Regolith geochemical exploration in the Girilambone District of New South Wales

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CHAPTER ONE – INTRODUCTION: REGOLITH GEOCHEMISTRY AND MINERAL EXPLORATION

1.1 Introduction

As the search for ore deposits continues throughout Australia and the world, the use of regolith geochemistry will play an increasingly important role in mineral exploration. In many instances the surface expression of mineralisation, traditionally targeted by mineral exploration efforts, may be obscured by more recent cover, durable weathered crusts or barren weathered zones. Gone are the days of mineral discoveries described by Joyce (1984) whereby the ‘initial discoveries of many, if not most, known mineral deposits have been made by untrained personnel who stumbled upon them (sic mineral deposits) by accident’. Within highly prospective mineral domains, it is largely believed that many of the near-surface mineral deposits have been discovered. Increasingly, mineral exploration will be directed towards mineralisation which displays subtle or no surface geochemical expression, obscured by transported cover or barren weathered zones (Rutherford & Cohen, 2001). Thus, the need to look below surface cover in addition to investigations of strongly weathered residual regolith has become fundamental to the discovery of new mineral deposits (Smith, 1996; Taylor & Butt, 1998). Furthermore, an increased understanding of regolith processes and the subsequent geochemical dispersion patterns due to weathering of mineral deposits would greatly improve the chances of success in the discovery of new deposits and additional mineral resources (Butt et al., 2000).

In recent years (post 1997), the majority of exploration efforts have been concentrated in or adjacent to mineral deposits discovered in the 1980s or earlier (Huleatt & Jaques, 2004), which has subsequently raised a new direction of mineral exploration. This is principally in the re-analysis of historical exploration, resource delineation and mine geological data in an effort to better determine the characteristics of mineral fields and in the hope of extending current reserves or stepping out to new discoveries. Furthermore, industry, government and research initiatives have generated a large volume of geochemical data from regional (Reimann et al., 1998; Cohen et al., 1999; de Caritat et al., 2001; Chan et al., 2003a; 2003b) and continental-scale (Cocker, 1999; Xuejing et al., 2004) research projects which are now readily available to the public.
domain. As such, Agnew (1999) suggests there exists a trend towards compilation and re-evaluation of existing data, from the prospect, regional, continental to global scales, which is likely to persist in the future of geochemical exploration.

Much of continental Australia is dominated by regolith, where deep weathering profiles cover much of the prospective surface area of known mineral provinces. In contrast to the relatively young landscapes of the Northern Hemisphere, the antiquity of Australian landscapes is well established (Bird & Chivas, 1989, 1993; Smith et al., 2000). The regolith forms a thin mantle at the Earth’s surface and results primarily from two geochemical processes, oxidation and hydration, to create a profile whereby surface material is most affected and grades to unweathered rock at depth. Regolith materials may in many circumstances represent significant (secondary) mineral deposits (e.g. bauxite, diamonds, gold, iron, kaolin, manganese, nickel, opal etc), although in most cases, the regolith represents a major hindrance to mineral exploration (Taylor & Butt, 1998; Smith et al., 2000; Taylor & Eggleton, 2001). The geochemical and mineralogical characteristics of regolith vary markedly from the parent rocks from which it formed, and with it, the geochemical signature of underlying mineral deposits. However, the same weathering processes can result in geochemical dispersion patterns that can form characteristic, albeit weak, target geochemical signatures (Smith et al., 2000) and may yield much larger exploration targets than the mineralisation itself (Butt & Zeegers, 1989, 1992). The vast majority of these regolith-dominated terrains in Australia have accommodated little to no exploration activity. This phenomenon is not limited to Australia alone, with regolith-dominated terrains featuring deep-weathering and transported overburden existing throughout the world and being largely under-explored (Smith, 1996).

