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Colour and Cash: The Exquisite Minerals of the Oxidized Zone

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Abstract: The geochemistry and chemical mineralogy of the oxidized zones of orebodies are extraordinarily complex, much more so than the primary deposits from which they are derived. The zones themselves are of great economic importance, especially to Australia. Many of the free-milling gold ores exploited over the last two decades are of supergene origin (secondary gold) and cobalt, nickel and copper deposits of the same kind are of increasing importance. We know much of the equilibrium chemistry of such mineral settings for some elements and something of the general processes that play a part in the development of ore grades in the oxidized zone. For other elements the situation is somewhat more sketchy and of certain aspects, including kinetics of crystallization, temperatures of mineral formation and solid-solution phenomena, we know very little indeed. Oxidized zone mineralization, some of which is exquisitely beautiful, is described in terms of its origin and the associated chemistry necessary to extract metals from these sorts of deposits. Further research directions are highlighted, together with problems that remain to be solved.

INTRODUCTION

The oxidized zone of an orebody is that part of it that lies above the water table. Its lower limit is not definite, but fluctuates with the seasons and local climatic influences. This is important for the chemistry of the oxidized zone in that ions in groundwaters can be introduced by these fluctuations (or drawn upwards by capillary action) causing local redox conditions to vary at the base of the zone. As its name implies, the oxidized zone carries the oxidized equivalents of primary materials generally formed deep in the earth when prevailing conditions were much different. These conditions would typically be characterized by relatively high temperatures and pressures, a lack of oxygen and high activities of sulfur and sulfide. Naturally, it is to be expected that minerals stable in this environment are thermodynamically unstable in the near-surface environment, which is characterized by abundant oxygen dissolved in water, lower temperatures, ambient pressures and sulfur species dominated by sulfate (Williams, 1990).

In general, elements reach higher or their highest oxidation states in the oxidation zone. For example, pyrite (iron(II) disulfide, $Fe^{2+}S_2{}^{2-}$) is oxidized as shown in (1). Subsequent oxidation of Fe(II) and hydrolysis leads to goethite (FeOOH), a characteristic iron mineral of the oxidized zone, according to (2) and (3).

$$FeS_2(s) + \tfrac{7}{2}O_2(aq) + H_2O(l) \rightarrow Fe^{2+}(aq) + 2SO_4{}^{2-}(aq) + 2H^+(aq) \quad (1)$$

$$Fe^{2+}(aq) + \tfrac{1}{4}O2(aq) + H^+(aq) \rightarrow Fe^{3+}(aq) + \tfrac{1}{2}H_2O(l) \quad (2)$$

$$Fe^{3+}(aq) + 2H_2O(l) \rightarrow FeOOH(s) + 3H^+(aq) \quad (3)$$

A weathered sulfide orebody exposed at the surface most frequently shows a characteristic zoning pattern with increasing depth. At the surface, chemically resistant minerals (e.g., quartz, SiO_2) remain, together with oxides and oxyhydroxides of certain metals. Notable among these are iron and manganese minerals. These constitute the weathered remnants of the orebody known as a gossan. Since pyrite and other iron- bearing phases are so common in sulfide ores, these gossans are usually reddish brown in colour and contain goethite, and sometimes its polymorphs lepidocrocite and akaganéite, and hematite (Fe_2O_3), together with a large number of rarer iron-bearing minerals.

When primary iron minerals are less abundant, a conspicuous gossan may not be formed. Alternatively, the gossan may manifest itself in other ways depending on the mineralogy of the primary ore from which it was derived. A notable example is the gossan associated with the Broken Hill, New South Wales lode which formed from ores lean in iron but very rich in manganese. Here, a black coronadite ($PbMn_8O_{16}$) gossan was extensively developed on the Number 2 and 3 Lead lenses (Birch, 1999). Beneath the gossan, a leached zone is often developed. Most transition and other heavy metals are leached and transported away from this zone in solution. Still deeper, the oxidized zone (*sensu stricto*) is encountered; this is a zone where the classical and aesthetically beautiful secondary minerals of the base and other metals are found. Finally, near the water table and the redox boundary between oxidizing and reducing conditions, a supergene enriched zone may be developed for certain elements. This is particularly important in many copper deposits and rich to bonanza grades comprised of native copper, chalcocite (Cu_2S) and its congeners such as digenite (Cu_9S_5) and djurleite ($Cu_{31}S_{16}$) have long been exploited in numerous and economically very important deposits, notably in the Americas (see, for example, Anthony et al., 1995), but also in Australia. Current examples for the latter include Girilambone, New South Wales (Fogarty, 1998) and Gunpowder in northwest Queensland (Richardson and Moy, 1998).

Aside from copper, the other coinage metals too can be supergene enriched. Silver has been won from many such deposits, but today these are largely exhausted. One example worth mentioning is the Chañarcillo field in Chile (Segerstrom, 1962), which produced 2,500 tonnes of silver between 1860 and 1885 from ores carrying native silver, chlorargyrite (AgCl), bromargyrite (AgBr), iodargyrite (AgI), together with solid-solutions of the three halides, dyscrasite (Ag_3Sb), acanthite (Ag_2S), stromeyerite (AgCuS), stephanite (Ag_5SbS_4), pearceite ($Ag_{16}As_2S_{11}$) and polybasite ($Ag_{16}Sb_2S_{11}$). The fabulous Consols mine at Broken Hill NSW presented a similar wealth of these and related phases (Birch, 1999). Enrichment of gold remains an important economic process. Emmons (1917) provided an early summary of gold enrichment in various deposits and speculated on a mechanism for it. A more recent publication (Berkman and Mackenzie, 1998) lists no fewer than 18 Australian gold deposits that involve significant supergene enrichment of gold to an economically important degree. This enrichment is not solely due to removal of more reactive material from the oxidized zone. Spectacular examples are known of deposits that have bonanza grades of gold near the water table as a result of transport and redeposition due to solution chemistry at ambient temperatures and weathering. Hannon South stands out in this respect (Lawrance, 1994). Gold was leached from the weathered profile to a depth of about 30 metres with grades of less than 0.1 ppm Au remaining. At the base of the oxidized zone secondary gold of very high fineness (> 999) was deposited in a supergene enriched blanket with grades of over 100 ppm Au in places. Truly, the latest golden era of mining in Australia, contributing to a very significant level of export earnings, relied on the chemical processes responsible for the transport of gold in aqueous solution under ambient conditions in the oxidized zone.

Given the above, a thorough knowledge of the geochemistry and chemical mineralogy of the oxidized zone is desirable. Unfortunately, our knowledge is imperfect in many pertinent areas and in others virtually non-existent. The chemical mechanisms for the transport of gold in the supergene environment remain contentious for instance. Ligands that may be involved include chloride ion, thiosulfate ion and organic species; some have suggested that colloids are involved. In similar vein, the chemistry of the formation of many of the minerals in supergene enriched silver deposits is entirely unknown, other than for the overall stoichiometric equations that can be all too readily chalked on the board.

On the other hand, the geochemistry and

secondary mineralogy of the base metals is much better understood. This situation arises in part because of a better chemical understanding of these elements, a wealth of chemical data concerning a few of them and a serendipitous delight in their mineralogy. Concentration is now particularly focussed on copper, lead and zinc.

$PbSO_4$	anglesite	$PbWO_4$	stolzite
$PbCO_3$	cerussite	$Pb_5(PO_4)_3Cl$	pyromorphite
$PbCrO_4$	crocoite	$Pb_5(AsO_4)_3Cl$	mimetite
$PbMoO_4$	wulfenite	$Pb_5(VO_4)_3Cl$	vanadinite

Table 1: Some simple oxyanion minerals of Pb(II).

PARTICULAR SUITES

A chemical curiosity of the "simple" inorganic chemistry of these elements is the formation of basic double salts. For Pb(II) and Zn(II) examples include hydrocerussite ($Pb_2(CO_3)_2(OH)_2$) and hydrozincite ($Zn_5(CO_3)_2(OH)_6$). However, both these ions tend to form simple salts in Nature. For Zn(II), smithsonite ($ZnCO_3$) is a reasonably common phase in oxidized zones, but the solubility of other simple zinc salts leads to a limited mineralogy of the element in such settings. This is so much the better in that equilibrium models for secondary zinc mineralization are that much easier to construct (Williams, 1990). On the other hand, Pb(II) forms a number of insoluble salts with a variety of oxyanions and these are reflected in oxidation zone mineralogy. Table 1 lists some of these phases; note that double salts with ions other than hydroxide are featured. Again, fortunately, reliable thermodynamic data are available for these species and they can simply be incorporated into models that describe their behaviour in the oxidized zone. Regrettably, we come unstuck (chemically speaking) with copper(II).

Copper is an element for chemical and mineralogical connoisseurs. Its propensity to form basic double salts is unparalleled in the Periodic Table and almost any ion imaginable will form a solid found in Nature (or the laboratory). Some mineral examples are given in Table 2. The situation is seen to be even more complex when it is realized that many of the species form solid-solution series; this is particularly true for the arsenate and phosphate examples listed. Further, other metals may enter into solid- solution. Thus, in the libethenite-olivenite series, Zn(II) and Co(II) may enter the lattice in all proportions (Hawthorne, 1976; Hill, 1976; Kato and Miura, 1977; Keller et al., 1979; Toman, 1978). In the adelite group of minerals, with formula $ABAsO_4(OH)$, end-member species have been named for $A = Ca$, $B = Mg$, Co, Cu (also for a vanadate analogue), Ni, Zn and $A = Pb$, $B = Cu$, Fe.

If other cations and anions can be present in the same lattice, the stoichiometries of known secondary Cu(II) minerals may become extremely complicated. Two examples involving multiple cations and multiple anions will suffice to illustrate the point. BolĆite has the formula $Pb_{26}Cu_{24}Ag_9Cl_{62}(OH)_{47}{\cdot}H_2O$; it crystallizes in the cubic system, space group $Pm3m$, with $Z = 1$ and with a proton disordered over the hydroxide sites. It is a rare mineral, but has been reported from a number of localities including various mines at BolĆo in Baja California, the South mine at Broken Hill, New South Wales, in ancient lead slags that had been immersed in sea water at Laurion, Greece, and as a corrosion product of debased silver coins recovered from the wreck of the Batavia off Western Australia (Williams, 1990). The much more common solid-solution series connellite-buttgenbachite, c. $Cu_{36}Cl_8(NO_3)_x(SO_4)_y(OH)_{64-(x+2y)}{\cdot}5H_2O$, contains four different anions with an extremely complicated pattern of mutual substitution over several sites in the lattice (Hibbs et al., 2001).

Anion		
Cl^-	$CuCl_2{\cdot}2H_2O$	eriochalcite
	$CuCl(OH)_3$	atacamite
		botallackite
		paratacamite
		clinoatacamite
PO_4^{3-}	Cu_2PO_4OH	libethenite
	$Cu_5(PO_4)_2(OH)_4$	pseudomalachite
		ludjibaite
		reichenbachite
	$Cu_3PO_4(OH)_3$	cornetite
AsO_4^{3-}	Cu_2AsO_4OH	olivenite
	$Cu_5(AsO_4)_2(OH)_4$	cornwallite
		cornubite
	$Cu_3AsO_4(OH)_3$	clinoclase
Anion		
SO_4^{2-}	$CuSO_4{\cdot}5H_2O$	chalcanthite
	$Cu_3SO_4(OH)_4$	antlerite
	$Cu_4SO_4(OH)_6$	brochantite
CO_3^{2-}	$Cu_2CO_3(OH)_2$	malachite
	$Cu_3(CO_3)_2(OH)_2$	azurite
$H_2SiO_4^{2-}$	$CuSiO_3{\cdot}nH_2O$	chrysocolla
NO_3^-	$Cu_2NO_3(OH)_3$	gerhardtite

Table 2: Secondary mineral diversity for copper(II). Minerals with extra cations are excluded. When several names are given, these refer to polymorphs of the same composition. Only a few examples are given here for illustration.

CHEMICAL AND PARAGENETIC RELATIONSHIPS

Comparatively simple primary metalliferous mineral suites of base metal orebodies in arid Australia (pyrite, chalcopyrite, galena, and sphalerite, with minor accessory phases) are accompanied by a bewildering array of secondary minerals in their supergene zones. This is as a consequence of saline (chloride, sulfate, carbonate) groundwater anion geochemistry with periodic fluctuations of the water table and capillary action contributing to a recharge of anions in the weathering zone. Arsenate, molybdate, tungstate and chromate are contributed by the breakdown of (usually) minor primary minerals. Silicic acid and phosphate species form through acid decomposition of gangue and host rock. Nitrate is common in groundwaters of Australian arid regions, due in part to formation of nitrogen oxides via electrical discharge during thunderstorms, but to some extent by leaching of nitrate formed in soils through biological action associated with termite mounds (Barnes et al., 1992).

Chlorides, especially those of Cu(II), are abundant in these settings. Atacamite and paratacamite are most common but the so-called rare species nantokite, CuCl, claringbullite, $Cu_4Cl(OH)_7$, and connellite are frequently encountered. Silver halides are common, being particularly abundant in the giant Broken Hill orebodies and surrounding deposits as noted above. Exotic secondary nitrates including gerhardtite, likasite, $Cu_3NO_3(OH)_5{\cdot}2H_2O$, and connellite-buttgenbachite are sometimes associated with the copper chlorides (Sharpe and Williams, 1999). Basic copper phosphates such as cornetite, and particularly libethenite and pseudomalachite, are common, associated with arsenate analogues clinoclase, olivenite, cornubite, cornwallite and other members of the adelite group, when arsenic-bearing sulfosalts are present in primary ores. Many other base metal arsenates and phosphates are found in more complex oxidized zones. Wulfenite, stolzite and crocoite, aside from the more commonly known localities, are present in many deposits of arid Australia. Chrysocolla is conspicuous in nearly all oxidized copper ores. More common sulfates (anglesite, brochantite, antlerite) and carbonates (malachite, azurite, smithsonite, cerussite) contribute to very complicated assemblages of astonishing mineralogical diversity. These are, however, not randomly distributed throughout the oxidized zone. Rather, there are noticeably distinct patterns of distribution related to depth, redox potential and pH conditions (Sharpe, 1998; Williams, 1990).

Naturally, it would be desirable to gain an understanding of the chemical conditions that give rise to these assemblages. This is evident for a number of important reasons, not just because of the intrinsic interest that the minerals of the oxidized zone engender. First, it can be said that the chemistry associated with dissolution of secondary minerals in heap-leach operations is just the reverse of that responsible for their formation. Behaviour in acid conditions and kinetic phenomena are of special importance here.

$$Cu_2CO_3(OH)_2(s) + 4H^+(aq) \rightarrow 2Cu^{2+}(aq) + CO_2(g) + 3H_2O(l) \quad (4)$$

$$Cu_5(PO_4)_2(OH)_4(s) + 8H^+(aq) \leftrightarrow 5Cu^{2+}(aq) + 2H_2PO_4^-(aq) + 4H_2O(l) \quad (5)$$

Furthermore, many acid leach reactions are not strictly analogous. For example, reaction of malachite (4) with acid is essentially irreversible because of the loss of carbon dioxide to the atmosphere. However, reaction of pseudomalachite (5) is reversible and, with recycling of leach liquors, phosphoric acid will build up and indeed inhibit further reaction at the same pH unless the circuit is bled. A second reason concerns the application of the aqueous mineral chemistry to hydrogeochemical methods used in the exploration for new orebodies that are blind or very deeply or intensely weathered. Related to this, in that secondary minerals act as metal ion buffers, are strategies to avoid transition and heavy metal pollution associated with mining and manufacturing activities. This includes the dispersion of toxic species in acid mine drainage settings.

Fortunately, reliable thermochemical data for many of the minerals referred to above are available in the literature and a number of examples are given by Williams (1990). Incorporation of the data in equilibrium models has led to explanations of associations, paragenetic sequences and modes of formation of complex suites. A couple of recent examples will illustrate the utility of the approach. Field observations over the last decade have revealed just how widespread are the secondary phosphates of Cu(II) in the oxidized zones of copper orebodies in arid Australia. Examples include deposits at Girilambone (Gilligan and Byrnes, 1994) and Goonumbla or Northparkes in New South Wales (Heithersay et al., 1990; Crane et al., 1998) and several smaller deposits in the Mt. Isa Block in northwest Queensland (Ball, 1908; Day and Beyer, 1995; Carter et al., 1961; Sharpe, 1998). All of these deposits are characterized by an abundance of the secondary copper phosphates libethenite and pseudomalachite associated with smaller amounts of cornetite and turquoise, $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$. Secondary mineral distributions in these deposits vary, but a number of recurring paragenetic relationships are evident. Characteristic zoning of the phosphate minerals has also been noted, with libethenite invariably being found nearer the surface. Rhythmically banded, botryoidal malachite- pseudomalachite composites comprised of individual layers up to a few tenths of a millimetre thick are commonly found near the surface and sometimes in the outcrop. It has been shown that this material simply reflects the fluctuating availability of $H_2PO_4^-(aq)$ or $HPO_4^{2-}(aq)$ versus $HCO_3^-(aq)$ or $CO_3^{2-}(aq)$ in mineralizing solutions. The rare occurrence of cornetite, confined to the Great Australia, Cloncurry, Queensland, Main Lode outcrop (Day and Beyer, 1995) and the Crusader mine, north of Kajabbi, Queensland, is due to its formation under somewhat more unusual chemical conditions (relatively higher pH, higher copper and lower phosphate ion activities). The equilibrium models also show that libethenite-pseudomalachite zoning with depth depends on intensity of weathering with most intense weathering at the surface leading to higher phosphate concentrations in downwardpercolating groundwater, thus making the formation of libethenite more likely (Crane et al., 2001a). Related studies have shown that basic copper phosphates and arsenates control the dispersion of copper in groundwaters adjacent to the Great Australia, Girilambone and Mungana North, Chillagoe, Queensland, orebodies (Elvy, 1999).

