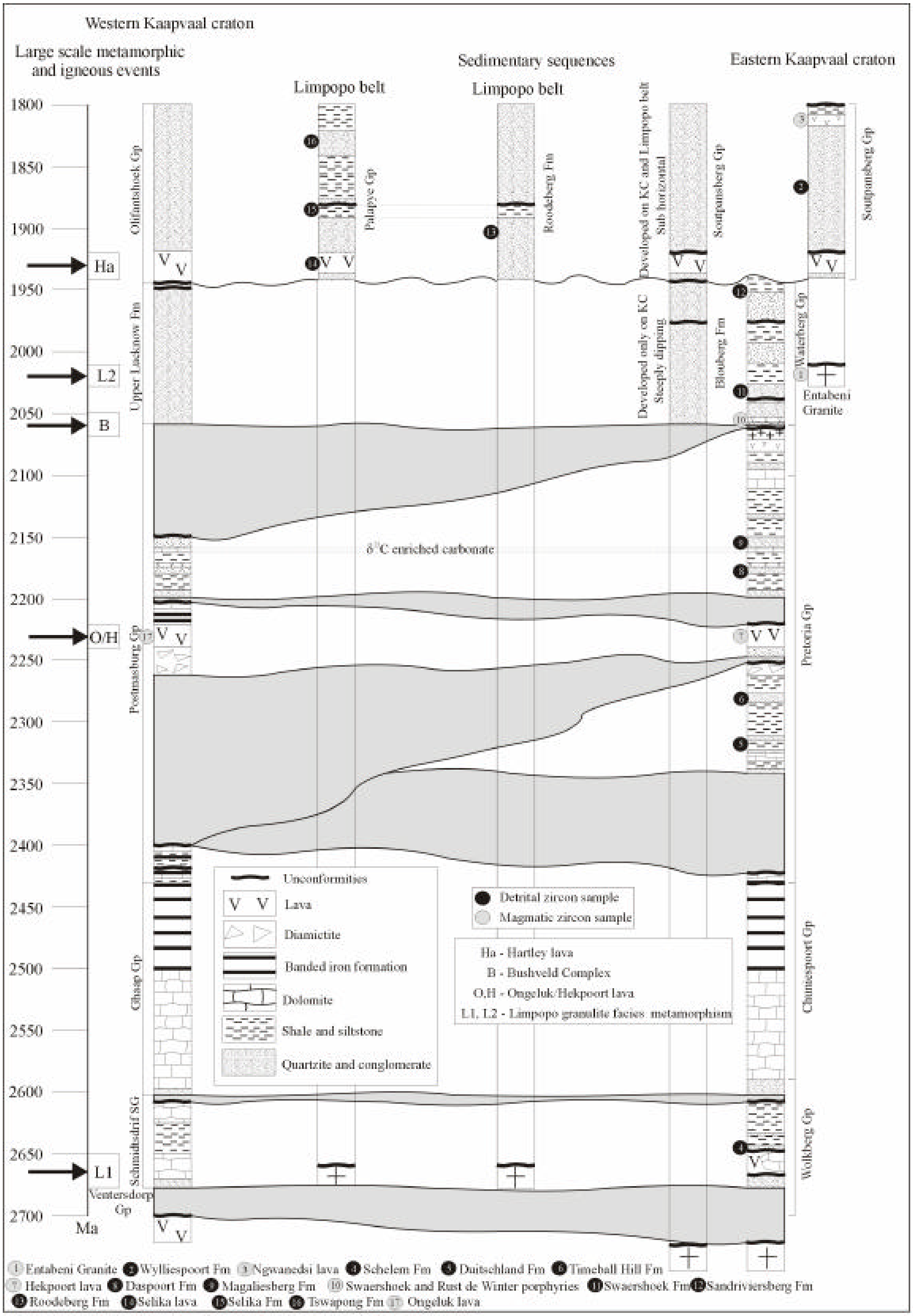

Figure 2.4 Tentative time-stratigraphic correlation of Neoarchean to Paleoproterozoic sedimentary successions on the Kaapvaal craton indicating units that have been sampled for SHRIMP dating of zircons during this study.

These successions are composed of conglomerate, quartzite, shale and volcanic rocks. Paleocurrent directions suggest that siliciclastic detritus was derived mostly from the north. A radiometric age of 1928±4Ma (Cornell et al., 1998) has been obtained for the Hartley lava that is present near the base of this succession (Fig 2.2). The upper age limit of this sedimentary succession is ill-defined.

2.4 Surrounding Mobile Belts and Cratons

The Kaapvaal craton is bordered towards the north by the Limpopo belt (Fig 2.5). Two periods of granulite facies metamorphism occur within the Limpopo mobile belt, the one at ca. 2.65Ga (Barton and Van Reenen, 1992; Van Reenen et al., 1987; Treloar et al., 1992) and the other at ca. 2.0Ga (Holzer et al., 1998). Towards the south, the Kaapvaal craton is bordered by the ca. 1.0-1.2Ga Namaqua-Natal metamorphic complex and towards the west by the ca. 1.8Ga Kheis belt (Hartnady et al, 1985; Cornell et al., 1998) (Fig 2.5). Towards the east, the Kaapvaal craton was rifted during the breakup of Gondwanaland. Paleogeographical reconstructions suggest that the Grunehogha province of Antarctica was connected to the eastern side of the Kaapvaal craton prior to the breakup of Gondwanaland Groenewald et al., 1991). The Archean Zimbabwe craton (Kusky, 1998) is situated towards the north of the Limpopo belt (Fig 2.5). The Zimbabwe craton is bordered on its western side by the Magondi belt. Magnetic lineations visible within the Limpopo belt continue into the Magondi belt (Fig 2.5). This suggests that structural lineations present within the Magondi and Limpopo belt may have developed during the same tectonic event. Granites intruding granulites of the Magondi belt have U-Pb zircon ages of 2.0Ga (Hilliard, 1999), similar to ages of granulites and granites from the Limpopo belt (this study, Fig 2.5). However, the currently most widely accepted model predics that the Limpopo belt developed during a continent-continent collision between the Zimbabwe and the Kaapvaal craton at ca. 2.65Ga (Barton and Van Reenen, 1992). In accordance with this model, several studies have documented the abundance of zircons with radiometric ages between 2.7-2.6Ga in the Limpopo Belt (i. e. McCourt and Armstrong, 1998, Kröner et al., 1999, Barton et al., 1992B, Barton et al., 1994, Kreissig et al., 2001).