Regolith research is not unlike the traditional fields of geology, soil science and geomorphology from which it has sprung, and bears similarities with these disciplines. The term ‘regolith’ has come into frequent use in the geoscience literature in the past few decades with an increasing number of studies which concentrate specifically on the weathered material found at the Earth’s surface and the processes and products of their formation. Regolith studies have sought to describe the distribution, genesis and age of regolith materials (Taylor & Eggleton, 2001). Particular research has focussed on past geological and climatic conditions (Bird & Chivas, 1989; Pillans, 1997; O'Sullivan et
regolith geochronology (Bird & Chivas, 1988; Bird et al., 1990; Dammer et al., 1996; Pillans et al., 1996; Dammer et al., 1999), regolith processes (Nesbitt et al., 1980; Kronberg et al., 1987; Middelburg et al., 1988; Williams, 1990), landscape evolution (Pain & Ollier, 1995; Ollier & Pain, 1996; Worral et al., 1999; Hill et al., 2003), land management (Wilford et al., 1997; Worral et al., 1999; Lambert, 2003), environmental geochemistry (Reimann et al., 1998; de Caritat et al., 2001) and applications to mineral exploration (Cohen et al., 1996; Taylor & Butt, 1998; Butt et al., 2000; Cairns et al., 2001; Taylor & Eggleton, 2001; Anand & Paine, 2002). In recent years, much of the regolith research has been driven by mineral exploration imperatives and the need for new mineral discoveries (Smith, 1996; Taylor & Butt, 1998). In Australia, these studies have primarily been concentrated in the older pre-Cambrian and Archaean geological domains of the Yilgarn and Gawler cratons (Gray et al., 1999; Butt & Scott, 2001; Craig, 2001; Anand & Paine, 2002) where weathered profiles have developed as typical ‘laterite profiles’ in ancient landscapes or in warm to humid tropical regions (Butt, 1987; Butt & Zeegers, 1989; 1992) where deep weathering profiles may form. It is well understood that weathering profiles form in warm and humid to tropical conditions (Ollier & Pain, 1996; Taylor & Eggleton, 2001). Thus the tropical regions generally represent a modern analogue of ancient areas, such as Western Australia. Contrary to earlier opinion, Bird and Chivas (1989) indicate much of the Australian regolith may have formed in comparatively cooler conditions and that laterisation and deep weathering are not exclusively the result of weathering in tropical and sub-tropical climatic regimes. Thus, these tropical analogues are not necessarily applicable to areas of now arid and semi-arid climates. Comparatively, landscapes in the eastern portion of continental Australia are much younger (although still amongst some of the oldest regions of the world) and ‘laterite profiles’ are of varying depth and are commonly less well developed or have been partially truncated by more recent tectonism and active landscape evolution processes. While the studies of the western cratons and tropical regions have been quite comprehensive and informative in understanding the processes of regolith formation, in the context of mineral exploration, the findings of these studies are not necessarily immediately applicable to more dissected landscapes of the eastern semi-arid counterparts. More recently, studies of the regolith and chemical associations related to mineral deposits in the eastern portions of Australia have been conducted to remedy this disparity in research (Cohen et al., 1996;
Scott, 1998; McQueen et al., 1999; Pwa et al., 1999; Rugless et al., 2000; Cairns et al., 2001; Chan et al., 2003a; Ackerman & Chivas, 2004a, b).

A number of geochemical dispersion models have been proposed by Butt & Smith (1980), Butt and Zeegers (1992) and Butt et al. (2000) which can be largely applied to various regolith settings. In particular, the Achaean Yilgarn Craton in Western Australia (Butt, 1985; Robertson, 1996; Gray et al., 1999; Butt & Scott, 2001; Craig, 2001; Anand & Paine, 2002) and the mineralised areas of tropical climates and the Pacific (Butt, 1987; Butt & Zeegers, 1989, 1992; Camuti, 1995) have been the focus of extensive regolith research. But, can these models be transferred from one particular regolith setting to another? However, fundamental to the application of geochemical dispersion models is the realisation that the dispersion of geochemical elements in the landscape can be predicted for various regolith-landform settings, an approach to which, is adopted in the current study.