A second example concerns the simplest of the copper chlorides, nantokite, CuCl. Nantokite was first reported in 1867 from the Carmen Bajo mine a few kilometres west of Nantoko, Chile (Palache et al., 1951). A second report was made by Liversidge (1894), regarding specimens found in a matrix of cuprite associated with native copper and cerussite from the Broken Hill South mine, New South Wales. A few other occurrences of nantokite have appeared since the early reports (Anthony et al., 1997). Complex crystals have been reported from the Southwest mine, Bisbee, Arizona (Graeme, 1993). It also has been found as a volcanic sublimate (Vergasova, 1983), but has continued to be regarded as being quite rare, until recently. Attention was drawn to the mode of formation of this comparatively rare mineral because of its discovery in considerable quantities in the oxidized zone of the Great Australia mine, near Cloncurry, Queensland, and its occurrence in a number of other Australian base metal deposits (Sharpe and Williams, 1999). Freshly broken specimens from Great Australia showed nantokite as colourless, water-clear masses, superficially resembling quartz, and showing a conchoidal fracture. The mineral is, however, thixotropic and is readily identified by its sectile nature, with a hardness of 2.5, similar to that of candle wax. On exposure to moist air, it oxidizes and hydrates within a few weeks to form a pale-green, crumbly powder consisting of atacamite or its dimorph, paratacamite. The abundance of nantokite at the Great Australia is noteworthy and tonnes of the mineral were mined and heap-leached to recover contained copper, even though its presence was unsuspected at the time. Nantokite altering to atacamite actually was observed first, but not recognized, in specimens from Cloncurry as early as 1887 when Lindon (1887) wrote:

> "I find that specimens of massive cuprite, or native copper changing to cuprite, from Cloncurry are very liable to be encrusted with malachite after keeping for a short time in the atmosphere of Brisbane."

Stability relationships between copper, nantokite, paratacamite and cuprite, Cu_2O, could be deduced using data taken from Robie et al., (1978), together with a value for the solubility product of paratacamite (Smith and Martell, 1976). These could be used to explain the fact that nantokite is the result of the alteration of native copper in a saline environment (Sharpe and Williams, 1999).

For Pb(II) and Zn(II), equilibrium modelling of secondary mineral assemblages is much simpler because of the fact that these ions usually form normal or simple salts with oxyanions. Reliable data are available for many of them (Robie et al., 1978; Smith and Martell, 1976). Nevertheless, much work remains to be done in this area so that a comprehensive database of stability constants is readily to hand; aside from known species, new minerals are reported at the rate of perhaps twenty per year.

AREAS IN NEED OF FURTHER STUDY

Less than satisfactory knowledge attends several aspects of oxidized zone mineralogy and geochemistry. One concerns structural and thermodynamic properties of the many solid-solution systems that exist in Nature. Few of these behave ideally or regularly and, in order to include them rigorously in equilibrium models, solid-state activity coefficients need to be taken into account. This is because the activities of the components in a solid-solution are not in principle equal to unity. By way of example, the AgCl–AgBr solid- solution may be examined. For (6), the equilibrium constant expression is that given in (7), reducing to (8) since $a_{AgCl(s)}$ is equal to 1 by definition.

$$AgCl(s) \leftrightarrow Ag^{+}(aq) + Cl^{-}(aq) \quad (6)$$

$$K_{sp} = a_{Ag^{+}(aq)} a_{Cl^{-}(aq)} / a_{AgCl(s)} \quad (7)$$

$$K_{sp} = a_{Ag^{+}(aq)} a_{Cl^{-}(aq)} \quad (8)$$

$$AgCl_xBr_{(1-x)}(s) \leftrightarrow Ag^{+}(aq) + yCl^{-}(aq) + (1\text{-}y)Br^{-}(aq) \quad (9)$$

$$K_{sp}(AgCl) = m_{Ag^{+}(aq)} \gamma_{Ag^{+}(aq)} m_{Cl^{-}(aq)} \gamma_{Cl^{-}(aq)} / N_{AgCl(s)} \gamma_{AgCl(s)};$$

$$K_{sp}(AgBr) = m_{Ag^{+}(aq)} \gamma_{Ag^{+}(aq)} m_{Br^{-}(aq)} \gamma_{Br^{-}(aq)} / N_{AgBr(s)} \gamma_{AgBr(s)} \quad (10)$$

For the solid-solution process (9), irrespective of whether the dissolution is congruent or not, activities of AgCl(s) and AgBr(s) are not equal to one (although they tend to unity for the major component as it approaches stoichiometric purity). Solutions and solids can be analyzed in any given case, but values of γ in the solid state need to be known to solve the expressions given in (10); m_i is the molality of the dissolved species and N_i is the mole fraction of the component in the solid-solution at equilibrium (γ_i for dissolved ions can be calculated from the Debye-Hückel or Pitzer formalisms). In the particular example chosen, values for solid-state activity coefficients are known as a result of the technical importance of it in the photographic industry. However, for most systems, including those mentioned earlier, the dearth of data is a serious shortcoming in our knowledge of secondary mineral chemistry.

Solid-solutions present other chemical surprises and it is evident that even the simplest of systems are sometimes not as well understood as might first be thought. One such system is that involving wulfenite, $PbMoO_4$, and stolzite, $PbWO_4$. In the study of groundwater geochemistry associated with the North Mungana orebody mentioned above, wulfenite and stolzite were found to limit the dispersion of Pb, Mo and W in solution. This discovery prompted a re-investigation of the variety "chillagite" (Pb(Mo,W)O_4, Mo $\sim$ W) from the Christmas Gift mine, Chillagoe, Queensland, and which was described as a new mineral nearly a century ago (Ullman, 1912; Smith and Cotton, 1912). Later workers concluded that it was merely a member of the solid-solution series extending between the end-members wulfenite, $PbMoO_4$, and stolzite, $PbWO_4$ (Quodling and Cohen, 1938). Both end-members crystallize in the tetragonal space group $I4_1/a$, and have been grouped with $CaWO_4$ (scheelite) and $CaMoO_4$ (powellite) in the Scheelite Group. Crystals from Chillagoe are frequently zoned, some crystals displaying rhythmic banding of Mo and W-rich material, which reflect the compositions of the solutions from which the specimens formed. Recently, however, single-crystal X-ray structure of a "chillagite" specimen from Chillagoe of approximately constant composition corresponding to wulfenite$_{60}$stolzite$_{40}$ was carried out. While the structure could be refined in space group $I4_1/a$, a significant number of symmetry-forbidden reflections was present in the diffraction record. These included 9 symmetry-forbidden reflections in the ($hk0$) zone and, significantly, the reflections 002, 006, $00\overline{10}$ and $00\overline{14}$ were observed in the [$00l$] axial direction; thus symmetry operations 4_1 and a could not be present. "Chillagite" actually crystallizes in the closely related space group $I\bar{4}$, as does a specimen of powellite from Tsumeb, Namibia (Crane et al., 2000b; Hibbs et al., 2001). Just what is responsible for the space group change is not completely understood, but such structural variations are common in solid-solutions and much systematic structural characterization, even for "simple" mineral cases, remains to be completed.

The temperatures at which secondary minerals form vary considerably and this fact is often overlooked. Most modelling has used data at 25°C and this is acceptable for most cases. On the other hand, subtle temperature variations serve to stabilize certain phases in preference to others. This is true of the hydrate posnjakite, $Cu_4SO_4(OH)_6{\cdot}H_2O$, versus brochantite, $Cu_4SO_4(OH)_6$, the former being stable at about 10°C. Antlerite will crystallize directly from solution under appropriate pH conditions only above about 35°C (Williams, 1990). It is difficult to estimate temperatures of crystallization in the oxidized zone. Recently, however, stable isotope methods have been applied to develop malachite, azurite and cerussite geothermometers (Melchiorre et al., 1999, 2000, 2001). Some surprising results have been obtained including that which shows significant amounts of cerussite in the Broken Hill, New South Wales ores to have formed at up to 50°C. Further applications of these kinds of studies will permit the "fine-tuning" of chemical models in the oxidized zone.

Finally, it must be stated that despite of the success of the equilibrium approach in explaining secondary mineral parageneses and stabilities in a wide variety of settings, other assemblages are subject to kinetic control. Some good examples of this added complexity concern a few of the secondary copper(II) chlorides and carbonate mentioned above. The three basic chlorides of stoichiometry $Cu_2Cl(OH)_3$ have standard free energies of formation at 298.2K in the order paratacamite < atacamite < botallackite, but are inter-related by a series of complicated kinetic phenomena. A fourth polymorph, clinoatacamite, is not as well characterized in this respect (Pollard et al., 1989, 1992a). Botallackite is a rare species, but atacamite and paratacamite are very widespread in oxidized zones of copper ore bodies. In the laboratory, precipitation of aqueous copper(II) chloride solutions with aqueous base first gives rise to claringbullite, which in time recrystallizes in turn to botallackite then atacamite then paratacamite. The last step can be almost completely inhibited by addition of excess chloride ion, while the addition of aqueous copper(II) chloride solutions to aqueous base gives rise to spertiniite, $Cu(OH)_2$, again under kinetic control, in a kind of "non-commutative" chemical reaction. This cascade towards compounds of increasing thermodynamic stability is a manifestation of the Ostwald Step Rule (Ostwald, 1897), which states

> "...if a reaction can result in several products, it is not the stablest state with the least amount of free energy that is initially obtained but the least stable one, lying nearest to the original state in free energy."

Similar considerations apply to the formation of georgeite prior to recrystallization to malachite (Pollard et al., 1991, 1992b).

While our understanding of the details of these kinds of processes is poor, kinetic phenomena are very important in particular cases. In acid mine drainage settings (Parker and Robertson, 1999), control of metal ion dispersion most frequently depends on metastable phases. These include, for copper and zinc, the various hydrates of the brochantite stoichiometry, $Cu_4SO_4(OH)_6$, devilline, $CaCu_4(SO_4)_2(OH)_6{\cdot}3H_2O$, and serpierite and orthoserpierite, $Ca(Cu,Zn)_4(SO_4)_2(OH)_6{\cdot}3H_2O$ (Krause and Täuber, 1992; Popov, 1999). Much remains to be done in this area.

CONCLUSIONS

Much is known of the mineral chemistry of the oxidized zone. Applications of this knowledge range from processing of ores to the search for new deposits and control of heavy metal pollution. Yet our knowledge is far from perfect and obvious gaps require many further detailed studies. In view of the importance of the oxidized zone in an economic sense, appropriate efforts will certainly be directed towards filling those gaps and helping to solve the problems that remain for geochemists and metallurgists.

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Surface Modification: Advancing the Functionality of Materials

The Pollock Memorial Lecture in Mathematics and Physics

MARCELA M.M. BILEK

INTRODUCTION

The surface properties of materials are most commonly optimised for their applications by coating with a layer of a material that has the required surface properties. Surface modification allows us to mix and match surface and bulk properties to optimise materials for their applications. For example, base metal door knobs can be made to shine like gold for decorative purposes, the surfaces of steel cutting tools can be hardened by a layer of titanium nitride, and skeletal prosthetic implants can be made more biocompatible by doping with magnesium (Bilek et al. 2000).

A good coating needs to be both contiguous and well adherent. Physical vapour deposition is a flexible coating technique with advantages over wet chemical methods such as electroplating, especially in minimising hazardous waste. The problems of porous films with voids have been solved by the use of techniques in which a fraction of the surface reacting species impinges with elevated energy. The downside of these techniques is that they often lead to significant amounts of intrinsic compressive stress in the films produced. This stress limits the thickness to which films can be grown and often causes films to delaminate exposing parts of the original surface. This is a particularly serious problem in applications where even small exposures of the original surface cannot be tolerated, such as in corrosion protection and biomaterials. In prosthetic implants, the delaminated material presents an even greater problem because it will be released into the body.

In this paper we describe a new generation of methods that offer solutions for the problem of intrinsic stress in surface modifying coatings. The physics behind their ability to alleviate intrinsic stress is presented together with experimental results. The paper concludes with a discussion of further work necessary to develop the techniques to a stage where they can readily be used to coat complex and varied shaped components used in real world applications, with particular reference to the field of biomaterials.

GROWTH MODES AND STRESS

Figure 1 shows schematically the types of microstructures produced as impact energy varies across a variety of thin film deposition techniques. Films deposited at thermal energies (a fraction of an electron volt) tend to grow as columns with voids in between. This is because the atoms have very low surface mobility and the voids are shadowed from incoming ions by the columns just as the floor of a gorge is shadowed from sunlight. In an attempt to reduce the very high surface energy of this structure, van der Waals forces between the columns result in a tendency for the film to try to contract - a tensile stress. The forces on the substrate, shown by the arrows in the diagram, are directed inwards. The integrity of these coatings and their usefulness in protecting a surface are compromised by the presence of the voids.

Contiguous coatings (ie coatings without voids or pores) are readily produced by a range of energetic ion assisted deposition techniques, such as sputtering and plasma enhanced chemical vapour deposition (PECVD). In all of these techniques a fraction of the species condensing on the surface to form the coating layer are ionised. The substrates are usually biased negatively so that the ionised species arrive at the substrate with energies of 50 to a few hundred electron volts. The energies of these impacts are sufficient to burry the ions a few atomic layers beneath the surface of the growing film and provide some mobility for minor atomic rearrangements. This densifies the structure and prevents the formation of columns and voids. A secondary effect of the buried ions is to cause a tendency for the deposited material to swell and try to expand laterally. This creates a significant compressive stress in the film, which results in strain and forces on the substrate as shown by the arrows in the diagram. As the thickness of the film increases the stress and stored strain energy increases.

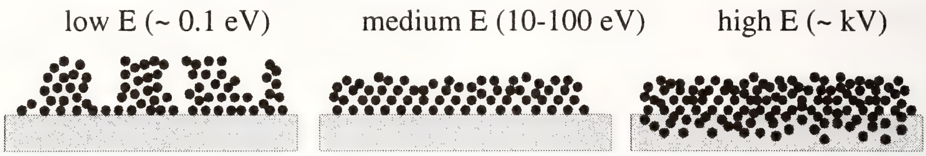

Figure 1: Schematic diagram showing film microstructures that result from various levels of ion bombardment. The low surface mobility in the low energy case leads to columns separated by voids, leading to tensile stress. Higher levels of ion energy result in ions being buried below the top few atomic layers, this results in densification and compressive stress. Very high energies produce a mixing layer at the substrate interface and appear to reduce the level of compressive stress.

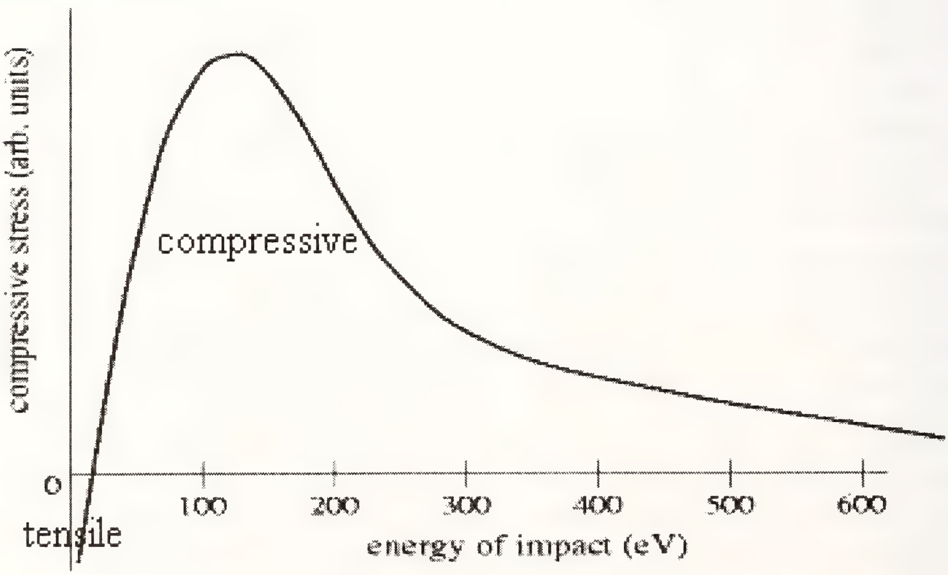

Figure 2: Schematic diagram of the generally observed relation between impact energy and intrinsic film stress.

Although strain energy is not a problem for many applications, it cannot be tolerated in situations where coatings need to be thick and completely free of cracks, such as in biomaterials. The classical Griffith criterion tells us that a crack will propagate and a film will delaminate if the strain energy relieved is greater than the total surface energy of the two new surfaces created by the delamination (ie substrate and underside of film).

It may be possible to overcome this limitation by using even higher impact energies. Recent experimental evidence shows that impact energies of a few kilo-electron volts or greater introduce enough energy to the atoms near the impact site to allow for significant atomic rearrangement and the relaxation of local stress and strain. For all materials studied to date, the stress versus impact energy behaviour has been found to be as sketched in Figure 2. High energy impacts also provide an additional benefit in the mixing of the substrate-coating interface because the first energetic impacts implant atoms under the surface of the substrate as shown in Figure 1. The diffuse interface provides for improved adhesion. The next section describes the new techniques for deposition with high-energy bombardment and the physics behind their success in eliminating stress.

