6 CONCLUSIONS

As stated in Chapter 1, this thesis attempted to address a series of problems associated with the Kheis Terrane and its relationship with the Areachap Group and the Namaqua-Natal Metamorphic Province (Figure 6.1) Most of these questions could be solved as outlined below.

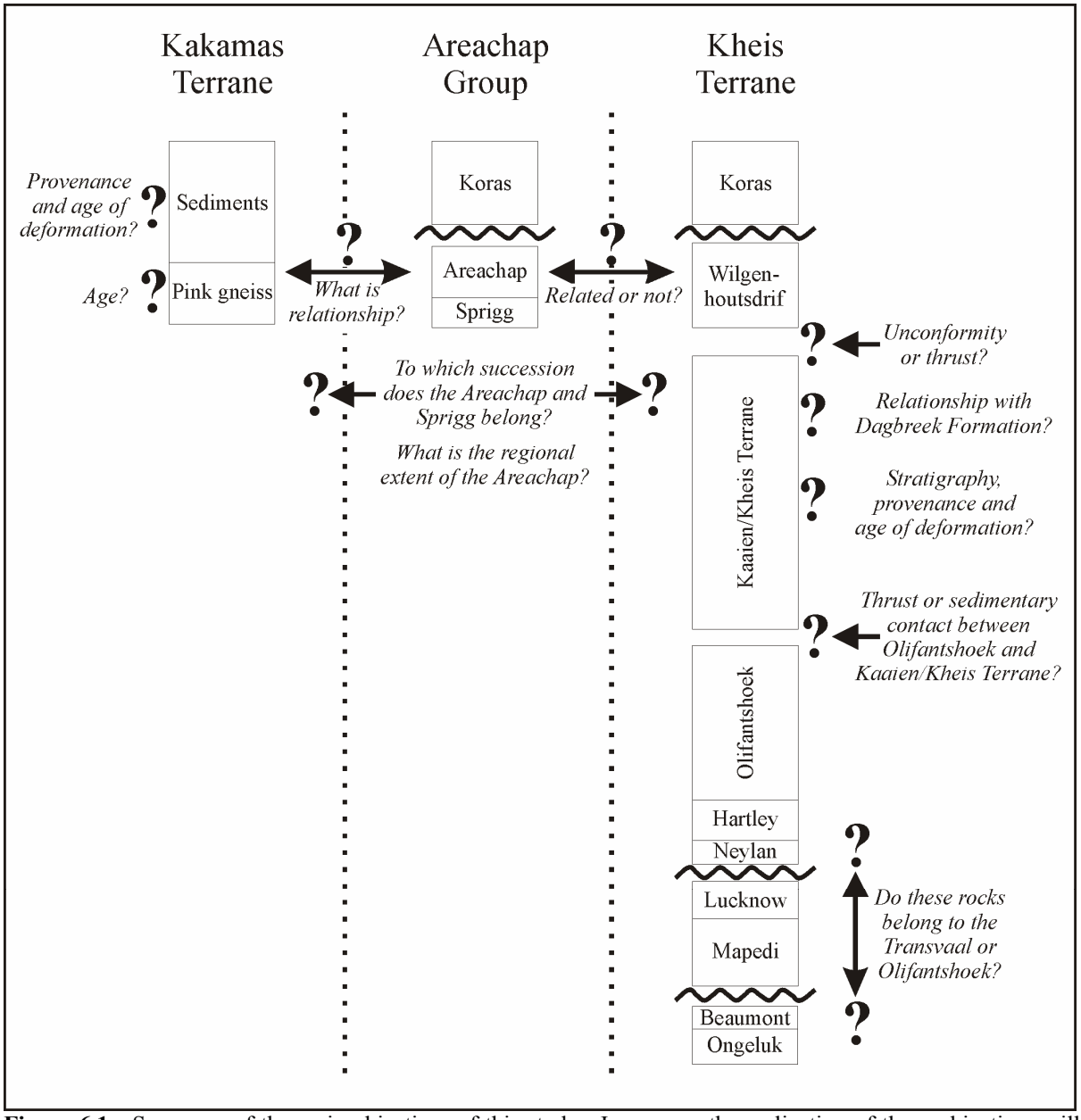

Figure 6.1: Summary of the main objectives of this study. In essence the realization of these objectives will allow for a better understanding of the relationship between the rocks of the Kheis Terrane, the Areachap Group and the rocks of the Namaqua-Natal Metamorphic Province in the North Cape Province of South Africa.