A wealth of knowledge exists on the subject of mineral exploration, which has been well documented by, for example Hawkes & Webb (1962), Levinson (1974), Siegel (1974), Rose et al. (1979), Joyce (1984) and Evans (1995). The applications of data analysis and interpretation of geochemical data sets has itself enjoyed equal long-standing attention by authors including Fletcher (1981), Howarth (1983), Rock (1988), Rollinson (1993), Lawie (1997), and Davis (2002). Many authors have contributed to the understanding of regolith formation, geochemistry and exploration geochemistry in various case studies throughout the world. While the technical aspects of regolith and exploration geochemistry, analytical techniques, computing power and data analysis capabilities have evolved, the objective of exploration geochemistry remains unchanged, that is to delineate geochemical signatures related to mineralisation (Rutherford & Cohen, 2001).

This study investigates the regolith geochemistry and copper mineral deposits of the Girilambone district of New South Wales in an exploration context. It is envisaged that these findings may be extrapolated to a regional scale, thus providing a regional analogue for investigations of the Girilambone district and elsewhere in the Tasman Orogen.
1.2 Status of the Australian Mineral Exploration Industry

The minerals industry is Australia’s largest export earner, contributing A$52.5 billion in 2003 (Geoscience Australia, 2004a). The cycles of economic prosperity of the minerals industry are well known and for some, well understood, whereby levels of mineral exploration expenditure have historically fluctuated in line with economic cycles. In past years, the Australian mineral exploration expenditure has peaked about four periods, these being 1972, 1982, 1988 and 1996/1997. Huleatt & Jacques (2004) consider the source of exploration funding of Australian (gold) exploration over the last thirty years. In the 1980s, rapid growth in exploration spending was fuelled by much higher commodity prices than seen in previous decades, and advances in metallurgical technologies allowing commercial treatment of low-grade ores. The 1990s saw exploration funding derived from consolidation and cost-cutting in the face of globalisation and lower commodity prices. At present (2005), the exploration industry is experiencing another ‘boom’, although the magnitude and significance of this recently arrived prosperity may not be realised for some time. The emergence of the Australian mineral industry from a period of extended downturn is due to recent increases in commodity prices, in particular gold, nickel and copper and is projected to strengthen globally (Jaques & Huleatt, 2002a). For the 2002-03 financial year, mineral exploration expenditure reached A$732.5 million (Australian Bureau of Agricultural and Resource Economics, 2004), while global mineral exploration increased significantly to approximately US$2.4 billion (Geoscience Australia, 2004b) and is expected to increase further in coming years.

A commentary on the state of Australian mineral exploration by Jaques & Huleatt (2002b) suggested that while new mineral discoveries are being made, ‘increased greenfields exploration, especially in areas under cover, is needed to exploit Australia’s potential’. Increasingly, consideration of the regolith and landform will be required if the success of mineral exploration program is to be realised. Smith et al. (2000) list some recent gold deposit discoveries in Australia in which regolith geochemistry and regolith-landform control over sampling have been instrumental in exploration success. These include Bronzewing, Plutonic, Jundee, Baxter (Harmony) and Dalgaranga in Western Australia, which further indicate the necessity of regolith research in conjunction with mineral exploration activities.
1.3 Regolith Research in Australia

The Australian Government backs collaborative research between its research bodies and industry through the funding of Co-operative Research Centres (CRCs), by subsidies and grants from the Australian Research Council (ARC) and funding of its principal research bodies Commonwealth Scientific & Industrial Research Organisation (CSIRO), Geoscience Australia (formerly AGSO and BMR) and the Australian Nuclear Science and Technology Organisation (ANSTO) of which CSIRO is the largest supplier of applied research and development to the Australian exploration and mining industry. Regolith research has attracted considerable interest in previous years and has been implemented in Australia by government research bodies, universities, mining and exploration companies and private researchers. In addition, each State and Territory also has a geological survey, or government agency responsible for mines, and all efforts are coordinated through the National Geoscience Agreement (Australian Government, 2002). The combined efforts of these researchers have been to advance mineral exploration in regolith-dominated terrain, by furthering the knowledge of ore systems, developing geochemical and geophysical methods to penetrate regolith cover and understanding weathering processes and associated geochemical dispersion patterns (Smith, 1996).