PLASMA BASED ION IMPLANTATION AND THE THERMAL SPIKE

Plasma based ion implantation (PBII) also known as plasma immersion ion implantation (PIII) is a technique in which a high negative voltage is applied to the component being treated while it is immersed in a plasma. On short time scales, of the order of the inverse plasma electron frequency (typically 0.01 to 1 ns), the electrons are accelerated out of the region surrounding the biased work-piece. This establishes a charged region with high electric field around the work-piece across which virtually the entire voltage difference between the work-piece and the plasma drops. This region, often called the ion matrix sheath, shields the plasma from the high-voltage of the work-piece. At greater time scales (given by the inverse ion plasma frequency, usually over 100 times longer than the time scale of electron motion) the more massive and less mobile ions start to accelerate across the sheath towards the surface of the biased work-piece. As the ions accelerate and implant beneath the surface of the work-piece the ion density in the sheath is reduced and it is no longer able to completely shield the plasma from the bias on the work-piece. Electrons at the edge of the sheath feel an electric field and they are repelled further into the plasma and thus the sheath expands. The sheath will continue to expand until a steady state ion density profile is established across it or until the plasma is depleted of ions. In order to avoid plasma depletion it is usually necessary to apply the high-voltage bias in pulses.

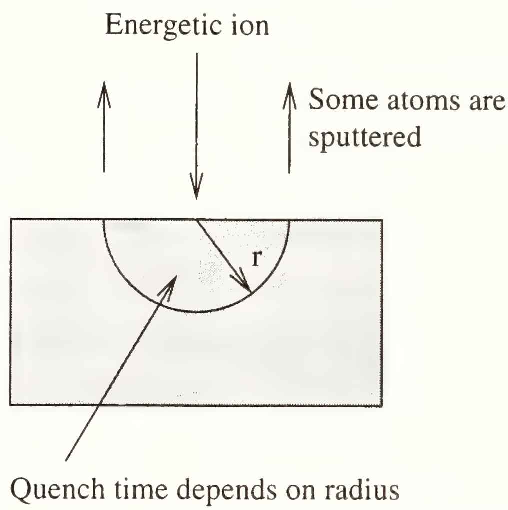

Figure 3: Schematic diagram of the thermal spike or high mobility region produced immediately surrounding the site of an energetic ion impact.

In some ways ion impacts on the surface of a film are a microscopic version of meteor impacts on a planet. In both cases the size of the affected area is dependent on the energy of the impact. For a meteor this is determined by its size and velocity. For the impact of an ion, it is also determined by the mass and energy of the impacting ion. The effected region is often referred to as a thermal spike and is shown schematically in Figure 3. It can be approximated as a hemispherical region with radius r ($r \propto \sqrt[3]{E}$) around the impact site. As with a meteor impact some material may be ejected in the form of sputtered surface atoms, but most of the energy is transferred to vibrational energy of the surrounding material. The energy is then gradually dissipated to the rest of the film as heat. It can be shown (Marks, 1997) that as the energy of the impact and hence the radius of the thermal spike increases the time it takes for the region to be quenched back to the initial temperature also increases. If the thermal spike endures for long enough there will be sufficient time for significant atomic movements and relaxation corresponding to local annealing. Thus high-energy impacts are an ideal way to relieve intrinsic stress during the growth process.

SOME RECENT EXPERIMENTAL RESULTS

Figure 4 shows scanning electron microscope (SEM) images (Tarrant et al. 2001) of films deposited using a cathodic arc carbon plasma (~50 eV ions), (a) without high-voltage pulsing of the substrate and (b) with high-voltage pulsing. The high-voltage pulsed power supply delivered 20 kV pulses lasting 20 ms at a frequency of 500 Hz. There is a dramatic reduction in cracking and delamination around the test scratch mark for the film deposited with the high voltage ion impacts. The reduction in intrinsic stress has allowed the deposition of extremely thick carbon layers. Figure 5 shows a cross-sectional SEM image (Tarrant et al. 2001) of a 11.4 μm thick film. Conventional cathodic arc deposition can achieve no more than a few hundred nanometers before the film spontaneously delaminates.

Titanium nitride films deposited with high voltage pulsing are also quite different from the gold coatings produced by a titanium cathodic arc operating in a nitrogen atmosphere. When high-voltage pulsing is used the colour of the films becomes purple. There is also a distinct change in the preferred orientation of the crystallites in the film. For the usual arc fabricated material a $< 111 >$ direction perpendicular to the plane of the film dominates, whereas with high-voltage pulsing the preferred direction becomes $< 200 >$. This is the crystal orientation observed in low stress material where minimisation of surface energy determines the orientation (Pelleg et al. 1991). The minimisation of bulk strain energy on the other hand leads to the $< 111 >$ orientation (McKenzie et al. 1999) in highly stressed material deposited using a cathodic arc without high-voltage pulsing.

Polymers have an attractive set of bulk properties. They combine lightness and strength with ease of fabrication. Their range of applications can be considerably enhanced by modifying their surface properties to give them metallic lustre or scratch resistance for example. It is difficult to make a good adherent metal layer on a polymer, due to the lack of chemical bonds between the metal film and polymer surface. However, PBII allows interface mixing and improves the chance of chemical bonding between metal and polymer (Yap et al. 1998). Lower intrinsic stress in the deposited film also reduces the tendency to delaminate.

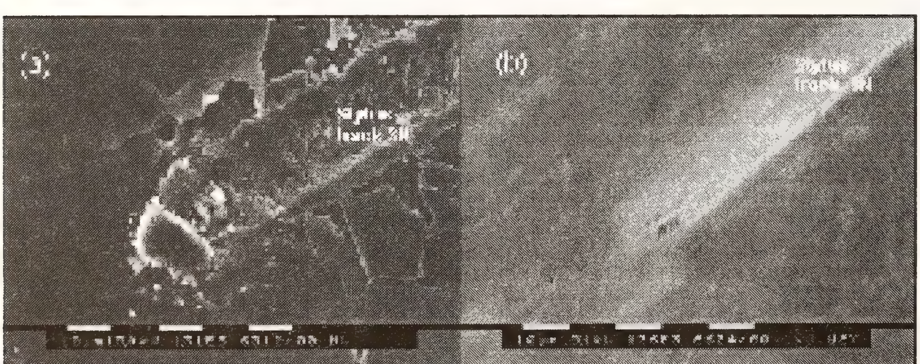

Figure 4: Scanning electron microscope images of scratched surfaces of 200 nm carbon films on silicon substrates produced (a) with no ion implantation and (b) with 20 keV ion implantation.

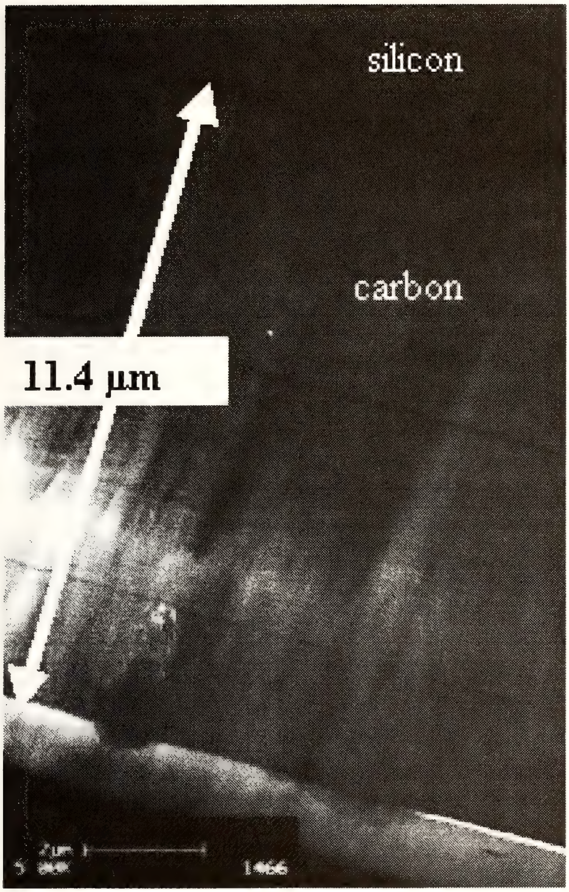

Figure 5: Scanning electron microscope image of an 11.4 micrometer thick carbon film on a silicon substrate produced with 20 keV ion implantation.

Skeletal prosthetic implants are bonded to the skeleton most effectively when there is a good compatibility between bone cells and the surface of the implant. The hospitalisation time of the patient is greatly reduced if the cells can be quickly recruited onto the new surface. Alloys of titanium have been found to be effective at bone cell recruitment while alloys of cobalt and chromium have excellent mechanical properties. A well bonded treatment of the titanium alloy coating on a cobalt-chromium substrate achieves almost the same recruitment of adhered bone cells as does the titanium alloy (Howlett et al. 1999). The implantation of magnesium without concurrent film deposition into an alumina substrate was also found to increase the recruitment of bone cells (Bilek et al. 2000).

THE TREATMENT OF COMPLEX SHAPES FOR BIOMATERIALS APPLICATIONS

The test samples reported on in the previous section were all small planar substrates, however the shapes of real devices, particularly in the biomedical field are much more complex, often having sharp points. Since the sheath controls the ion implanting process it is essential to understand and to be able to correct for the behaviour of the sheath around complex objects. Solving the equations of sheath expansion near a curved surface of small radius shows that the sheath there is thinner than it is near a flat approximately planar part of the substrate (Bilek 2000). This can be understood by realising that as the ions are accelerated towards a pointed part of the substrate they are also converging so the reduction in density caused by their acceleration cannot be as great as that near a flat part of the substrate. Since it is the reduction in ion density in the sheath which causes it to expand, the sheath will always expand less near a sharp corner or curve than at a planar surface. In fact in some situations it could conceivably even contract if the ion focusing is great enough.

If the sheath becomes too thin anywhere around the substrate, electric breakdown will occur between the substrate and the plasma. Such a breakdown causes ablation of material on the surface of the work-piece where it occurs and damages the surface. In a drifting plasma, such as produced in laser ablation or the cathodic arc, the sheath behaviour is further complicated by the plasma drift. Because the drift maintains a higher plasma density on the side of the work piece facing into the plasma beam the sheath on this side will be thinner than that on the wake side. Further work is required to study experimentally and theoretically the development of the sheath around complex substrates and develop control strategies suitable for reliable plasma based implantation of the devices used in the medical industry.

CONCLUSION

Plasma based ion implantation with energies upwards of 1 keV and concurrent deposition using a cathodic arc plasma source has been found to produce good quality films with significantly reduced stress. A further benefit of this surface modification technique is that it induces mixing at the interface. Interface mixing together with stress reduction leads to improved adhesion and the ability to deposit much thicker films than would be possible using the plasma source alone. These advances are of special significance in the field of biomaterials, where even minor delamination cannot be tolerated. The next step in the application of the technique to prosthetic implants of complex shape is the development of a process control strategy capable of ensuring a uniform treatment without electric breakdown across the plasma sheath.

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The Centenary of Mary Everitt's "Gundungurra" Grammar

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Abstract: Year 2001 marks the centenary of a unique scientific paper (Mathews & Everitt, 1900), on the gunḏuŋara Aboriginal language, whose primary authorship has been in dispute ever since it was read before the Royal Society of New South Wales on 5th December 1900. Complex grammatical forms and structures, accurately preserved in the raw phonetic data within the paper, have been largely overlooked by successive generations of scholars and linguists (Kohen, 1993; Russell, 1914; Turbet, 1989; Dixon, 1980). In fact, Appendix 2 of the present paper is the first attempt by anyone in 100 years to decipher the gunḏuŋara women's Evening-Star Song, a treasure originally published in (Mathews & Everitt, 1900), whose meaning no modern scholar has ever even speculated about. Such has been the rate of research in this neglected field. And, whereas numerous large biographies including (Elkin, 1975) were long-ago written about one of the coauthors, the other coauthor Mary Martha ("Minnie") Everitt (1854–1937) is still virtually unknown and the important story of how the paper came into being has never been properly told. New advances at the cutting edge of linguistic theory now enable us to demonstrate that the grammar is actually women's language likely to have been collected by Mary Everitt, not her male "coauthor", thus shedding light on the principal authorship of this historic and important century-old paper.

INTRODUCTION

gunḏuŋara Aboriginal people were referred to by Barrallier (Barralier, 1802) as "the mountaineers", by the Sydney Gazette as "mountain men", and by Governor Macquarie (Macquarie, 1814) as "the wild mountain blacks". They occupied muran-ḏaru which was the general region south-west of present-day Sydney, including the entire Cox's River Valley from the Cowpastures and Southern Tablelands to the Blue Mountains beyond Lithgow (Illert, 1998, pp. 10–11). Unlike neighbouring Aboriginal tribes they had a tradition of warrior chieftains who, throughout the first half of the 19th century, openly waged war against European soldiers and Native Police with varying degrees of success (Illert, 1998).

By the 1870's isolated farmer settlers had begun intermarrying with the local Aboriginal people, and Roman Catholic missionaries were running several small schools for Aboriginal children throughout the Burragorang and Wollondilly river valleys (Smith, 1991). Scattered groups were still living "wild" along the Cox, ḏuribuluḏ = "river-land" (see Appendices 4 and 5; references Barrett, 1993 and 1995, and Illert, 1998), well into the 20th century - for example when the Hughes Brothers escaped from Katoomba jail in 1921 and were recaptured living in a "blacks camp" on the Upper Cox River, or, in 1929 when the seminarians Keith Bush and Steve Ford, walking from Wentworth Falls to Picton, passed an Aboriginal camp near the junction of the Cox and Wollondilly Rivers (Barrett, 1995, p. 115: based upon reminiscences by the late Keith Bush).

Thus Mary Everitt, Mistress in charge of the Girls Department of the Superior Public School in South Parramatta, one of the co-authors of the December 1900 paper, quite understandably mentions:

> 'having visited and camped with the natives of Burragorang, on the Wollondilly River, the most isolated and

> hence the best preserved and primitive remnant of the Gundungurra speaking people - two of our principal informants being "Billy Russell", and "Bessy Simms", who were able to satisfy us in every particular ... ' (Mathews & Everitt, 1900, p. 263).

Being a teacher Mary Everitt could only have undertaken this visit to the Nulla Nulla camp in the upper reaches of the Wollondilly River Valley - mainly to see William Russell, Mrs Annie Sherritt, and the Rileys (Long, 1973) - during one of the school holiday breaks which were four weeks at Christmas, one week at easter, and two weeks during winter (McPherson, 1998). We know it was the winter holiday break because this coincided with the planet Venus attaining its once-every-586-day (synodic) maximum angular separation from the Sun (45.58 degrees), becoming most conspicuous in the evening sky in early May 1900 and thereafter remaining prominent throughout June, hence the Evening-Star Song (see Appendix 2). Additionally Mary Everitt mentions taking "... about half a dozen lessons, between July and November 1900 ... [from] Mrs Bessie Simms, at La Perouse ... " who advised her to further "verify her grammar ... at Burragorang" (Long, 1973).

Throughout this epic research and fieldwork Mary Everitt claims to have been assisted by her niece who had "a better ear, and better theory than I ... " (Everitt, 19 June 1901). But there is no reason to believe that the other co-author of the final paper, the surveyor R.H. Mathews (1841–1918), accompanied them on any occasion or played any active part at all in documenting the language. On the contrary, Mary Everitt's claim was that she studied the language "... for many months, and wrote a little grammar on it which was incorporated in a paper by a member of the Royal Society [of New South Wales], and read by him before that body last December" (Everitt, 12 June 1901).

A.L. Bennett of The Oaks – a contemporary of the parties involved who himself, 14 years later, compiled William Russell's memoirs – cheekily gave the credit for the entire paper to Mary Everitt, only mentioning R.H. Mathews obliquely as an afterthought:

> "... as to the grammatical structure of this language compared with that of other tribes. I refer to Miss M.M. Everitt's "The Organisation Language and Initiation Ceremonies of the Aborigines of the South East Coast of N.S.W."; and odd writings of Mr R.H. Mathews, scattered through some of his many pamphlets on the Australian race in general" (Russell, 1914, p. 7).

With this book selling for a shilling a copy each year at the Camden Show, during the lifetimes of both Mary Everitt and R.H. Mathews, there clearly was some contemporary public awareness of unrefuted claims that the grammatical research was conducted by Mary Everitt and her niece and that it was their field-trip to the Burragorang – perhaps with a detour to Picton to visit Mark Feld whose account of local Aboriginal legends and place-names appeared in July 1900.

In 1900 Charles Butler's coach service from Camden to Yerranderie was yet to begin regular runs (Barrett, 1995, pp. 9, 12 & 70) and although the Warragamba (bush) Walking Club had formed in Sydney as early as 1895 (Hilder, 1988, pp. 80–84; Tompkins, 1907) – no doubt with some students from Parramatta's Superior Public School as members – it seems likely that Mary Everitt and her niece would have made their ambitious and epic journey to the remote upper reaches of the Wollondilly River valley on horseback, up and down the Burragorang's precipitous 2000 foot cliffs, at the onset of the bitter winter of 1900 which culminated in unprecedented frosts and snowfalls in New South Wales central districts. Throughout July/August that year, nearly a metre of snow fell at Bathurst with Forbes reporting its first known snowstorm since European settlement. The Budawangs were blanketed (Hilder, 1998, p. 80) and the Shoalhaven Aboriginal William

Bothong even recorded snowfalls on Woodhill Mountain. Years later, Bernard O'Reilly likewise recalled a dreadful winter in the Kanimbla Valley, he thought it was 1902, in which:

> "... ice, even at noon, blocked ripples of the creek, and there were over sixty hard frosts in succession, frosts which killed big gum trees on Round Ridge and Blackfellows Hill" (O'Reilly, 1958, pp. 59 & 265).