First problem statement: *At present the subdivision between the Griqualand West Sequence and the Olifantshoek Sequence (SACS, 1980) is taken at the base of the Mapedi Formation (SACS, 1980). But the Neylan Formation that overlies the Lucknow Formation (SACS, 1980) incorporates a major conglomeratic unit at its base and is in turn overlain by the volcanic and volcanoclastic Hartley Formation (Cornell et al., 1998). Based on this change in depositional environment observed from the Lucknow Formation to the Hartley Formation the currently accepted stratigraphic subdivision (SACS, 1980) should be drawn into question. Therefore it was investigated and decided whether the Mapedi- and Lucknow Formations belong to the Olifantshoek Group or the Transvaal Supergroup. .*

Solution to first problem: It was found that that the conglomerate at the base of the Neylan Formation represents a major sequence boundary and regional unconformity. Furthermore detrital zircon populations in the Lucknow Formation are significantly different from those of the Volop Formation of the Olifantshoek Group, above the Neylan Formation. Therefore the base of the Olifantshoek Group should be taken at the base of the Neylan conglomerate. The Mapedi- and Lucknow Formations therefore belong to the Transvaal Supergroup. The Neylan conglomerate is also taken as the base of the newly defined Keis Supergroup that incorporates the Olifantshoek-, Groblershoop- and Wilgenhoutsdrif Groups.

Second problem statement: *The true nature of the contact between the rocks of the Volop Group and the Groblershoop Formation of the Olifantshoek Sequence remains uncertain as some workers proposed that they are separated by a terrane boundary, the so-called Dabep Fault (Moen, 1999), whereas others suggest a normal sedimentary contact (Smit, 1973 and Smit, 1977). It is important to address this problem as it indicated whether the rocks of the Groblershoop Formation represent a continuation of the geology on the Kaapvaal Craton or if it represents a separate tectonic domain.*

Solution to second problem: A transitional contact was found between the rocks of the Olifantshoek- and the Groblershoop Groups to the west of Olifantshoek. The Dabep fault therefore does not represent a terrane boundary and forms part of a series of late stage faults and shear zones that transect the rocks of the Kheis Terrane. The Blackridge fault may be the true terrane boundary between the rocks of the Keis Terrane and the Kaapvaal Craton.

Third problem statement: *The internal stratigraphy and provenance of the rocks belonging to the Kheis Terrane prior to its deformation must be determined if the origin of the Kheis Terrane is to be understood. To solve this problem the relationship between the rocks belonging to the Olifantshoek and Kaaien Groups (both as defined by SACS, 1980) must be understood. This was achieved by the detailed study of profiles across the Kheis Terrane as well as U-Pb dating of detrital zircon grains and determining the provenance of the rocks in question.*

Solution to third problem: An internal stratigraphy for the rocks of the Kheis Terrane prior to its deformation was established. It is referred to as the Keis Supergroup composed out of the Olifantshoek-, Groblershoop- and Wilgenhoutsdrif Groups. Detrital zircon populations in the Olifantshoek-, Groblershoop- and Wilgenhoutsdrif Groups are very similar and a large amount of these zircon grains are represented by a 2.0Ga to 1.8Ga age fraction for which there is no real suitable source on the Kaapvaal Craton.

Fourth problem statement: *The age of the deformation of the rocks of the Olifantshoek and Kaaien Groups, and therefore the timing of the origin of the Kheis Terrane is still highly debated, and this problem was addressed by means of Ar-Ar dating of rocks throughout the study area.*

Solution to the fourth problem: Ar-Ar dating of muscovite from the Kheis Terrane did not reveal any ages of ~1.8Ga as is currently accepted to represent the age of the deformation of the rocks of the Keis Supergroup in the Kheis Terrane. Instead Ar-Ar dating provided ages in the region of 1100Ma. An unpublished age of ~1290Ma for Kalkwerf Gneiss, which has been deformed with the rocks of the Kheis Terrane, also indicate that the Kheis Terrane must have originated after ~1.3Ga. This, as well as the age of ~1172Ma for the initiation of rifting in the Koras Group may indicate that the Kheis Terrane formed sometime between 1290Ma and 1172Ma.

Fifth problem statement: *At present a structural contact between the Wilgenhoutsdrif Formation and the underlying Groblershoop Formation is inferred (Stowe, 1983). It is important for deciphering the formation of the Kheis Terrane, to understand whether the basal units of the Wilgenhoutsdrif Group represent a structural contact or an unconformity.*

Solution to the fifth problem: The contact between the Wilgenhoutsdrif Group and the underlying Groblershoop Group appears to originally have been an unconformable and not a structural contact. The Grootdrink Formation at the base of the Wilgenhoutsdrif Group erosively removes the uppermost part of the Skurweberg Formation of the Groblershoop Group, the Witkop Member, in all but a few localities in the Kaaien Hills. Zircon populations in the Wilgenhoutsdrif and Groblershoop Formations are very similar, indicating that they must be closely related. The unconformable contact between these successions could have acted as a décollement surface during later deformational events.