1.4 Studies of the Regolith Profile

Chemical weathering of rocks is a global-scale phenomenon affecting the Earth’s surface and controlling the geochemical cycle of major and trace elements, including those associated with economic mineral deposits. The investigation of weathered profiles provides insight into the processes and products of chemical and physical weathering of the Earth’s surface material, and in this study, is particularly concerned with the process of regolith formation in the vicinity of mineral deposits. This has obvious implications for the design and implementation of geochemical mineral exploration programs which seek to identify economic mineral deposits from surface, regolith and whole-rock geochemical investigations and for understanding the complex cycling of geochemical elements. Knowledge of the mobility of elements and their occurrences at various scales, from mineral provinces and regional exploration to mine scale investigations, is relevant to geochemical exploration programs.
Studies of regolith geochemistry can take two approaches. The first of which is to study the geochemistry of aqueous fluids in groundwater in contact with mineralised systems (Giblin & Dickson, 1984; Elvy, 1998; de Caritat et al., 2003; Kirste et al., 2003) and the second is to examine the mineralogy and geochemistry of the weathering profiles (Kronberg et al., 1987; Mosser & Zeegers, 1988; Nesbitt & Young, 1989; Leah, 1996; Rutherford, 2000; Butt, 2001; Cairns et al., 2001; Robertson et al., 2001; Anand & Paine, 2002; Tonui et al., 2003). This study has adopted the latter approach. As with any scientific investigation, a series of questions must be posed in order to focus the scope of investigation. Smith (1996) established a series of such questions, which largely encompass the direction of regolith research and indeed mineral exploration at present:

1) What is the geochemical fingerprint of a concealed ore deposit in deeply weathered terrain?
2) Do ore deposits buried beneath transported cover have a surface or near-surface geochemical expression?
3) Can large ore systems be distinguished from minor mineral occurrences at the prospect stage?

This study is an investigation of the regolith processes and geochemical dispersion of trace elements associated with mineral deposits in a deeply weathered regolith terrain, and seeks to identify the surface geochemical expression of various mineral deposits and the geochemical associations of copper ore bodies in the weathered profile. Two study sites in the Girilambone district of New South Wales have been chosen to facilitate this investigation. Geochemical and mineralogical analysis of mineralised and un-mineralised portions of the regolith profile and ore zones below the influence of weathering are examined here.