One needs to reflect upon the physical (as well as intellectual) achievements of this 46 year old Parramatta schoolmistress who professed to suffer from the "severe colds I catch in Parramatta" (Everitt, 12 June 1901) and who, unlike R.H. Mathews, was actually a grammarian and linguist with sufficient qualifications and wit to professionally teach at Parramatta's Superior Public School. She and her niece actually "lived" linguistics whilst R.H. Mathews was a retired 59 year old at the time – one would imagine well past riding horses down 2000 foot cliffs, through snowdrifts, into iced river valleys – an armchair expert occasionally travelling the countryside in a leisurely fashion to attend Boonans and discuss bizarre "man-making" rituals and marriage practices usually with men of the tribe. Women's lullabies (see Appendix 2 and Illert, 1999) and children's songs and games, the domestic fun-things that are equally part of any culture, are largely missing from his 170 published papers.

This sort of chauvinistic and sometimes prurient stuff (Roth, 1910) may have livened male conversation round 19th century Royal Society dinner tables but it made Aboriginal people objects of study in a way that did little to rectify contemporary European prejudices about their supposed "primitiveness" (Long, 1973; Roth 1910) "inferiority" (Telfer, 1949) and "superstitiousness" (Feld, 1900). It's like studying Australian society today, but limiting the investigation to European religious art and to rituals (funerals, marriages and baptisms etc) performed in churches on Sundays.

A.P. Elkin's 1975 review article on R.H. Mathews' achievements devoted twenty six pages to his anthropological investigations but said virtually nothing about his linguistic salvage work - in relation to which some quite serious matters of plagiarism may have to be addressed. What was missed was the fact that one can emphasise inevitable differences in social and cultural practices and spiritual beliefs, but Aboriginal people also had a language and an oral tradition that was subtle, with a grammar as sophisticated as any modern European language (see the various Notes and Appendices at the end of this paper).

"SATURNALIAN" CONTRIBUTIONS TO PHILOLOGY

In 1874 the Roman Catholic priest Fr. Dillon, at the Pocket Creek farming community, claimed that every young Aboriginal in the Valley had been taught to read and write (Smith, 1991, p. 14). By 1891 Aborigines comprised one third of the total Cox's River population and even the Aboriginal Protection Board's 1890 report peevishly admitted that Burragorang Aboriginal people were surviving and "not addicted to bouts of intemperance" which was in stark contrast to their wards elsewhere, for example at La Perouse, whom Philip Cohen described as:

> '... demoralised degraded beings who infested the ... camps on the southern shores of Sydney Harbour or at Botany ... reek[ing] with rum and debauchery, and in many instances with butchery ... The white lads and young men of the time visited those camps in droves, and often night was made hideous by the saturnalian performances of both blacks and whites ... [They spoke] impure language ... mixed up with pigeon English, as well as the dialects of the natives of other tribes which had joined them ... More

than 40 years ago I brought to Sydney from the Hastings district two Aboriginal lads, bright intelligent fellows, ... one day I took them over to the blacks' camp, which was at the time situated at Rose Bay. My boys could understand but very little of the gibberish they heard there, and when I questioned them on the subject their reply was "too much Irish" ... ' (Cohen, 1890).

Cohen was a vexatious arguer about the meaning of Sydney's Aboriginal place-names. In a letter of reply Richard Hill politely asked Cohen how it was that he knew so much about blacks camps:

'... "reeking with rum, debauchery and butchery" ... My late brother George never tasted spirits in his life, and in his company I and many others ... have visited these camps and spent days there on more than one occasion, but never did any of us ... provide the blacks with rum' (Hill, 1890).

A third correspondent, Alex Oliver pointed out the impossibility of Cohen's references to the supposedly original "Comlerai blacks of Port Jackson and Botany" whom Cohen claimed in years past to have known, and to have hunted and fished with, and learned their language from. In fact the Kamilaroi tribe is from north-west of Maitland, way the other side of Newcastle, and certainly nowhere near Sydney. And why should Aboriginal lads from "the Hastings district" understand the Sydney language, any more than a Frenchman would understand Latvian or Arabic?

More than a century later we might have more important things to think about were it not for the fact that this is evidence for a popular oral tradition that Kamilaroi's were the original Sydney tribe. We encounter it elsewhere.

William Albert Cuneo (1860-1942), who wrote some poems and plays, likewise claimed intimate knowledge of his "friends" the local "Kamilaroi" Aborigines (Cuneo, 1899). He was born at Binalong and became Stationmaster at Thirlmere from 1885, where he was also Postmaster from 1887 to 1907 (Meredith, 1989, pp. 30-47; Smith, 1991, pp. 3-5).

Cuneo (1893) published "A Brain Record" in the *Picton Post & Advocate* newspaper recounting historically important bush yarns and stories. We know that Cuneo wasn't born till 1860, so he simply couldn't have been the white lad who witnessed mʊran-gʊli's Ascension to Chieftaincy ceremony in 1846. Clearly these are stories learned by Cuneo, from his mining partner Ben Carlon (1841-1925), and actually dating back to the 1840's (Meredith, 1989, p. 30; Smith, 1991, pp. 7-8). Interpreted in this light, with possible errors removed, there is no reason to believe that the other historical details of the stories are especially untrue - but there are telling minor details that are wrong. For example, one of Carlon's stories says:

"I think I was about four years old when Dad (Patrick Carlon) bought the farm at Burragorang, then the headquarters of the Kamileroi tribe that claimed sovereignty over a tract of country much larger than the present County of Camden ..." (Cuneo, 1899).

Although any Burragorang Aboriginal from that time would have affirmed that they were gʊnd̠ʊŋara - not Kamileroi - yet another story tells of an Aboriginal runner arriving at the Burragorang, carrying a message-stick from the Edwards River, being welcomed and "escorted to the boundary of the Kamilaroi dominions ...".

Maybe this particular misconception originated from the name of "Comleroy" Road – the first road north from Sydney dating back to the early 1800's – which turns north from the Bell's Line Road at the approach of Kurrajong township (today's road turns north at Windsor). There is also a misnamed Mount Kamilaroi near the Nattai/Wollondilly junction. But, whatever its origin, systematic mis-information like this demonstrates that popular stories of the time, about Sydney, relied very little upon first hand information obtained from actual Aboriginal people who were often the subjects of discussion.

MISSIONARY CONTRIBUTIONS TO PHILOLOGY ?

At the other extreme, E.J. Telfer's book tells the story of missionary work at La Perouse. How a Christian Endeavourer, who initially went there to install a stove at the old Customs House, was shocked to find that white people often came from the city to:

> "lure the dark folk into sin. They brought cards and dice, and taught the natives to gamble, drink, and swear. ...Miss Watson, before being appointed a missionary, sometimes stayed in Sydney on Saturday nights and sought out the aborigines around Paddy's Markets, shielding them from temptation, keeping them from hotels, and getting them home early ...[she] walked from Stanmore to La Perouse, a distance of at least nine miles, returning home in time for the evening service ...there were many adversaries. Many of the white residents, who had been benefiting themselves through the credulity and defencelessness of the aborigines, regarded the advent of the missionary with suspicion and aversion, realising, no doubt, that hope of their gains was gone ..." (Telfer, 1949, pp. 39-41).

On the surface this sounds almost rational but there were also reports (refer Missionary Journals) of zealous converts running from tent to tent at the Port Kembla Aboriginal camp hysterically shouting "Its Christ you want. I was once like you, but now I am satisfied".

Miss Retta Dixon (who married L.W. Long) replaced Miss J. Watson, serving as the missionary at La Perouse from 1898 to 1905. In 1973 some papers were deposited with the Australian Institute for Aboriginal and Torres Strait Islander Studies by E.C. Long - the retiring director of the Aborigines Inland Mission who was also, importantly, the son of Retta Dixon. He seems to be attributed with the claim that "...Miss Dixon ..., along with Miss Everitt, was one of the first resident missionaries at La Perouse" (Organ 1993, p. 200).

Now this is an interesting proposition.

Mary Everitt had a busy and distinguished career as a teacher and educationalist from the time of her graduation in December 1878 (from the then co-educational Fort Street Teacher Training School, in Observatory Hill, Sydney) till her retirement as Head-Mistress of the Girls Department at the Crystal Street Public School at Petersham on 31st July 1909. The only break in this long career, during which time she could have "resided" at La Perouse, were the "two full years" 1896 and 1897 which she took off - supposedly because of "increasing short sight ...it was only the chance of at last getting suitable spectacles that justified my application for re-admission into the service in January 1898" (Everitt, 11 Nov. 1908).

This "broken service" cost her nearly 20 years worth of accrued superannuation, up to 1896, the Chief Inspector of the New South Wales Department of Public Instruction deciding flatly to keep her contributions. Upon rejoining the New South Wales teaching service in 1898, she mentions having thereafter "insured my life instead of contributing to the Superannuation Fund" (Everitt, 11 Nov. 1908).

Both Miss Watson and Mary Everitt moved on, in 1898, when Retta Dixon was appointed to La Perouse. And there is absolutely no documentary evidence that Mary Everitt was a missionary or even religious. None of Mary Everitt's letters mention Christianity. E.J. Telfer's classic book doesn't mention her once! Nor do the early missionary newspapers. Surely a founding missionary in the same league as Retta Dixon, one who supposedly knew Retta Dixon, would have been mentioned somewhere in these latter sources - at least once - if it were true.

It seems, by the 1970's, the descendants of the La Perouse Christian Endeavourers started to find it convenient to retrospectively imagine links between their ancestors and people like Mary Everitt who was clearly not bent on extinguishing "heathen" language and culture but, rather, made a great effort to document and preserve it. In contrast, where in the missionary journals of that time are the joyous accounts of Aboriginal words and songs being saved along with souls?

What we do reliably know about Mary Everitt is that she was one of three daughters born to the carpenter John Everitt and Martha Susannah Thomas who were married in St Lawrence's Church of England, George Street, Sydney, in 1853. Their first daughter Jane had been born at Petersham in 1850 and baptised there in St Peter's Church of England, Cooks River. Mary herself was born in 1854 and baptised at St Lawrence's Church of England in Sydney, whilst Emily was born in 1858 at Kensington. John Everitt died young shortly after the birth of his third daughter.

In December 1878, at the age of 24 years, Mary was awarded her teacher training qualification from the Fort Street Teacher Training School in Sydney. As a temporary assistant she attended Sussex Street from 16 January 1879, Ashfield from 9 March 1880, and Parramatta South from 8 April 1880. She was appointed Mistress in charge of the Girls Department at Wagga Wagga School from 1 October 1880 where she had the additional responsibility of supervising student-teachers in the class rooms. Many years later, one of the student-teachers from that time, the subsequently famous poet Mary Gilmore (whose portrait was painted by William Dobell) reminisced with delight about the experience (McPherson, 1997, p. 54). On 1st October 1883 Mary Everitt was given the important position of Mistress in charge of the Bathurst Girls High School which was one of only three within New South Wales at the time (ie Sydney, Bathurst & Goulburn. Maitland Girls High did not start till the following year).

By 1st July 1885 Mary was given the extremely important and senior position of Principal of the Hurlestone Training School, which was the first training institution exclusively for women-teachers within New South Wales It was from here that she resigned on 31st December 1895. When she reapplied for admission into the teaching service, on 28th December 1897 she was appointed Mistress in charge of the Girl's Department at the Superior Public School at South Parramatta (now the Parramatta Public School in Macquarie Street) where she stayed for a decade. It was during this period, particularly in the years 1900 and 1901, that she visited Bessy Simms and Queen Emma at La Perouse and made field-trips to the Upper Wollondilly to the Nulla Nulla Camp to gather the necessary material to write her paper on the Gundungara Aboriginal language.

On 17th August 1907 she was appointed Mistress in charge of the Girls Department at the Crystal Street Public School, at Petersham, from which she retired aged 55 years on 31st July 1909 due, supposedly, to "a kind of chronic bronchial asthma which promises to affect my work ...". When Mary Everitt died, aged 83 on 23 June 1937, she was a resident of Cronulla Street, Hurstville - within about 10 miles of La Perouse. We don't know if today's Everitt Street at Maroubra was named after her.

The first missionary at La Perouse in the early 1890's, Miss J. Watson, lived at Stanmore and walked to La Perouse and back each weekend (Telfer, 1949, p. 14). Her successor in 1898, Retta Dixon, was a resident of Petersham - the same general neighbourhood as the Everitt family. Educated women were uncommon in those times so it is indeed likely that Miss Watson and Mary Everitt, perhaps even Retta Dixon, grew up together and attended the same local schools and educational institutions. It is also likely that Mary Everitt did initially find her way to the La Perouse mission strolling along with Miss Watson on a Saturday afternoon in the early 1890's. As a teacher Mary is even likely to have donated some of her weekend time giving lessons at La Perouse to elevate literacy and numeracy amongst the Aboriginal people and she may actually have resided there during the years 1896 and 1897 with Miss Watson.

But it does not follow that Mary Everitt was, herself, a missionary or even religious. Her claimed bronchial problem (Everitt, 12 June 1901) may have necessitated some time in the sun at the seaside to recover, or she may have wanted to help her friend Miss Watson, or she may have been motivated by social justice considerations, or some combination of these factors. But, whatever her contributions at La Perouse, the known missionaries of the time chose not to record them.

SCHOLARSHIP AND PUBLICATION

Of far greater importance was the fact that Mary Everitt knew, and was personally known by, an amazing number of leading Aboriginal Elders from that time. Her correspondence of the 19th and 24th of June 1901 lists letters from or conversations with Bessy Simms, Granny Giles, Emma Timbery, Lizzy Malone, Clara Phillips ("Gungee"), Kate Saunders, Jimmy Lowndes and Robert Racklin in contrast to the published paper (Mathews & Everitt, 1900) which, true to form for R.H. Mathews, mainly lists male Elders by name:

> "Jerry Murphy a native of Bega, and also a resident for many years at Cooma, Steve of Braidwood, [William] Budthong of Shoalhaven, [George] Timbery of Wollongong, Ned Caroll of Goulburn; and ... many others, including some old women ..."

With the exception of William Russell the male informants listed in this paper, obviously by Mathews, are from everywhere other than the Burragorang and every tribe other than the gʊnd̲ʊŋara Yet the language is gʊnd̲ʊŋara and it is demonstrably women's language. For example the paper claims that:

> 'There are two genders, the masculine denoting the male sex; and the feminine, denoting the female sex; generally expressed by the use of different words. "bowwil" = man; "bullan" = woman. The sex of animals may also be distinguished by the prefixes "go-wul" = male, and "ngo-wal" = female'.

These "prefixes" are actually the words gʊ(n):w(ur)ʊl(a) = lazy (i.e. not "male"; refer to Appendices 4 and 5), and ŋu(ru):w(ur)ʊl(a) = busy, industrious (i.e. not "female"; refer to Note B "stamping hand" and Appendix 2 "twinkling star"). And, whilst bula:n = pair of breasts may actually be a complimentary word for "woman", bʊ(lu:i:d̲ar):w(urʊla):w(ur)ʊl(a) = dwarf or midget (probably referring to penis size) is not a complimentary or correct word for "man".

Clearly a female informant was responsible for this vocabulary!

R.H. Mathews himself, was clearly uncertain over gʊnd̲ʊŋara gender expressions when he wrote in his solo paper: "... the males of animals are distinguished by the addition of goomban, and the females dhoorook ... Others again have the suffix koual for the male, and noual for the female ..." (Mathews, 4 Oct. 1901, p. 142). One could well ask what was the supposed difference?

Furthermore a note written by Mary Everitt (Long, 1973), attached to an offprint of the 1900 paper, specifically states:

> "as taught to me by Mrs Bessie Simms, at La Perouse, in about half a dozen lessons between July and November 1900. ... Mrs Simms ... advised me to verify her grammar ... at Burragorang. This grammar, however, is Mrs Simms only, and is based upon Dr Roth's method ..."

...so much for Mathews' male "informants".

R.M.W. Dixon (Dixson, 1980) has conjectured that "Mathews frequently doctored his field-notes for publication" but, not actually knowing the gʊnd̲ʊŋara language, he was unable to convincingly demonstrate or quantify the full extent of it. However we can give examples from the paper (Mathews and Everitt, 1900).

(**a**) Mary Everitt heard "ben-g:u:l-warea" for the expression ɖuŋ-g:i:lʊ-wuru = my rear. This mishearing of ɖ as "b" is so wrong and distinctive (see Note A) that she self-corrected this mistake elsewhere. R.H. Mathews however, perpetuating the mistake in 1904, served up "ben:g:a:l:" ("back") supposedly as a "ngunnawal" word from Ned Carrol of Goulburn (see Appendix 3(i) and Mathews, 1904).

Likewise, in The Evening Star Song (Appendix 2), Mary Everitt mis-phoneticised garʊ as "jirra", evidently hearing g as "j". And sure enough, three years later, R.H. Mathews (1903) faithfully parroted garʊ as "jarra" in his allegedly "thurrawal" word "bulla:jarra::ng:" ("shine") which is obviously bulʊ-garʊ:(i)-ɲ(uŋ:n̲ʊra) = going down there(distant). And there are too many other examples like this.