Sixth problem statement: *The rocks of the Dagbreek Formation (SACS, 1980) are separated from the rest of the rocks of the Kaaien Group (SACS, 1980) to the east by the Brakbosch Fault and from the rocks of the Areachap Group (Geringer and Ludick, 1990) to the west by the Trioolspan Shear Zone. To understand the origin of the Dagbreek Formation and its place in the geology of this part of the Northern Cape Province it was of utmost importance to understand the relationship of the Dagbreek Formation with the Kheis Terrane to the east and the Areachap Group to the west.*

Solution to sixth problem: There are many similarities in the geology and detrital zircon populations of the Dagbreek Formation and the rocks of the Keis Supergroup, and particular the upper part of the Groblershoop Group and the lower part of the Wilgenhoutsdrif Group. This suggests that the Dagbreek Formation may represent a back-thrusted and therefore duplicated part of the Keis Supergroup.

Seventh problem statement: *When it comes to the Areachap Group, it was important to determine if this suite of rocks belongs to the Kheis Terrane or the Kakamas Terrane of the NNMP. To answer this question it was necessary to determine the relationship between the rocks of the Areachap Group and the Wilgenhoutsdrif Group to the east and the Kakamas Terrane of the NNMP to the west. This is of critical importance in the development of a comprehensive tectonic model that will explain the geology of the area in question.*

Solution to seventh problem: The Areachap Group can be extended to the north where it appears to conform to the so-called Kalahari line in Botswana. It forms a very distinctive feature on aeromagnetic maps between the Kaapvaal Craton and Kheis Terrane in the east and the Kgalagadi Terrane in the west. This would imply that it originated as arc-type of

environment during a collision between the Kaapvaal-Zimbabwe Craton and the Kgalagadi Terrane, the same event that was responsible north-south tectonic fabric of the rocks of the Keis Supergroup in the Kheis Terrane. Therefore it is concluded that the Areachap Group is much more closely related to the Kaapvaal Craton than the Namaqua-Natal Belt. The suture zone between the Kaapvaal Craton and the Namaqua-Natal Belt is must therefore be situated to the west of the Areachap Group.

Eighth problem statement: *The internal stratigraphy of the Areachap Group (Geringer and Ludick, 1990), particularly the position of the sedimentary Sprigg Formation, was also problematic and it was therefore important to determine if the Sprigg Formation forms part of the Areachap Group or not.*

Solution to eighth problem: Detrital zircon populations of the Kheis and Kakamas Terranes are very different. The rocks of the Keis Supergroup of the Kheis Terrane derived form rocks older that ~1.8Ga and those of the Korannaland Group of the Kakamas Terrane from rocks younger than ~1.8Ga. Detrital zircon grain populations from the Sprigg Formation contains zircon grains that were derived form both sources indicating that it must have been deposited after the formation for the Namaqua-Natal Metamorphic Province. It is clear that the Areachap Group is older than this event and therefore the Sprigg Formation does not belong to the Areachap Group.

Ninth problem statement: *The origin of the pink granitic gneisses of the Kakamas Terrane of the NNMP has been debated over many years with some workers suggesting that they are of sedimentary origin (e.g. Von Backström, 1964). It was thus important to determine if these granitic gneisses are of intrusive or sedimentary origin and than also to determine when they were deposited or intruded.*

Solution to the ninth problem: The pink gneiss of the Kakamas Terrane, the Kokerberg gneiss contains one population of magmatic zoned zircon grains and it was determined that the Kokerberg gneiss intruded the rocks of the Richtersveld Terrane at ~1166Ma ago.

Tenth problem statement: *The pink granitic gneisses of the Kakamas Terrane are closely associated with the sedimentary rocks of the Puntsit-, Goedehoop-, Sandputs and Collinskop Formations, to name a few. The relationship between these units and their relationship with*

the pink granitic gneiss as well as their provenance and age of deformation remain unclear (Von Backström, 1962; 1964; 1967 and Geringer et al., 1988). This was a critical issue that needed to be resolved if a comprehensive plate tectonic model was to be developed that will attempt to explain the evolution of the western margin of the Kaapvaal Craton and its relationship with the NNMP.

Solution to the tenth problem: From field relationships as well as the dating of detrital zircon grains from the Goedehoop-, Sandputs- and Collinskop Formations of the Goedehoop Formations of the Korannaland Group in the Kakamas Terrane, it is clear that these succession were derived form older rocks like those of the Richtersveld Terrane and also from the granitic gneisses, like the Kokerberg gneiss. However, these metasedimentary rock units did not source any zircon grains from the Kaapvaal Craton suggesting that they were therefore deposited prior to the formation of the Namaqua-Natal Metamorphic Province and therefore the amalgamation of the Kaapvaal Craton with the cratonic fragments represented by the Kakamas-, Bushmanland- and Richtersveld Terranes.

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12th of January, 2006