1.5 Advances in Geochemical Exploration

Advances in the study of regolith geochemistry have been greatly aided by the advent of modern analytical chemistry, which has allowed accurate determination of trace elements to low levels of detection and at a relatively low cost (Hall, 1996). Subtle low-level anomalies in elemental concentrations can be detected using sensitive analytical techniques such as Instrumental Neutron Activation Analysis (INAA) and Inductively Coupled Plasma Mass Spectrometry (ICPMS). It is these subtle variations in geochemical concentrations that hold the key to mineral exploration beneath cover...
(Karger & Sandomirsky, 2001; Rutherford & Cohen, 2001). In recent years, various regolith components have been identified as useful sampling media for geochemical exploration programs and include lateritic residuum (ferruginous duricrust and gravels), bedrock, soil, surface lag, calcrite, saprolite, groundwater, river and stream waters, soil gas, ocean, lake and stream sediments, regolith profile resistate minerals, vegetation, termite mounds and even ice and snow (e.g. Alipour et al., 1996; Mann et al., 1997; Hall, 1998; Arne et al., 1999; Pwa et al., 1999; Cairns et al., 2001; de Caritat et al., 2001; Anand & Paine, 2002; Kebede, 2004). While many applications in mineral exploration are more or less the same as those of 20 years ago, there have been significant technical changes in the methodology of modern mineral explorers. Possibly the most influential effect has been that of improved data-handling capabilities and modern computing (Davis, 2002) and more advanced techniques of can be employed for detection of low-contrast multi-component geochemical anomalisim (Karger & Sandomirsky, 2001). Furthermore, vast quantities of geochemical and geological data have been generated from decades of continuous mineral exploration, mining and scientific investigation, which by and large, are stored in mining and exploration company databases and archived by government departments that oversee the mineral industries of various states/countries. These data represent a considerable expense of time, expertise and investment capital and a source of immense historical geological information and value. Rutherford and Cohen (2001) suggest that interpreting these data may very well form the new frontier of mineral exploration as historic data are re-evaluated in the hope of identifying subtle geochemical anomalies, which until the advent of high powered computing had eluded discovery.

In this investigation, data from 30 years of exploration by various companies in the Girilambone district are combined with data from this and other current studies to create a large multi-element geochemical database. Aspects of regolith formation, landscape evolution and geochemical dispersion in the weathered profile and primary environments of ore-related elements are discussed within the context of their application to geochemical exploration programs. The incorporation of pre-existing data was pivotal in the conception of this project, the compilation of which has facilitated geochemical investigations of the regolith and ore systems associated with mineral deposits of the Tritton and Girilambone copper deposits. While these data could feasibly generate many more aspects of geological investigation, it has not been the intent of this
study to explore every facet of the available data for perhaps little reward. Rather, this study is designed to enhance aspects of mineral exploration for similar deposits and in localities with similar regolith occurrence.

1.6 Girilambone District – An area of known mineral wealth and future prosperity

The Girilambone district has been subject to mineral exploration and mining since the end of the eighteenth century and is located on the eastern margin of the highly prospective Cobar Basin. Metasediments of the Ordovician ‘Girilambone Beds’ host numerous copper and minor gold occurrences, including the Girilambone and Tritton copper deposits which form the focus of investigation. The nearby Cobar mineral field is host to three principal styles of mineralisation incorporating copper, gold, lead, zinc and silver mineralisation. Early exploration discoveries include the CSA and Great Cobar mineral deposits which are attributed to the discovery of outcropping gossans, while more recent exploration successes, such as Elura (Zn-Pb-Ag) and McKinnons (Au), have been credited directly to modern geochemical exploration techniques (Cohen et al., 1996). The Girilambone deposits include copper and gold mineralisation of the Girilambone and Girilambone North deposits, where secondary copper carbonates, copper oxides and native copper have been exploited from the weathered zone. In both instances, primary sulfide mineralisation has been enriched in the supergene profile to provide a significant leachable copper resource. Other mineralisation represented in the Girilambone region includes the Tritton massive sulfide deposit, which is currently being developed, and previous mining sites including Budgerigar, Budgery, Hermidale and Tottenham.

There are significant areas of the Cobar basin that are underdeveloped as they are largely covered by transported material. This area has formed the focus of recent studies by the NSW Department of Mineral Resources in conjunction with CRC LEME which conducted extensive drilling and geochemical sampling throughout the region in an effort to provide sufficient information to encourage exploration in this area. Thus, at a period of renewed interest in the Girilambone district, this study provides a timely account of mineral exploration and regolith geochemistry at the mine scale, which may be extrapolated to regional scales and beyond.
1.7 Scientific Objectives

It is hypothesised that by trace element geochemical analysis and accompanying mineralogical determination of well-oriented and characterised regolith, soil, ore and host-rock samples, the subtle yet distinct variations in ore deposit geochemistry can be identified and subsequently modelled.