Incidentally, in 1901, the correct verb gʊl(a):i = shine(ing) (as in "shining star", Appendix 2) had actually been given by Mathews as a supposedly "dharruk" word "killi" ("shine"). So we begin to see another even more alarming problem here. These words do not represent the same concept ('shining') in different languages as Mathews claimed. They are actually different concepts within the same universal south east Australian Aboriginal language which, through ignorance, Mathews perceived as several different Aboriginal languages - "thoorga", "thurrawal", "dharruk", "gundungurra", "ngunnawal" and "ngarrugu".

(**b**) Mary Everitt quite astutely recorded Bessy Simms' phrase mʊ(ra):n:ŋu(ru) g(ʊra):i-ɲu(ŋ):ɲin ɖuŋ-g:i:lʊ-wuru = run - come here (approach) - my rear. R.H. Mathews frugally broke this into two components, in 1904 serving up come-running, mʊ(ra):n:ŋu(ru) g(ʊra):i, as a supposedly "ngunnawal" word "come" and then, in 1908, the other half approach my rear, gʊra:(i-ɲuŋ:ɲin) ɖuŋ-g:i:lʊ-(wuru), as its supposedly "ngarrigu" counterpart "come". One can't just cut a phrase in half like this and expect both halves to still mean the same thing. The logic of this is presented in a concise and visually obvious way in Appendix 3(i) and, after thoughtful study, the reader will notice that R.H. Mathews again parroted Mary Everitt's distinctive telltale misphoneticisation of the ɖ sound (as "b") in his 1904 and 1908 papers. This isn't gratuitous speculation. From the point of view of probability theory, the likelihood of all these "coincidences" occurring simultaneously is multiplicative, hence diminishingly small. There can be little doubt that Mathews obtained these words, complete with distinctive misphoneticisations, from Mary Everitt's gʊnd̲ʊŋara material to which he had access at least since the year 1900.

(**c**) But the most telling example arises from Mary Everitt's quite correctly given expressions for *sun-set* and *sun-rise* (see Appendix 1). In a careless slip, Mary Everitt gave the sentence *I will come running back here at sunrise* - with the wrong accompanying translation "will run I back sun will sink, or, I shall return at sunset" (see Appendix 3(ii)). This was all R.H. Mathews needed. Now armed with gʊnd̲ʊŋara phrases for *sun-rise* and *sun-set*, but unknown to him with their meanings switched, he carefully extracted the noun-phrase "sun", d̲ʊla:n-wiɲ = orbiting thing, leaving behind what he thought must, by a process of elimination, mean something like "going up/down" (see Appendices 1 and 7). And, had these meanings not been switched, Mathews' footsteps would have been invisible and he would have gotten away with misleading statements in his 4 Oct. 1901 paper which was, significantly, published overseas without any acknowledgement of Mary Everitt, nor even a reference to their previously published "joint paper" from which he drew phonetic data. Specifically, in his 4 Oct 1901 solo paper Mathews opined 'A prepositional meaning is often obtained by a verb; thus, instead of having a word for "up" or "down", a native will say, boomaningga = *up I will go*; woorara-muningga = *down I will go*'. Now this is simply untrue; bulu means *up*, and bulʊ means *down*, and the language has a precise Boolean algebra employing these words. The Appendices clearly show how *up* and *down* were actually used. The only reason Mathews had a "verb" was because that's what was left from the expressions "sun goes up/down" (in Appendix 1) once the noun-phrase "sun" is removed. To make it a bit less obvious he installed the word *here* in place of *there* giving quite wrong expressions bu(lʊ)-ɲu(ŋ):ɲin-ga(rʊ:i) = "boo-ma:nin-gga:" = *down here(close) go[ing]*, and wuru:(nʊ)ra-ɲu(ŋ):ɲin-ga(rʊ:i) = "woora:ra-mu:nin-gga:" = *away-yonder(distant) here(close) goes* (this is a self contradictory jumble, and a bad guess). Mary Everitt's examples, carefully analysed in our Appendices 1, 2 and 3, clearly show the logic of something *coming-here(close)* or *going-there(distant)*, but it is absurd, if not logically forbidden, to make Mathews' combinations of *coming-there(distant)* or *going-here(close)* - even in English it is wrong. Mary Everitt gave no examples of these wrong cases. Her grammar makes complete sense whilst Mathews' is logically absurd.

As a woman, Mary Everitt wouldn't have been encouraged to either write a solo paper or to personally present it to the Royal Society of New South Wales. Protocol of the time required that it be done through a male intermediary, in this instance by R.H. Mathews who was clearly muddling the roles of referee and co-author. Yet even whilst Mary Everitt's grammar was being "refereed" by Mathews for the Royal Society of New South Wales, he must have, in the author's opinion, also been plagiarising her phonetic data to secretly write his solo paper for the *Proceedings of the American Philosophical Society.* This follows when one considers the months of delay required for sea-mail first from Australia to America, then for a reply back to Australia, then for Mathews' reply to the reply plus, of course, refereeing and ultimately printing - all by 4th October 1901. Even with modern e-mail it can take a year or more to get a scholarly paper refereed and published. The author sees abuse of trust at every level.

The kindest interpretation is that, by mid 1900, Mathews was flustered at the prospect of some genuine field-work by a professional grammarian of Mary Everitt's calibre and that this triggered perhaps uncharacteristic intellectual dishonesty on his part. However R.M.W. Dixon takes a stronger position, pointing out that Mathews routinely falsified his field notes over a period of many years and that all of his 170 published papers are therefore potentially suspect.

Whatever the case R.H. Mathews used his influence to promote his alleged expertise in the coastal "Thurrawal language" and also the masculiness (hence presumed reliability) of his named Aboriginal informants - as compared to Mary Everitt's informants "many others, including some old women" (Mathews & Everitt, 1900, p. 262). This self-serving and irrational comparison left Mary Everitt, on 12 June 1901, defensively explaining to the editor of *The Bulletin* that she had personally known:

> "...the late Mrs [Lizzy] Malone (from whom Ridley [1875] got his Turruwul and Wodi-Wodi words) ...I have many Turruwul words, and have studied the language a little, but don't pretend to understand it. With the Gundungurra, however, it is different. I have made it a study for many months, and wrote a little grammar on it which was incorporated in a paper by a member of the Royal Society [R.H. Mathews], and read by him before that body last December. I sent them last February (solely on my own account) drawings and descriptions of rock carvings at Burragorang, which they accepted, but afterwards said the paper was too short, and desired something added. I added the enclosed tradition, and had already sent it to the member who had engaged to communicate it, when a point of difference taken by me at this person decided me

> to take back the whole paper, and withdraw it altogether. I am not a member of the Royal Society myself, but the little I have had to do with [it] impresses me with their courtesy and fair play. My objection is not in the least to them. I only tell you this to show you how carefully and thoughtfully I have studied the subject. The drawing will follow, if all be well, for your examination, in a few days. My address [Superior Public School, Parramatta] will show you I have but little time for my recreation, i.e. the blacks, but I am asking for three months leave because of the severe colds I catch in Parramatta, and then (if I be successful) I might see the Burragorang again and be quite sure about the pigment on the caves [see Note B]. I am sure as it is, & others agree with me but the subject is hard ... I couldn't take your pay, being a Government servant ... [also] would you mind returning my cave-painting paper at once, if you don't want it, as I might make other use of it. And do you know I think we lose points of ethnological interest by paraphrasing the poor blackfellows traditions. The very one I sent you helps corroborate the theory of the enormous time they have been here - and is one among many that geologists do not disdain to notice - I refer here to the loose sand being turned into sandstone. You know that [Rev. Julian] Tenison-Woods believed the Hawkesbury Basin to be all of blown sand formation, and all agree that some of it was. Perhaps the poor darkies were here - but I got lost when I tried to study this among the geologists terrifying millions".

And, how convenient it was for Mathews that his male elders were all sufficiently far away that Mary Everitt would have experienced difficulty consulting them and cross-checking his information. Undeterred, the pesky woman began writing letters, specifically citing:

> "... a letter from Robert Racklin ... well up on his countryman's ways, a fully initiated member of the Numba Tribe [in the Shoalhaven] ... I keep carefully the few letters I have received from any of his people" (Everitt, 10 July 1901).

Thus the break with Mathews occurred in record time, and Mary Everitt was committed to working without his interference. The materials sent to the editor of *The Bulletin* demonstrate that, in addition to linguistic research, Mary Everitt had amassed enough information for several papers about cave-paintings, rock-carvings, and traditional legends.

THE GREAT LOSS

Unfortunately, however, the handicap of being a woman in that age was too great. Despite vigorous efforts, nothing further by Mary Everitt made its way past (male) editors into print. To the enduring shame of the scholarly community of that time, Mary Everitt's extensive and precious collection of linguistic and anthropological materials was almost all lost at the time of her death. It was known to contain historic pictures, taken by the photographer J. Robinson of Carlton, of prominent 19th century Aboriginal Elders including:

> "... a much faded group of Granny Giles, her brother, my old friend Jimmy Lowndes, Mrs Amm (still alive), and another man, whom I never knew, and who is dead ..." (Everitt, 24 June 1901).

Also there were Mary Everitt's extensive field-notes and diaries containing precious phonetic data and historical materials, along with the letters she received from Aboriginal correspondents and "kept carefully". Amongst this was "the lark song" and an Aboriginal language account (i.e. the Aboriginal version) of the April 1770 Botany Bay landing of Captain Cook as told by:

> "Granny Giles' husband - Old Cooman, or Goomung, [the] great grandfather of Mrs Timbery. He was a tiny child when Capt. Cook came. He was alive, an extremely old man, when Dunbar was wrecked (in 1859)". (Everitt, 12th and 24th of June 1901)

Popular accounts of "Saturnalian" activities at La Perouse (Cohen, 1890), combined with R.H. Mathews' dismissal of Bessy Simms, Queen Emma and Granny Giles as merely "...others, including some old women" (Mathews & Everitt, 1900), had the cumulative effect of portraying Mary Everitt's Aboriginal linguistic informants as unimportant and unreliable. In fact they were "Aboriginal Royalty" with a direct bloodline to Spear-man, gu:mʊ, who had thrown spears at Captain Cook's landing party 130 years previously. That they were still in residence on their own traditional lands, with continuously transmitted stories and oral traditions, spoke volumes for their reliability as linguistic informants. This is precisely why Mathews, in the author's opinion, used gender as a weapon, not only to write Mary Everitt out of history but also her Aboriginal informants.

Although much of National Heritage value was lost when Mary Everitt died, at least some of her precious materials did miraculously survive – however the traditional Aboriginal owners have understandably decided not to share with the broader Australian community whose Federal Court recently refused to hear their native title claim. We will respect this decision by relevant Aboriginal elders.

A PHOTOGRAPH FROM THE 1901 FIELD TRIP ?

Mary Everitt's two letters respectively dated 12th and 19th June 1901, both have the return address Superior Public School, Parramatta. She must then have obtained the requested three months leave, "...to see the Burragorang again ...", as her letters respectively dated 24 June and 10th July 1901, both have the return address at Bargo Road, Upper Picton which is, essentially, Thirlmere.

Jim Smith (1991. p. 9) comments that "...Cuneo ...met Miss Everitt". We don't know quite where he obtained that piece of information, but it is probably true as we know that in late June and early July 1901 she posted letters to the editor of *The Bulletin* whilst at Thirlmere, and probably received at least one reply prior to setting off for the Burragorang, and Cuneo was the Thirlmere Postmaster at the time. But one should not read too much into it. Most likely, Mary Everitt was staying with Mr M. Feld of Picton whom she had probably visited the previous year and encouraged to publish his reminiscences.

In any case, by 1901 Charles Butler's coach service was running on a regular basis between Camden and Yerranderrie and it continued to do so till 1917 - see photos in (Barrett, 1995, pp. 9 & 12). Mary Everitt and her niece would most likely have taken the coach this time, either by catching the train back to Camden or else by travelling overland to The Oaks and catching the coach from there. Whilst at The Oaks they may have met A.L. Bennett, setting him on the path collecting his:

> "fairly complete vocabulary of Gon-dun-gorra words and legends, which I trust may some day be printed for the information of those interested" (Russell, 1914).

The Yerranderrie coach would have descended 2000 feet into the valley from Nattai, crossing the Nattai River near its junction with the Wollondilly River, thence proceeding along the eastern bank of the Wollondilly River, crossing at the old ford at Coleman's Bend, from whence it was a short journey back to the Nulla Nulla camp on Byrnes Creek.

This itinerary was a bit circuitous but preferable to riding horses directly from Thirlmere down Little River, to the Nattai, thence following the stagecoach route. But one does not know, difficulty did not seem to deter

Mary Everitt and this may be exactly what they did do on both occasions. Thirlmere was a bit out of the way for travellers intending to catch the new coach.

There is a wonderful photograph from this time, which could be of Mary Everitt and her niece standing in front of the Red Hands Cave at Bimlow in mid 1901 (Barrett, 1995, p. 116), the very picture sent to the editor of The Bulletin but never published. Also in the picture are a couple of lads, one on a horse that has a distinctive "M" brand on its shoulder - therefore probably a local guide from the Maxwell's mini-village at Bimlow which is now submerged in the reservoir (Barrett, 1995, p. 43). A second classic photograph (Barrett, 1995, p. 48) shows what could even be the same pair of "lady walkers" at the Kill farmhouse in 1917. It looks like an auntie and her niece, albeit 16 years later, and the older woman's hat seems to match the 1901 photograph. At the very least these pictures show the places and the clothing of the period.

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NOTES

(**A**) Ambiguity in the pronunciation and spelling of south-east Australian Aboriginal words can be reduced through the use of an alphabet of only 18 characters, comprising 4 "vowels" and 14 "consonants", as below:

a b d d̲ ɖ g i l m
n ŋ n̲ ɲ r u w y ʊ

where ʊ = aya.

This phonology contains no vowels e or o, and none of the consonants c, f, h, j, k, p, q, s, t, v, x or z. Probably there is no y either. The four allowable "vowels" are a, i, u and ʊ though the latter, actually a vowel-consonant-vowel cluster, is not strictly a vowel but it behaves like one. This notation constitutes an almost standard usage of the International Phonetic Alphabet - the exception being that (for typographical reasons) we've commandeered the handy keyboard character ʊ as above. For a general overview of Australian phonetics see (Yallop, 1982).

(**B**) The answer to *The Bulletin* editor's question is that the hand imprintations in the Bimlow cave are in red ochre. Hence it has come to be called red-hands cave. The Aboriginal name for the cave was murʊla:n:g(ʊla:i)-gulʊ:ŋ(uru):gʊn:g(ʊn) = *hand imprintations* which was given as "murrolu:n:g::gulu:ng::" by William Russel in 1914 (W. Russell, 1914, p. 20), and as "murrolu:n:::::gun:g" by Jimmy Pippen in 1890 (J. Barrett, 1994, p. 93). murʊla:n = *five-things* whilst gʊla:i = *shining* can also mean *radiating-vitality* hence living. Thus murʊla:n:gʊla:i = *five-living-things[fingers]* is just a word meaning *hand*. gulʊ (as in koala bear) usually means *lethargic* or *petrified* or *fossilised* but, in this case, it means an *imprintation*. ŋuru-gʊn:gʊn = *extremely-oscillatory* captures the notion of hands *stamping* or *smacking* the cave wall. Hence gulʊ:ŋ:gʊn:g means *stamped-imprintations*.

(**C**) The verb malʊ:i = *blocking, obstructing, shielding* occurs in the song in Appendix 2.

In fact, the name of a small bark shield used to deflect spears was recorded as "mela:tho:n" (L. Atkinson, 1853) deriving from the noun malʊ-d̲ʊ(la):n = *blocking/obstructing thing* = [a] shield. We also have the completely equivalent expression "hila:ma:n" (J. Rowley, 1875) and "ilee:mo:n" (W. Tench, 1788) deriving from d̲ʊla-ma(lʊ)-n. Additionally the place-name "mul:warrie", said by C. Macalister (1907) to mean "long water", actually derives from mal(ʊ)-wurʊ(la) = *obstruction-s(plural)* = "cataracts".

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Left: Queen Emma of La Perouse, the great granddaughter of Granny Giles, photographed at La Perouse in about 1900. From E.J. Telfer's book, 1949. (Photo reproduced by courtesy of the La Perouse Korewal Elders Council)

Below: This photograph: "Aborigines from Holt's property of Sylanvia", from page 25 of David Kirkby's (1970) book *From Sails to Atoms, the first fifty years of Sutherland Shire*, shows "Granny Giles" = bʊru:ŋ (sleepy/quiet person) in the front, with Jimmy Lowndes immediately behind her, amongst a group on Thomas Holt's Sylvania property in the 1870's. This picture is one of several taken by J. Robinson of Carlton. Another occurs along with an interesting article in the "St George Call", 14th May 1904. (Photo reproduced by courtesy of the La Perouse Korewal Elders Council and the Sutherland Shire Council)

APPENDIX 1

sunrise and sunset

In the gʊnd̲ʊŋara language *sun-set* isn't so much a word as a concept that can be expressed by a phrase made from several fundamental words belonging to two interspliced expressions, a noun-phrase *[the] sun* and a verb-phrase *going-down-there* (= setting), in an interlocking sequence:

$$\underbrace{\text{bu(lʊ)}}_{=\ \textit{down}} - \overbrace{\overbrace{\underline{\text{d}}\text{(ʊla:n)}}^{\textit{thing}} - \underbrace{\text{ga(rʊ:i)} - \text{ɲ(uŋ:}\underline{\text{n}}\text{ʊra)}}_{=\ \textit{going there (distant)}} - \overbrace{\text{wiɲ}}^{\textit{orbiting}}}^{=\ \textit{sun/moon}}$$

Because such expressions can be unwieldly, taken whole, they are routinely "condensed" when spoken. In the above case all those words and portions of words within brackets were omitted a century ago when Bessy Simms gave the contracted version of this expression which Mary Everitt recorded as "bee:t::go::ńyâ::winyoo" ("*goes down sun*").