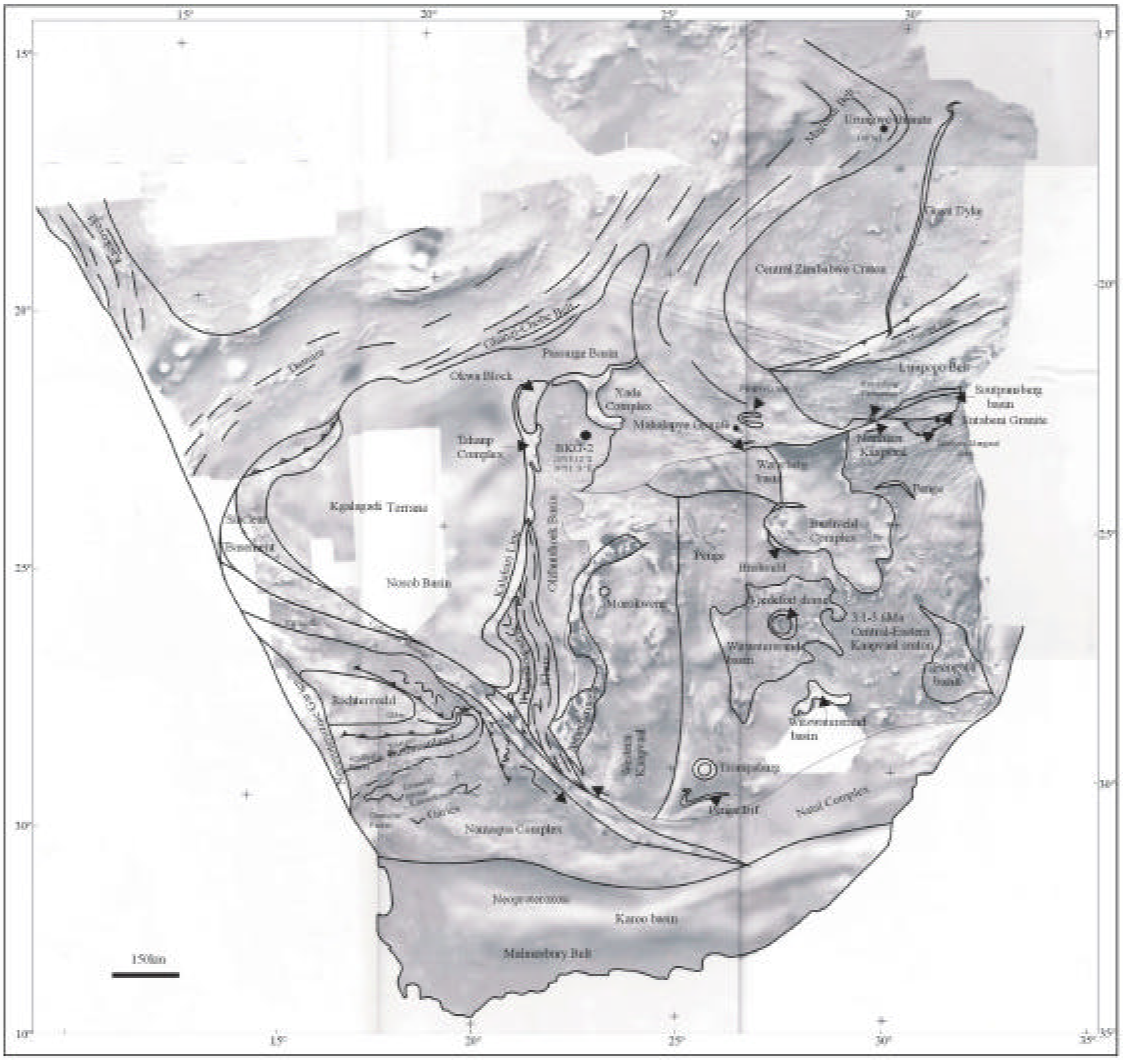

Figure 2.5 Aeromagnetic map indicating the major geologic features of southern and central Africa (modified from De Beers, 1998).

The ca 2.06Ga Bushveld complex (Buick et al., 2001; Walraven and Hattingh, 1993; Walraven, 1997), ca. 2.02Ga granitic rocks of the Vredefort structure (Walraven et al., 1990; Kamo et al., 1996; Gibson et al., 1997) and 1915Ma Trompsburg Suite (Maier et al., 2003) may have influenced the deposition of the Waterberg Group. Other important cratons and mobile belts present in southern Africa are the Kgalagadi terrane, the Richtersveld and Bushmanland cratons, the Okwa block, the Namaqua-Natal and Damara belts (Appendix III)((Fig 25). These cratons and mobile belts are, however, not of importance as source areas to the late Archean to Paleoproterozoic sedimentary sequences on the Kaapvaal craton because ages within these mobile belts that separate different cratonic blocks are younger than 1.5Ga.

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