This project aims to establish the geochemical signatures of mineralised systems in the weathered profile of mineral deposits using study sites in the Girilambone district of New South Wales. It investigates the regolith development and weathering of host lithologies and the influence of weathering on mineralised geochemical signatures in the landscape and in the weathering profile. Furthermore, this study aims to assess the mineral exploration implications in this and regions of similar climatic regime and regolith development and compare them with ore systems of varying terrains.

This study was facilitated by sampling and analysis of soil, regolith, rock and mineralisation from Girilambone North and Tritton copper deposits. Preliminary orientation investigations of regolith profile and soil sample preparation were conducted in the early stages of this study, to assess the viability of further work. From these studies, a number of objectives were developed to accompany the themes outlined above.

**Girilambone North study area:**

1) To identify the sub-surface regolith characteristics of the weathered profile by mineralogical and chemical analysis of regolith materials from the Larsens East and Hartmans open pits;
2) To trace the geochemical signature of mineralisation through the weathered profile from the primary mineralised zone;
3) To model trace element dispersion in the regolith profile and surficial regolith environments due to secondary weathering processes;
4) To delineate the surface geochemical expression of primary and secondary mineralisation from re-evaluation of historic exploration and mining geological data;

**Tritton study area:**

5) To identify the geochemical signature of mineralisation and host lithologies in weathered and unweathered material;
6) To determine the surface expression of concealed mineralisation by multi-element determination of residual soils; and to compare with previous geochemical exploration programs incorporating chemical analysis of various soil horizons and saprolite;

7) To investigate the regolith-landform evolution and subsequent regolith architecture within the Tritton study area, by regolith-landform mapping and detailed investigations of the surficial and weathered profile regolith environments, to aid in the interpretation of surface geochemical investigations at the local scale.

A sub-theme of this study is to evaluate the various methods of data analysis, statistical treatment of data and data visualisation methods. Many such techniques have been deployed by geoscientists in the past and a wide range of seemingly plausible approaches exist. Hence, this study also seeks to investigate various aspects of data analysis and interpretation.

1.8 Thesis outline

The following is a brief account of the succeeding thesis chapters. The study is broken essentially into four components; introduction and background to geochemical exploration and regolith geochemistry, site geology, geomorphology and regolith characteristics (Chapters 1-3); study methodology (Chapter 4); results of geochemical and other investigations at Girilambone and Tritton study areas (Chapters 5 and 6 respectively); and discussion of scientific investigations and conclusions (Chapters 7 and 8).

Chapter Two, *Regolith Geochemistry, Mineral Exploration and Data Analysis – a Literature Review* details the current knowledge within the fields of regolith geochemistry and its various applications to mineral exploration, as well as discussing advances in the field of geochemical exploration itself. Chapter Two extends the general discussion of these aspects provided thus far in this introductory chapter and detailed accounts from decades of Australian and international research is discussed with the aim of identifying key areas of interest to the research community and industry practitioners. Advances in the use of exploratory data analysis techniques and statistical methods are explored to provide a basis on which much of later geochemical data analysis is based.
Chapter 1

The third chapter of this study is a comprehensive account of the Geology, Mineralisation and Regolith Setting of the Girilambone District, New South Wales. The geology of the region is discussed in detail, placing the Girilambone deposits within an active back arc-setting, where mineral deposits are hosted by Ordovician turbidite successions. These rocks have undergone low-grade regional metamorphism and were subjected to a complex tectonic development giving rise to the enigmatic and poorly understood rocks of the Girilambone Group. An intricate climatic history of possibly warmer and more humid climates in the Miocene, followed by prolonged periods of aridity and tectonic quiescence have preserved a deeply weathered regolith profile of up to 100 m in depth. Chapter Three also establishes the Girilambone district as a highly prospective mineral province and demonstrates the historical significance of mining and exploration activities. Numerous mineralised occurrences are recognised throughout the district and the greater Cobar Basin, with particular attention paid to discussions of the Girilambone North and Tritton copper deposits on which this study is based.