Sunset, beet gon'-yâ win-yoo; lit., goes down sun.

Likewise *sun-rise / dawn* (= birth / commencement [of the] day) can be formed by splicing two expressions together, a noun-phrase *[the] solar shine-cycle which [is]* and a verb-phrase *rising-up*, in an interlocking sequence which can be counted-off using the alternate fingers of a hand:

$$\overbrace{\overbrace{\text{wiɲ:(}\underline{\text{d}}\text{ʊla:n)}}^{\textit{[the] sun}} - \underbrace{\underbrace{\text{i:bʊ(lu)}}_{\textit{rising}} - \overbrace{\text{ŋ(uru:gʊla)}}^{\textit{shine-cycle}} - \underbrace{\text{bʊ(lu)}}_{\textit{up}}}_{=\ \textit{being born, commencing}} - \overbrace{\text{miɲ}}^{\textit{which [is]}}}^{=\ \textit{[the] solar day which [is]}}$$

Again, all those words and portions of words within brackets were omitted a century ago when Bessy Simms gave the contracted version of this expression which was phonetisised and recorded by Mary Everitt as "win'yoo:::a:boo:ng'::bâ:mīn" ("*sun rises*")

Sunrise, win'-yoo-a boong'-bâ-mīn; lit., sun rises.

APPENDIX 2

The gʊn\underline{d}ʊŋara Women's Evening-Star (= Venus) Song

Mary Everitt (1900) mentioned "having visited and camped with the natives of Burragorang, on the Wollondilly River ..." and recording the following evening-song "from the lips of some of the old women" whose menfolk were away participating in an initiation ceremony. Unfortunately she supplied no translation, because 'our informants could not give us any meaning of the words of the(se) song(s), except that "jirran din-ngee" means *sun going down* ...'. But the sun and the moon aren't the only celestial objects that rise and set, and the noun in this phrase is *star* (singular).

$$\underbrace{\text{\underline{d}i:n}}_{=\textit{tiny-thing (singular)}} - \underbrace{\text{ŋ(uru):i}}_{=\textit{twinkling}} \longrightarrow \text{“dī:n - ng:eē ”}$$

as in the repeat-word *twinkling stars* (dual or plural)

$$\text{\underline{d}i:n} - \text{\underline{d}i:n} - \text{ŋuru} - \text{ŋ(uru:i)} \longrightarrow \begin{pmatrix} \text{“ji:n:ji:n:nuru:ng ”} \\ \text{(“\textit{sparkling stars}”)} \\ \text{L. Malone, 1875, \underline{d}ariwʊl} \end{pmatrix}$$

Hence the song:

$$\underbrace{\underbrace{\text{wiɲ}}_{\textit{orbiting}} - \overbrace{\overbrace{\text{bu(lʊ) - ɲun:\underline{n}ʊ(ra)}}^{\textit{down-there (distant)}} - \underbrace{\text{gʊla}}_{\textit{shining}} - \overbrace{\text{garʊ:i}}^{\textit{going } *}}^{=\textit{setting}} - \underbrace{\text{\underline{d}i:n:ŋ:i}}_{\textit{star}}}_{=\textit{Venus}},$$

$$\underbrace{\underbrace{\text{mal(ʊ:i)}}_{\textit{[becoming] shieded/obstructed [by the horizon]}} - \underbrace{\text{wuru}}_{\textit{away}}}_{=\textit{vanishing}} - \overbrace{\text{miɲ}}^{=\textit{which [is]}} - \underbrace{\text{gʊ(n):wurʊ(la)}}_{=\textit{gradually}} \longrightarrow$$

"wam - bâ':oon:neē - (n)gâlâ' - jirra:n' - dī:n:ng:eē,
mīl::warroo - wīn - go:w'ra "
(= setting Venus which [is] gradually vanishing [below the horizon])
M.M. Everitt, 1900, gʊn\underline{d}ʊŋara

Note: * R.H. Mathews (1903) parroted this distinctive mis-hearing of garʊ as "jarra" in his allegedly \underline{d}ariwʊl word, "bulla:jarra::ng:" ("shine"), which is obviously bulʊ-garʊ:(i)-ɲ(un:\underline{n}ʊra) = *going-down-there* = "setting".

APPENDIX 3

"come(ing)-here"

We have now discussed celestial objects *going* down *there* (= setting). Mary Everitt also supplied the following examples of *coming-here*, in which words can occur together in sentences or interspliced as follows:

i) *come-run-ing [up] here behind me*

$$\underbrace{\text{mʊ(ra):n:ŋu(ru)}}_{=\ \textit{run}} - \underbrace{\text{g(ʊra):i - ɲu(ŋ):ɲin}}_{\textit{come here = approach}} - \underbrace{\text{ḏuŋ - g:i:lʊ:wuru}}_{=\ \textit{my rear}}$$

⟶

"mu:n':na - g:ī:ngoo:nīn - ben':g:u:l:war'eea"
(= "come up here to the back of me")
M.M. Everitt, 1900, gʊnḏʊŋara

"mu:n:na - g:ai:: - ::::"("come "), ŋunuwʊl ???
":: - ::: - ben:g:a:l:"("back"), ŋunuwʊl ???
":: - yerra::: - bin:g:a:lai:"("come"), ŋaragu ???
R.H. Mathews, 1904, 1908

ii) *I [will] come running back here [at]* ***sunrise***

$$\underbrace{\text{mʊ(ra):n:ŋu(ru)}}_{=\ \textit{run}} - \underbrace{\text{ŋʊ}}_{\textit{I}}$$

$$\underbrace{\underbrace{\text{ɲin:g(ʊra):i}} - \overbrace{\text{w:i:lʊ}}^{=\ \textit{return}} - \overbrace{\text{wiɲ:i:bʊ:ŋ:bʊ}}^{=\ \textit{sunrise}\ *} - \underbrace{\text{ɲuŋ}}}_{=\ \textit{come here}} \longrightarrow$$

"mu:n':na - gâ
nin':g:â - w:i:lli(n) - win'yoo::boo:ng:ba - nig"

(= "will run I back sun will **sink**, or, I shall return at **sunset**") ???*
M.M. Everitt, 1900, gʊnḏʊŋara

APPENDIX 4

lazy = "male"

Bessy Simms was obviously joking when she said that the prefix denoting masculinity was "go'-wul". This expression is a well known combination of two fundamental words: gʊn which can be translated as *very*, whilst wurʊla (the standard plural ending for nouns) translates as *several* or *lots of*. She obviously combined and contracted these two fundamental words as follows, gʊ(n):w(ur)ʊl(a) = gʊ:wʊl, creating an expression (literally "very lots of [time]") which means gradually, slowly, "by-and-by" or lazy. And she was by no means the only person to ever give this expression or use it this way. It was the basis of "Black Maria's Lullaby", from Moss Vale, dating back to the 1830's (Illert, 1999). Mary Everitt also recorded the expression gʊ(n):wurʊ(la) in the "Evening Star song" supplied here in Appendix 2. Even as early as 1793 Captain J. Hunter recorded the word gʊ(n):w(ur)ʊl(a):i as "the male of animals" = "cowull", and "a shag or cormorant" = "gowalli". Also "cooerwull", in the sense of "trickling" instead of "gushing", is the name of a brook at Lithgow and C. Lyne (1882) wrote of a homestead '... situated ... not far from ... the shores of a lake which in this part of the Colony is called, in the language of the Aborigines, a "cowall" or "cowell".' Furthermore, C.E.W. Bean (1910) advised "If one gets bogged in a creek or a cowal (which is a small tree-grown, swampy depression often met with in the red country) ...". There even exists a widely recorded repeat-word meaning slowly, gradually or delayed (= plenty [of time]):

$$\underbrace{\text{gʊ(n)}}_{=\ very} :\ \underbrace{\text{w(ur)ʊl(a)}}_{=\ lots\ of\ [time]} - \underbrace{\text{gʊ(n)}}_{=\ very} :\ \underbrace{\text{w(ur)ʊl(a)}}_{=\ lots\ of\ [time]} \longrightarrow$$

"go:w:go:w" ("by and by") M.M. Everitt, 1900, gʊnd̲ʊŋara	"gu:wa:gu:" ("bye and bye") g:wa:gun: ("presently") R. Dawes, 1790, eora	"ko:w::wol" ("much") Dr. R. Oldfield, 1828, eora
"kau:wul::" ("large") "kau:wul:kau:wul" ("many") Rev. L.E. Threlkeld, 1834, awabakal	"gau::gau::" ("by and by") R.H. Mathews, 1904, ŋunawʊl	"co:wal:co:wal" ("very big/many") J.F. Mann, 1840, eora
		"ka:wai::" ("by and by") E.M. Curr, 1887, durga

hence *to play*

$$\underbrace{\text{wurʊ(la):g(ʊn - wurʊla):gʊ(n)}}_{=\ delaying/\ dithering/\ wasting\ [time]} - \underbrace{\text{bʊl(u):i:ri}}_{to\ commence\ (or\ be)}$$

⟶ "wo:g::ga:bal:i:ri" ("play"), ŋunuwʊl
"wurra:::::i:ri" ("play or dance"), d̲ariwʊl
R.H. Mathews, 1904, 1903

APPENDIX 5

trickling/flowing rivers

The words d̲ʊra = *through*, and bulʊ = *down*, can be combined to produce the verb d̲ʊra:i:bulʊ = *flowing*, which we would expect to encounter in the word "river" because, after all, rivers flow down through the countryside. For example, traditional gʊnd̲ʊŋara groups from the Upper Cox River have a well documented historical association with Hartley and Lithgow. Billy Lynch (Lynch 1896) in an interview described gʊnd̲ʊŋara people from the Kanimbla and Megalong sections as "therabulat" which just means [people from the] flowing [portion of the] river, deriving from a standard word creek / river (= flowing thing):

$$\underbrace{\text{\underline{d}ʊra:i:bulʊ}}_{=\ \textit{flowing}} - \underbrace{\text{n:\underline{d}(ʊla)}}_{\textit{thing [river]}} \longrightarrow$$

"thera::bula::t" ("the Cox's River")
"::le::tt" ("the River Lett")
Billy Lynch, 1896, gʊnd̲ʊŋara

"tarra::pala::tt" ("the River Lett")
Cullen, Lithgow Mercury, 1931
Jenny Clay and Betsy Grant, 1880, gʊnd̲ʊŋara

"tur:i:ba:n:" ("creek")
J.F. Mann, 1840, eora

On the other hand those near the source of the Cox, centred on Pipers Flat Creek (which is still relatively unchanged and has a major concentration of art and camping sites), were called the "wywandy" meaning [*people from the upper or] trickling [portion of the] watershed*:

$$\overbrace{\text{(gʊn):wurʊ(la:gʊn):wu(rʊla)}}^{=\ \textit{slowly}} - \underbrace{\text{n:(\underline{d}ʊla)}}_{\substack{\textit{thing}\\ \textit{[watershed]}}} - \overbrace{\text{\underline{d}(ʊra):i:(bulʊ)}}^{=\ \textit{flowing}}$$

...the same phrase occurring in the Yass vocabulary:

$$\overbrace{\text{gʊ(n:wurʊla)}} - \underbrace{\text{\underline{d}ʊra:\underline{d}ʊ(la:n)}} - \overbrace{\text{g(ʊn:wurʊla)}} - \underbrace{\text{b(ulʊ):i}}$$

⟶ ("goo::dra:di::g::b:ee"
("*water falling over rocks*" at site of present Burrinjuck Dam)
Lucy Carroll, 1911, ŋunuwʊl)

APPENDIX 6

"put(ing) into"

A first fleeter William Dawes (1790) recorded the word "gnarra" ("a knot or to tie") deriving from ŋara = *spiral, coiled or looped.* This word features in expressions for woven nets and baskets which Aboriginal people created in various clever ways, actually without any knots, using a variety of natural fibres. Also John Rowley (1875) recorded "rao:rao" "(*net*)" = gʊra:gʊra = *into-into.* Additionally there is a common adjective murʊ:gʊn = *gentle(ly).* Combining all this information provides a fuller expression for a *net bag* or *woven basket* (= woven thing into [which one] puts):

$$\underbrace{\underbrace{\text{gʊr(a)}}_{\textit{into}} - \underbrace{\text{bu(lʊ)-murʊ:(gʊn)-i}}_{\textit{gently dropping} \;=\; \textit{“putting”}} - \underbrace{\text{\underline{d}ʊla:(n)}}_{\textit{thing}}}_{\textit{putting–into thing} \;=\; \textit{bag/basket}} - \underbrace{\text{ŋ(ara)}}_{=\ \textit{net/woven}} \longrightarrow$$

"karr:::::t::-(karr:::::t::)" ("fishing net")
":b:::ee:la::ng"
R.B. Smyth, 1876, Yarra

":ba::::thu::ng" ("net bag")
Rev. J. Bulmer, 1876, kurnai

"gur:b:maru::i:d::"
("woman's [string net] bag")
L. Atkison, 1853, ŋunawʊl

":ba::::dyu::ng" ("woman's bag")
":bu::::ddhu::ng" ("net bag")
R.H. Mathews, 1902, ŋarugu, kurnai

or

$$\underbrace{\text{ŋara}}_{=\ \textit{net/woven}} - \underbrace{\text{gʊr(a-bulʊ):mu(rʊ:gʊn):i-(\underline{d}ʊla:n)}}_{=\ \textit{bag/basket}} \longrightarrow$$

"narra:::m::i::" ("a net")
Capt. J. Hunter, 1793, eora

"ju:gu::ma::::" ("net bag")
R.H. Mathews, 1901, darug

or

$$\underbrace{\underbrace{\text{bulʊ:mu(rʊ):g(ʊn):i}}_{\textit{putting}} - \underbrace{\text{\underline{d}ʊ(la):n}}_{\textit{thing}} - \overbrace{\text{ŋa(ra)}}^{=\ \textit{net/woven}} - \underbrace{\text{gʊra}}_{\textit{into}}}_{=\ \textit{bag/basket}}$$

⟶ "poolla::::da::noo:ko" ("woven basket")
"b:::i::n:nu:k" ("woven basket")
":moo:k:::::kurra" ("small square net used in streams")
R.B. Smyth, 1876, Southern Australia, Lower Murray

We can see from this example exactly why celestial objects need to *go-down-there(distant)* as in Appendices 1 & 2. They don't *go-down-here(close)* = bu(lʊ)-ɲu(ŋ):ɲin-ga(rʊ:i) as R.H. Mathews asserted in his paper. Things may *come-down-here(close)* or be *put-into* something *here(close).* But anything else violates the natural Boolean logic of the language.

APPENDIX 7

"Thoorga" = gʊnd̲ʊŋara ?

We can demonstrate quite clearly that R.H. Mathews had the words sunrise and sunset interchanged, consistent with Mary Everitt's mistake (Appendix 3(ii)), and that he therefore didn't properly understand the fundamental words of the language, or how they combine to make expressions. In one paper he gave the supposedly "Thoorga" words bag-go-rañ kar-rick-bung-a-leen = **sunrise** and bag'gorañ = **sun**. From Appendix 1 it is clear that:

bu(lʊ)-garʊ:(i) - ɲ(uŋ:n̲ʊra) ⟶ "ba:ggora::ñ:" = *going down there (distant)*

is a standard *verb* (as in "setting of the sun"), and not the *noun* "sun" as R.H. Mathews claimed. The second expression combines this verb with the actual noun.

d̲ʊla:n-gʊla-wiɲ = *shining orbiting thing (= "sun")*

as follows:

gar(ʊ):i – d̲(ʊla:n) – bu(lʊ)-ɲ(uŋ:n̲ʊra) – gʊl(a):wiɲ

⟶ "karr:i:ck::bu:n::gal:een" = setting sun

...which is not the word "sunrise", obtained from William Bothong of the Shaolhaven or otherwise, as claimed by R.H. Mathews. It is clearly a telltale expression, parroted complete with reversed meaning, from Mary Everitt's (1900) gʊnd̲ʊŋara grammar, leaving subsequent researchers such as Diana Eades (1976) to forlornely comment: 'Although Mathews probably knew exactly what the phrase or sentence for "sunrise" here consisted of, we have no way of knowing. Because all his vocabularies are by no means extensive, all the elements in phrases such as the above cannot be analysed'. And there is even more to the colorful history of this particular expression for *sunset*. Whilst surveying the Omeo Road, in the 1850's, N.D. Pettit and W. Dawson recorded from kurnai informants:

ga(rʊ):i – d̲(ʊla:n) – bul(ʊ)-ɲ(uŋ:n̲ʊra) – g(ʊla:wiɲ)

⟶ "go:i:t::bil:yu::k:"

...explaining confidently that "goit-bil-yuk" literally meant "*sun-in-west*".

This level of misinformation, masquerading as informed opinion and unchallenged over the ensuing 150 years, clearly illustrates limitations not only in the primary 19th century linguistic data but, also, in subsequent scholarship. It is a good example of why we need to know how expressions are constructed and what individual words mean.

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A Ph.D. thesis on gʊnd̲ʊŋara language, deduced largely from Mary Everitt's (1900) paper, is currently in preparation by the present author for submission at the University of Western Sydney. Additional references are contained therin.

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Thesis Abstract: The Genesis and Tectonic Significance of Chromitite-bearing Serpentinites in Southern NSW

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Abstract of a Thesis submitted for the Degree of Doctor of Philosophy
University of Technology, Sydney 2000

The Tumut Serpentinite Province consists of four major serpentinite belts and numerous small serpentinite bodies, that occupy a long narrow tract within the Lachlan Fold Belt of southern NSW. The tectonic setting of one belt, the Coolac Serpentinite Belt, has been contentious. Much of the uncertainty results from lack of a combined study on the major belts and inadequate age constraints. Resolving the uncertainty will benefit construction of a tectonic model for the evolution of the Lachlan Fold Belt.

The belts mainly comprise massive serpentinite or harzburgite, with internal shear zones of schistose serpentinite, and intrusions of plagiogranite, gabbro, basalt, pyroxenite, dunite and chromitite. The main foliation has a consistent NNW–SSE trend and is similar in the adjacent rock units. The various rock types of the serpentinite belts are geochemically akin to similar rocks from ophiolite sequences.

Podiform chromitites are geochemically, mineralogically and geometrically akin to those in the mantle sequence of most ophiolites. The different chromitite types are interpreted in terms of the degree of evolution of the MORB-type magma and hence the extent of fractionation of the source. Serpentinisation and rodingitisation occurred during progressive cooling of the chromitites and host rocks and were accompanied by systematic fracturing and remobilisation of chemical components.

Radioisotope dating gives an age of crystallisation of 412–400 Ma for the plagiogranites and leucogabbros, whilst an inherited zircon age of 430 Ma appears to be derived from Early Silurian felsic volcanic rocks of the region. As the plagiogranites, leucogabbros and other rock types within the serpentinite belts have common deformational and metamorphic histories, their crystallisation age constrains the ages of deformation and metamorphism.

The serpentinite belts are interpreted as ophiolites of the 'embryonic' type that formed within a back-arc basin setting in the Late Silurian-Early Devonian. Crystallisation of the MORB sequence and emplacement onto continental crust, together with metamorphism and deformation may have only spanned 20 Ma. In the Late Silurian to Early Devonian, the Tumut Serpentinite Province differed from basins elsewhere within the Lachlan Fold Belt in that a volcanic arc was ruptured by mantle-derived MORB magmas which ascended to the surface. Their extrusion was short-lived and after the Early Devonian, the development of the Tumut region differed little from that in the rest of the Lachlan Fold Belt.

The development of oceanic crust within the Tumut Serpentinite Province and the generation of granitic magmas within the central and eastern parts of the Lachlan Fold Belt are symptomatic of the same Late Silurian to Early Devonian tectonothermal event. An important aspect of this is that oceanic and crustal rocks need not form from different events or in substantially different tectonic settings.

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Thesis Abstract: Characterisation of Sperm Surface Antigens in the Guinea Pig

Isurani Ilayperuma

Abstract of a Thesis Submitted for the Degree of Doctor of Philosophy
University of Otago, Dunedin, New Zealand

Fertilisation is one of the most complex and exciting areas in biology. Mammalian fertilisation involves sperm capacitation in the female reproductive tract, passage through the cumulus mass, induction of the acrosome reaction, penetration through the zona pellucida and fusion with the egg plasma membrane. The surface of the sperm head plays a central role in each of these events. The mammalian spermatozoon has a highly regionalised surface. Identification and characterisation of sperm membrane proteins that are involved in gamete recognition and sperm-egg membrane fusion is one of the key problems in current research on mammalian fertilisation.

G11 is a sperm-specific membrane protein implicated in sperm-egg binding and fusion. The main body of this thesis describes characterisation of the G11 antigen. The G11 antigen was purified using anion-exchange chromatography, immuno-affinity chromatography and preparative SDS-PAGE and was subjected to amino acid microsequencing. Internal amino acid sequence data on the 48 kDa G11 antigen revealed sequence homology with the recently discovered guinea pig sperm protein, sperad. Sperad is a transmembrane protein present in the peri-acrosomal membrane of the acrosome-intact spermatozoa. Guinea pig sperad has already been cloned and sequenced. A striking feature of the cytoplasmic domain of sperad is the presence of a repetitive proline-rich sequence, PPQPEQ, which is unique to sperad. Oligonucleotide primers made from the published sperad nucleotide sequence were used to amplify the cytoplasmic domain of sperad from a guinea pig testis cDNA expression library. Three additional forms of the sperad cytoplasmic domain were consequently identified. These isoforms of the cytoplasmic domain of sperad were tested for their ability to bind monoclonal antibody G11 by expression in a prokaryotic gene fusion system as fusion with glutathione S-transferase. Results obtained from these experiments confirmed that the G11 epitope is specific for the cytoplasmic domain of sperad. It is likely that the predominant epitope recognised by the monoclonal antibody G11 is the intracellular repetitive PPQPEQ motif.

Evidence suggests that mammalian spermatozoa fuse with eggs using the equatorial segment plasma membrane. My findings provide evidence that the equatorial segment plasma membrane contains sperad. Sperad is of interest in the context of sperm-egg adhesion and egg activation for a number of reasons. First sperad carries a Arginine-Glycine-Aspartic acid sequence that could potentially dock the equatorial segment plasma membrane with the integrins on the egg surface. Second it is related to a biliary glycoprotein family of adhesion molecules. Third, the repetitive proline-rich cytoplasmic domain of sperad, which is unique to sperad, could act like other cytoplasmic proline-rich regions as an intracellular signaling molecule. Since the cytoplasmic domain of sperad is exposed to the egg following sperm-egg fusion it could act as an egg-activating molecule.

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Thesis Abstract: Reef Growth and Lagoonal Sedimentation at High Latitudes, Lord Howe Island, Australia

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Abstract of a Thesis Submitted for the Degree of Doctor of Philosophy, University of Sydney, New South Wales, Australia.

The southern limit of coral reef growth in the world occurs on Lord Howe Island (33°30´S, 159°05´E) in the form of a discontinuous 6 km long fringing reef along the western side of the island. Compared with other fringing reefs worldwide it is large being attached to the shoreline only at its northern and southernmost ends while the central portion encloses a lagoon over a kilometre wide. The reef and lagoon are developed over an antecedent surface composed of reefs of Last Interglacial age and calcarenite dunes; however, there appears to be little relation between its topography and that of the modern surface.

Carbonate sediments were being deposited within the lagoon around 6500 years BP coincident with sea level reaching close to its modern level. High-energy open ocean conditions dominated the reef with robust branching corals dominating the developing reef. Sedimentation during this initiation phase strongly reflected the morphology of the antecedent surface. Growth of the reef crest between 6000 and 5000 years BP lead to a reduction in the energy environment of the lagoon allowing for mud deposition. During this period sedimentation occurred at rates of around 5 mm/yr, but up to 10 mm/yr, which infilled almost all the available accommodation space in the lagoon. By 4000 years BP the reef and lagoon were very close to the modern surface having accumulated over 11 m, possibly up to 30 m, of sediment. Sediments younger than 3000 years BP form a veneer over these older units with the main deposition being confined to embayments, the coastal plain and infilling blue holes.

Reef growth and lagoonal infill at the southernmost environmental limit have been luxuriant and rapid, comparable with low-latitude reef systems. The main period of growth occurred during the mid-Holocene. Modern sedimentation appears to be restricted to the lagoon and there is little reef progradation. The reef on Lord Howe therefore appears to be related to luxuriant growth in the mid-Holocene.

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Journal & Proceedings of the Royal Society of New South Wales, Vol. 134, p. 48 48, 2001
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Studentships

William Anthony Higgs

William Higgs is nearing the completion of a PhD in the Biomaterials Science Research Unit at the University of Sydney. He is working on the development of improved orthopaedic bone cement and already has been able to follow the complex rheological behaviour during the complete curing process. His research is leading to improvements in the understanding and clinical application of orthopaedic bone cements. He shows innovative approaches which are yielding notable progess, the outcome of dedicated and energetic work. Already he has published several papers, presented the results of his work at international conferences and received awards.

Louise van der Weyden

Louise van der Weyden is working for a PhD in the faculty of Pharmacy at the University of Sydney. Her studies aim to characterise the phenotype of ATP-differentiated myeloid cells, and to determine the signal transduction pathway responsible for mediating these effects. A measure of her success is the number of publications already coming from her research. Her initiative has led to seminal contributions in her research areas, especially molecular biology. She has received several awards.

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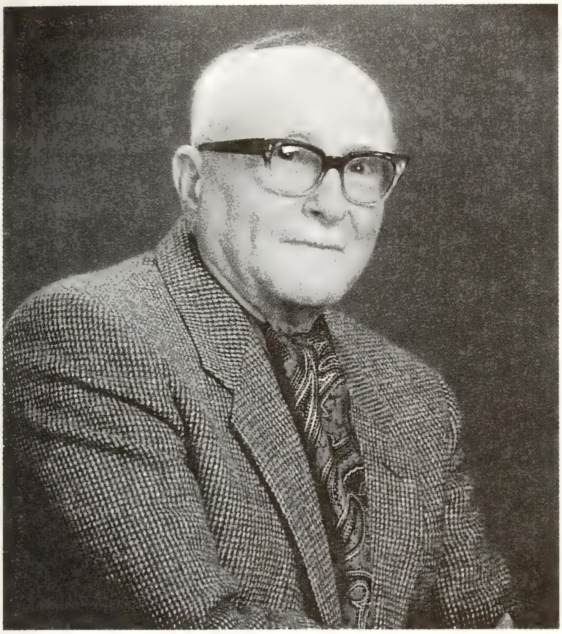
Biographical Memoir



LEO EMIL KOCH
1903–2001

Leo Koch was born in Cologne on 4 October 1903. In the early 1920's he began the study of chemistry, and particularly physical chemistry, at the Universities of Freiburg and Marburg. Hr graduated from the University of Cologne in 1925. He came to geology through mineralogy and went on to undertake postgraduate studies in geology (particularly petrology) and mineralogy, being awarded the D.Phil. from the University of Cologne in 1930. In the next three years his petrological and field studies of the volcanic rocks of the Eiffel region of Germany proved of practical value in the use of these materials for construction purposes. In these years he also carried out petrological studies of industrial slags. For his research, Leo Koch was awarded, 1n 1934, Dr. Habil., from the University of Cologne, this being the highest possible research doctorate, In 1935 Leo Koch was appointed lecturer in the Department of Mineralogy and Economic Geology in the School of Mines at the Technische Hochshule in Aachen.

However the call to adventure was there, and political problems were emerging in Germany. In 1936 he accepted appointment as inaugural Professor of Geology and Mineralogy at the newly established University of Tehran, Persia (now Iran), where the Shah was attempting a process of westernisation. Despite being contracted to lecture in French, Leo Koch learnt Persian and was able to communicate more readily with students and a wider range of local people. Dr Koch taught mainly engineering and architecture students and was consultant to various government departments. He travelled widely within the region, climbing the highest peaks and advising on the tunnels and bridges along the Trans-Iranian Railway, then under construction, and on dams and earthquake zones. Mineral deposits also were not forgotten.

In 1941 World War II impinged on Iran, when it was occupied by both British and Russian troops. Leo Koch always considered himself lucky to be captured by the British, as all his colleagues, save one, taken by the Russians simply vanished without trace, he said.

Leo Koch found himself interned at Tatura, Victoria, but he must have used his time well, improving his English and studying local phenomena. Very rapidly after the end of the War, he was unconditionally released and, in 1950, granted Australian citizenship.

Leo Koch's great dream was to build a complete system to link all aspects of science - a multi-dimensional system. This has been the aim of philosophers from earliest times. Dr Koch knew Greek and Latin and a host of other languages and read widely amongst the literature from ancient to recent times, and in his last years became very interested in the developing field of Mathematical Geology.

Following his several years as a Commonwealth Research Fellow, at the University of Sydney, he addressed an ANZAAS Conference (1948) and the Geological Section of the Royal Society of NSW on his ideas (see Abstract of

Proceedings of the Geological Section of NSW, 1948, vol. 82, p. xxi). He later published a full paper in the *Australian Journal of Science.*

From Sydney, where he taught practical geochemistry to senior students in 1950 he joined the staff of the then New South Wales University of Technology in the School of Mining Engineering and Applied Geology, and set about applying his high training and knowledge to the unique geological forms of Australia and to the education of its student geologists. Perhaps more important for Leo was his conviction of the value of the new University's Humanities program, which was intended to broaden the preparation of science and engineering students. When in 1960, a Faculty of Arts was added to the University of New South Wales, and Humanities were matched with a Science for Arts students requirement, Leo enthusiastically volunteered to teach not just his specialist engineers and scientists, but also the "long-haired" Arts types. He designed a unique course to introduce them to the Geology of the Sydney Region.

Appointed Senior Lecturer in 1961, despite his many accomplishments he failed to gain promotion to Professorial rank. He retired in 1969, but continued his researches

Leo Koch loved scientific meetings, where facts and ideas were put forward for information and discussion. For many years. until increasing frailty prevented him, he was a regular attender at the Society's meetings, and those of the New South Wales Division of the Geological Society of Australia. He was always interested in any new information about local geology, which he could readily examine and analyse and then pass on to his students. The meetings of the Royal Society of New South Wales were, and still are, wide-ranging, covering topics in chemistry, physics, astronomy, botany and geology. It was his habit, at these meetings, to sit and take in both the speaker's ideas and information and then the discussions of the various listeners. Then, when the chairman thought (perhaps even hoped!) that all avenues of thought on the topic had been exhausted, Leo would ask for permission to speak. He always had much that was pertinent to say, but sadly it was often just too late at night, as we were needful of dinner, or just some fresh air. He had powers of concentration and stamina that were well beyond most of us.

In his later years, when confined to his home, he continued to communicate with colleagues, some as eminent as Sir Karl Popper, others local workers, by letter and phone, and to experiment with models of space and time, trying to perfect his integrated system, the Tetraktys, hinted at by the Greeks, but eluding scientists through the ages. He was "seeking form and beauty among the shapeless proliferation of branches of science and their profusion of data and knowledge." Perhaps time will tell that Leo Koch was fifty years ahead of his time, but his work in this field has yet to be fully acknowledged.

A man without pretension, he had a sense of humour, and was not above parodying "Chermans" with his jokes about "sausage dogs who are half-a-dog high and two-and-a-half-dogs long". As a former student has written "for those of us whose lives were touched by his teaching, his voice, his energy, his love for the rocks and forms and the life-force that shaped them, all these things remain in our mind's eye. And they will do so till we see him once again, meeting him perhaps as he once met a wise and holy man on the highest pass of a Persian mountain range, who offered the stranger tea, and recited a classical poem. In the mountains, you can touch the face of God, Leo told me." Leo Koch died on 20 January, 2001.

David Branagan & Edric Chaffer

Achnowledgements: data and information partially drawn from SMH (17.3.2001) and material supplied by Jessica Milner Davis.

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Annual Report of Council

For the year ended 31^{st} March 2001

PATRONS

The Council wishes to express its gratitude to His Excellency the Honourable Sir William Deane, AC, CBE, Governor General of the Commonwealth of Australia, and His Excellency the Honourable Gordon Samuels, AC, CVO, Governor of the State of New South Wales for their continuing support as Patrons of the Society during their term of office.

The Council also wishes to express its gratitude to Her Excellency Professor Marie Bashir AC for her gracious acceptance of Vice Regal Patronage.

MEETINGS

Eight ordinary monthly meetings and the 133^{rd} Annual General Meeting were held during the year at various locations.

SPECIAL MEETINGS AND EVENTS

14^{th} October 2000:
An excursion to the University of Western Sydney, Parramatta Campus was undertaken under the guidance of Professor Carol Liston, to inspect the historical buildings erected during the 19^{th} century. They represent some of the oldest three storey masonry buildings in Australia and include those constructed by Governor Macquarie.

13^{th} February 2001:
The Society was co-sponsor with the Australian Nuclear Association, the Australian Institute of Energy and the Nuclear Engineering Panel of the Institution of Engineers Australia, of a meeting held at the Institute of Engineers, Milsons Point. Dr Michael Clarke (Griffith University) and Mr Sandy Rintoul (Robertson Research) spoke to the topic: The Future of Coal—Good Guy—Bad Guy.

15^{th} March 2001:
The Annual Dinner of the Royal Society of New South Wales was held at the Royal Sydney Yacht Squadron, Kirribilli, NSW. The outgoing Governor of the State of New South Wales, His Excellency the Honourable Gordon Samuels AC, CVO accepted an invitation to deliver the after-dinner address. His Excellency was accompanied by Mrs Samuels.

MEETINGS OF COUNCIL

Twelve Meetings of Council were held, nine at the Society's office at 134 Herring Road and three at the new location at Unit 6, 142 Herring Road, North Ryde. Council discussed possible changes to the Rules and By-Laws.

PUBLICATIONS

Journal

Vol. 133 (Parts 1–4 incl.), 2000 was published during the year in two issues: July 2000 and December 2000.