Chapter four Methods of Study details the methodology employed in project planning, field investigations and sampling, sample preparation, chemical analysis, data handling, interpretation and analysis. Chapter Four demonstrates a learned approach to geochemical exploration methodology, sample preparation and analysis, data analysis and interpretation, critical to the success of mineral exploration programs and geochemical investigations of regolith and ore systems. Geochemical sampling programs from previous exploration initiatives including Rotary Air Blast (RAB), vacuum and reverse circulation (RC) drilling programs and soil sampling from the Girilambone North and Tritton study areas are detailed. Furthermore, geochemical sampling programs undertaken in this study are identified. A strong emphasis on data quality and integrity is evident throughout this study, which seeks to demonstrate the importance of geological data and the way in which they are collected, stored and used. This chapter details methods undertaken to ensure the quality of data derived from this and previous investigations.

The fifth chapter Girilambone North Copper Deposits details results of geochemical and mineralogical investigations of the Larsens East and Hartmans open pit mines of Girilambone North. Samples of retained drill cuttings were collected and analysed by INAA and ICP-AES/MS to gather a large multi-element geochemical data set on which
to base investigations. Two profiles extending from surface level, down through the supergene weathered profile to the primary mineralised zone containing significant copper sulfide mineralisation are examined. This chapter reports the results of these geochemical investigations and re-evaluates geochemical data from soil, RAB-drilling, vacuum-drilling, as well as exploration and resource delineation drilling programs conducted by previous mining and exploration companies.

Chapter 6 *Tritton Copper Deposit* discusses and presents soil, regolith, rock and mineralisation geochemical characteristics of the Tritton Copper Deposit. These samples were largely analysed by INAA in the course of this study, and compared with a comprehensive data set derived from various exploration ventures including soil geochemical investigations, RAB-, vacuum- and exploration drilling programs. Lithogeochemical variance of host rock, mafic intrusive rocks and mineralisation in the primary and weathering profile environment are investigated in detail. This chapter also recognises the regolith-landform characteristics of the surficial regolith environment and regolith profile, thus providing evidence of the geochemical dispersion mechanism in the study area. The surface geochemical expression of the concealed Tritton mineralisation is identified in soil and saprolite sampling, although is of limited spatial extent, and has resulted in a subtle multi-element geochemical anomaly at the up-dip and up-plunge extensions of mineralisation.

Chapter 7, *Discussion*, provides an analysis and interpretation of investigations conducted at Girilambone North and Tritton mineral deposits. These two study areas were found to represent different regolith environments, for which geochemical exploration practices should differ. This chapter identified the regolith expression of mineralised bodies in the Girilambone district, and suggests suitable exploration strategies for locating similar deposits in this region. Moreover, it provides a discussion of regolith features and the use of regolith materials in mineral exploration programs and a critical analysis of scientific practices undertaken in studies of this kind. Geochemical studies of the Girilambone North deposits model the trace element dispersion of ore-related elements through the weathered profile and patterns of relative enrichment and depletion. Surface geochemical investigations from previous exploration efforts are compared with the sub-surface geochemistry identified in the present study and the mechanism of geochemical dispersion and anomaly formation
discussed. At Tritton, multi-element geochemical associations of mineralised and host lithologies are identified and compared with anomalous geochemical responses in soil samples traversing the up-dip and up-plunge extension of mineralisation. Furthermore, concepts of data analysis and interpretation, sampling methodology, analytical techniques and exploration practices are discussed in the light of the proceeding information.

The final chapter, Conclusions presents a short summary of regolith geochemical investigations of the present study and suggests future directions for geochemical exploration in the Girilambone district and areas of further research in general.

Additional information, which is supplementary to that in the main text, is stored in appendices, which form Volume 2. Pertinent datasets derived from the present study are stored digitally on a CD in the back of Volume 2.