Parts 1 and 2 essentially contained 20 peer-refereed extended abstracts of papers presented during the 23^{rd} Annual Conference of the Mineralogical Societies of the various Australian States at Broken Hill, NSW, in June 2000.

Also included were the Presidential Address (Foundation of Sydney School of Co-ordination Chemistry), the Annual Report of Council for 1999–2000 including citations for 1999.

Part 3 and 4 carried the 32^{nd} Liversidge Research Lecture, a peer-refereed paper on minerals from the Queen Sally Mine in Queensland, Higher Degree Abstracts (physics, computer modelling of the human brain, geology-tectonics of South Island, New Zealand, and geochemistry) as well as obituaries, the Financial Statement for 1999–2000, a list of current members and an index to Vol. 133.

Council wishes to thank all voluntary referees for their time and efforts.

Bulletin

The Bulletin was published during 2000–2001. Council's thanks are extended to the various authors of short articles for their contribution and to the other voluntary helpers who facilitated the production and distribution of the Bulletin.

AWARDS

The following awards were made for 2000:

Royal Society of New South Wales Medal;
Dr Philip Richard Evans (for achievements in science and service to the society)
Hon Secretary of the Society.

Clarke Medal (Botany);
Professor Sarah Elizabeth Smith
Faculty of Agriculture and Natural Resource, Science, Adelaide University, South Australia

Edgeworth David Medal;
Dr Michael Soon Yoong Lee
Department of Zoology and Entomology,
The University of Queensland

The following were not awarded for the year 2000:

The James Cook Medal
The Walter Burfitt Prize
The Archibald D. Olle Prize

MEMBERSHIP

At 31st March 2001 membership of the Society was:

Patrons	2
Honorary Members	12
Full Members	243
Associates, Spouse Members	26
TOTAL	281

The deaths of the following members were announced with regret:

Dr Leo Koch
Sir Mark Oliphant
James Lee Heron
Sir Rutherford N. Robertson, AC, Rt

Fourteen members resigned and five new members were admitted.

OFFICE

The Society continued during the year to lease for its office and library a half share of Convocation House, 134 Herring Road, North Ryde on the southeastern boundary of the Macquarie University Campus. At the end of 2000 the Society moved into new quarters at Unit 6/142 Herring Road, North Ryde on the northeastern boundary of the Macquarie University Campus.

Council greatly appreciates the continuity of its lease by the Macquarie University.

LIBRARY

Acquisition of journal literature by gifts and exchanges has been continued during 2000–2001. Exchange material from overseas and some Australian literature is, as in previous years, forwarded to the Dixson Library, University of New England, where it is made available locally and on inter-library net-work (loan).

The remaining literature is added to the collection of the Head-Office library at North Ryde where it is available to members and approved visitors.

Council thanks Mr Karl Schmude and his staff for their continuing efficient maintenance of the Society's Collection at the Dixson Library. The Dixson Library advises the Hon. Librarian at the Head Office of any missing issues and action is taken by the Hon. Librarian.

An accession list of literature received during the year at the Head Office is compiled and an appropriate notice appears in the Society's Bulletin for the information of members.

ABSTRACT OF PROCEEDINGS

5th April 2000:
The 133rd Annual General Meeting and the 1089th General Monthly Meeting were held at the City Tattersalls Club, Sydney.

The President, Professor A.T. Baker was in the Chair. The Annual Report of Council and the Financial Report for 1999–2000 were adopted. Mr B.E. Holden, Chartered Accountant was re-appointed Auditor for 2000–2001.

A/Professor A.T. Baker yielded the Chair to the incoming President Professor P.A. Williams who thanked the outgoing Committee for its work during the preceding year and invited the outgoing President A/Professor A.T. Baker to deliver his Presidential address "The Foundation of the 'Sydney School of Coordination Chemistry' ".

The following awards for 1999 were announced and presented by the guest speaker Elizabeth Macgregor, Director of Museum of Contemporary Arts, Sydney:

The Royal Society of New South Wales Medal 1999	Dr Daniel John O'Connor
The Clarke Medal for 1999	Professor Richard Shine
The Edgeworth David Medal for 1999	Dr Merlin Crossley
The James Cook Medal 1999	Dr Peter Colman
The Archibald D. Ollé Prize	Associate Professor Anthony T. Baker
Senior Research Studentships 1999	Miss Alison Basden
	Miss Sharon Downes

The following members were elected to Council for 2000–2001:

President	Professor P.A. Williams
Vice Presidents	Dr D.J. O'Connor
	Dr E.C. Potter
	Professor W.E. Smith
	Professor D.J. Swaine
Honorary Secretaries	Dr P.R. Evans (general)
	M. Krysko V. Tryst (editorial)
Honorary Treasurer	A/Professor A.T. Baker
Honorary Librarian	Miss P.M. Callaghan
Councillors	Dr D.F. Branagan
	Mr D.A. Craddock
	Mr J.R. Hardie
	Dr M.R. Lake
	Mr E.D. O'Keeffe
	Em. Professor A.G. Shannon
	Professor R.S. Vagg
Branch Representatives	Dr M.P. Fewell (N.E. Branch)
	Mr H.R. Perry (S.W. Branch)

3rd May 2000:
The 1090th General Monthly Meeting was held at the University of Technology, Sydney. Dr W. O'Reilly addressed the Meeting on "Forensic Dentistry".

7th June 2000:
The 1091st General Monthly Meeting took place at the University of Technology, Sydney. A/Professor R.W. (Bob) Jones delivered an address on "Conservation and the Scientist".

5th July 2000:
The 1092nd General Monthly Meeting was held at the University of Technology Sydney. Professor Michael Wilson delivered the 32nd Liversidge Research Lecture entitled: "Funeral Arrangements for Plants: An Essay in Organic Chemistry".

2nd August 2000:
The 1093rd General Monthly Meeting was held at the Coles Room, State Library of New South Wales, Sydney. Dr Tony Collings delivered our address entitled: "Drugs and other Measurements for the Olympics 2000".

6th September 2000:
Because of the proximity of the Sydney Olympics 2000, no General Monthly Meeting took place.

4th October 2000:
The 1094th General Monthly Meeting took place in the rooms of the City Tattersalls Club, Sydney, Professor Stephen Leeder delivered an address on "Genetically Modified Foods–Dinner with the General Manager (GM)".

8th November 2000:
The 1095th General Monthly Meeting was held at the University of Technology, Sydney. The evening was devoted to the RSNSW Studentship Awards 2000. The two award winners addressed the meeting:

Louise Van Der Weyden (University of Sydney) spoke on "ATP Stimulated White Cell Maturation via the P2Y11 Receptor and AMP Signalling Pathway".

William Higgs (University of Sydney) spoke on "The Development of New Biomaterial for Orthopaedic Surgery".

SOUTHERN HIGHLANDS

The Southern Highlands Branch held eleven well attended meetings. A special event was held for year 10 students in the district. Some 330 students attended and were entertained and challenged by Dr Mike Gore.

16th March 2000:
Dr Kirsten Benkendorff, a Postdoctoral Research Fellow, Biological/Chemistry Sciences. University of Wollongong addressed the meeting on conservation of Marine Biodiversity.

20th April 2000:
Professor Ian Hendry, Developmental Neurobiology, John Curtin School of Medical Research, spoke on "Development and Redevelopment in the Nervous Systems".

18th May 2000:
Dr Elizabeth Chua, Research Fellow, Department of Medicine, University of Sydney, spoke on the epidemic preparations of Thyroid Cancer in New Caledonia.

15th June 2000:
James Moody, engineer in Vipac Scientists and Engineers Ltd, gave a brief historical overview of Australia's space involvement.

20th June 2000:
Dr Mike Gore gave his 'quick-fire' series of demonstrations on "Science in Action" to our audience of 330 year 10 students.

20th July 2000:
Dr Matthew Morell addressed the meeting on "The Australian Wheat Crop–Meeting the International Competition by Exploiting Innovative Science".

17th August 2000:
Dr K.G. McCracken, AO, a member of the Branch, spoke on "The Secret Life of the Sun".

21st September 2000:
Professor Daniel T. Potts, Edwin Cuthbert Hall, Professor in Middle Eastern Archaeology, University of Sydney, spoke about his excavations at Tell Abroq, United Emirates, from 1989–1998, researching the Life of inhabitants around 2000BC.

19th October 2000:
James Woodford, Science and Environment writer for the Sydney Morning Herald, talked about the "unbelievable" genetic make up of the trees from three different stands now discovered.

16th November 2000:

Dr Tony Fischer, Plant Physiology, University of California, DAHS, presently a Research Progression Manager at ACIAR, spoke about the challenge of feeding the world over the next 20 years.

15th February 2000:
Dr Fred Watson, Anglo-Australian Observatory, spoke on "Australia and the Telescope Super League".

Winner of the Grandi's 1999 Science Prize for year 11 students was Miss Clare Roxburgh from Frensham School.

Thanks are offered by the Committee to Winifred West School Ltd for the use of their Lecture Theatre during the year for a nominal fee and to all voluntary workers of the Branch.

NEW ENGLAND BRANCH

The Branch reported a minimum of activity for the year.

The Royal Society of New South Wales Council's Financial Report for 2000

Your Council Members submit the following financial statements of the Society for the year ended 31 December 2000

COUNCIL MEMBERS

The names of Council Members throughout the year and as at the date of this report are:

Prof A T Baker
Dr D F Branagan
Miss P M Callaghan
Mr D.A. Craddock
Dr P R Evans
Mr J Hardie
Mrs M Krysko von Tryst
Dr M R Lake
Dr D J O'Connor
Mr E D O'Keeffe
Mr R Perry
Dr E C Potter
Dr A Shannon
Prof W E Smith
Prof D J Swaine
Emer Prof R S Vagg
Emer Prof R Vernon
Prof P A Williams
Mr C M Wilmot

PRINCIPAL ACTIVITIES

The principal activities of the Society during the year were: organisation of meetings and publication of the Journal & Proceedings and the Bulletin.

SIGNIFICANT CHANGES

No significant change in the nature of these activities occurred during the year.

OPERATING RESULT

The surplus for the year amounted to $15,623

Signed in accordance with a resolution of the members of the Committee.

President ....

[Original signed by P.A. Williams (President)]

Acting Hon. Treasurer ....

[Original signed by P.R. Evans]

Dated this 28th day of March 2001

The Royal Society of New South Wales
Income & Expense at 31 December 2000

	Notes	2000	1999
		$	$
INCOME			
Membership Subscriptions	1	14,503	15,712
Application for Membership	2	0	152
Journal Subscriptions		12,022	5,581
Reprints & Other Publications		110	525
Investment Income		6,216	6,681
Summer School		0	1,445
Annual Dinner		172	(268)
Other		0	35
TOTAL INCOME		33,023	29,863
EXPENSES			
Accounting & Auditing Fees		475	575
Bank Charges & Govt Duties		46	118
Bulletin		1,732	1,765
Depreciation		1,000	474
Insurance		582	842
Journal & Proceedings		7,023	10,901
Miscellaneous		247	14
Monthly Meetings		729	727
Office		710	837
Provision for Doubtful Debts	1	2,066	1,743
Rent		1,818	2,000
Salaries		686	6,184
Superannuation		0	508
Telephone		286	407
TOTAL EXPENSES		17,400	27,095
SURPLUS FOR THE YEAR		15,623	2,768
Balance at 1 January		115,472	112,704
Balance at 31 December		131,095	115,472
Transfer from Library Reserve		7311	0
		138,406	115,472

The Royal Society of New South Wales
Balance Sheet at 31 December 2000

	Notes	2000 $	1999 $
ASSETS			
Current Assets			
Cash	3	17,190	11,409
Investments	4	5,808	5,641
Receivables	1	5,411	420
Cash on Hand		872	0
Total Current Assets		29,281	17,470
Non-Current Assets			
Investments	4	139,790	132,000
Property & Equipment	5	16,481	17,481
Total Non-Current Assets		156,271	149,481
TOTAL ASSETS		185,531	166,951
LIABILITIES			
Current Liabilities			
Sundry Creditors & Accruals		279	4,098
Other	6	4,456	2,701
Total Current Liabilities		4,735	6,799
Non-Current Liabilities			
Creditors & Accruals	6	0	7
Total Non-Current Liabilities		0	7
TOTAL LIABILITIES		4,735	6,806
NET ASSETS		180,817	160,145
MEMBERS' FUNDS			
Accumulated Funds		138,406	115,472
Library Reserve		0	7,311
Library Fund	8	13,754	13,909
Trust Funds	9	23,171	22,588
NSW Centenary of Fed. Fund	14	5,000	0
Studentship Fund	15	486	865
TOTAL MEMBERS' FUNDS		180,817	160,145

The accompanying notes form part of these financial statements

The Royal Society of New South Wales Notes to and Forming Part of the Accounts for Year Ended at 31 December 2000

1. **STATEMENT OF ACCOUNTING POLICIES**
These financial statements are a special purpose financial report prepared for use by the Council and Members of the Society. the council has determined that the Society is not a reporting entity.
The statement has been prepared in accordance with customary accounting practices on an accruals basis and on historic costs, taking no account of changing money values, or, except where specifically stated, current valuations of non-current assets.
Where required, comparative figures have been adjusted to conform with changes in presentation for the current financial year.
Council determined that the Society be registered for the GST with the ATO. The ATO's reporting requirements necessitated changing the accounting method to a full accrual system. Late dues are retained as Receivables, when previously they had been written off as Doubtful Debts at year end. Only sums owing by members who have resigned or died or who have been removed from the membership list under Rule 5(b) are expensed under Provision for Doubtful Debts.

		2000 ($)	1999 ($)
2.	**APPLICATIONS FOR MEMBERSHIP**		
	Council waived charges for Applications for Membership in 2000.		
3.	**CASH**		
	Cash on Hand	6	28
	Cash at Bank	17,184	11,380
		17,190	11,409
4.	**INVESTMENTS**		
	Current		
	Deposits at Call	5,808	5,641
	Non-Current		
	St George 551555467	139,790	132,000
5.	**PROPERTY**		
	Office Equipment & Furniture At Original Valuation of:	12,400	12,400
	Less Accumulated Depreciation	9,519	8,519
		2,881	3,881
	Library at 1936 Valuation	13,600	13,600
		16,481	17,481
6.	**LIABILITIES**		
	Current - Other		
	Journal Subscriptions Pre-Paid	4,369	2,552
	Life Members Subscriptions Pre-Paid	0	16
	Membership Subscriptions Pre-Paid	0	133
	Tax Payable	87	87
		4,456	2,701
	Non-Current - Creditors & Accruals		
	Life Members Subscriptions In Advance	0	7

		2000 ($)	1999 ($)
7.	**LIBRARY RESERVE**		
	Distinction of this reserve has served no useful purpose for many years and so it has been transferred to Accumulated Funds		
	Balance at 1 January	7,311	7,311
	Transferred to Accumulated Funds	(7,311)	0
	Balance at 31 December	0	7,311
8.	**LIBRARY FUND**		
	Balance at 1 January	13,909	13,173
	Donations and Interest	875	774
		14,784	13,947
	Library Purchases and Expenses	(1,030)	(38)
	Balance at 31 December	13,754	13,909
9.	**TRUST FUNDS**		
	Included in Trust Funds are		
	Clarke Memorial Fund 10	3,442	3,291
	Walter Burfitt Prize 11	3,203	3,101
	Liversidge Bequest Fund 12	8,799	8,846
	OlléBequest Fund 13	7,727	7,350
	Total Trust Funds	23,171	22,588
10.	**CLARKE MEMORIAL FUND**		
	Capital	5,000	5,000
	Revenue		
	Income	169	134
	Expenditure	(18)	(10)
	Surplus (Deficit)	151	124
	Balance at 1 January	(1,709)	(1,833)
	Balance at 31 December	(1,558)	(1,709)
	Total Fund Capital & Expenditure	3,442	3,291
11.	**WALTER BURFITT PRIZE FUND**		
	Capital	3,000	3,000
	Revenue		
	Income	377	308
	Expenditure	0	(510)
	Surplus (Deficit)	377	(202)
	Balance at 1 January	4,350	4,552

	2000 ($)	1999 ($)
12. LIVERSIDGE BEQUEST FUND		
Capital	3,000	3,000
Revenue		
Income	159	143
Expenditure	57	(598)
Surplus (Deficit)	102	(455)
Balance at 1 January	101	557
Balance at 31 December	203	101
Total Fund Capital & Expenditure	3,203	3,101
13. OLLÉ BEQUEST FUND		
Capital	4,000	4,000
Revenue		
Income	454	333
Expenditure	(501)	0
Surplus (Deficit)	(47)	333
Balance at 1 January	4,846	4,513
Balance at 31 December	4,799	4,846
Total Fund Capital & Expenditure	8,799	8,846
14. CENTENARY OF FEDERATION FUND		
Revenue		
Income	5,000	0
Expenditure	0	0
Surplus (Deficit)	5,000	0
Balance at 1 January	0	0
Balance at 31 December	5,000	0
15. STUDENTSHIP FUND		
Revenue		
Income	827	1,865
Expenditure	(1206)	(1,000)
Surplus (Deficit)	(379)	865
Balance at 1 January	865	0
Balance at 31 December	486	865

The Royal Society of New South Wales
Statement by Members of the Council

In the opinion of the committee the financial statements:

1. present fairly the financial position of The Royal Society of New South Wales at 31 December 2000 and the results for the year ended on that date in accordance with Australian Accounting Standards and other mandatory professional reporting requirements.

2. at the date of this statement, there are reasonable grounds to believe that the Society will be able to pay its debts as and when they fall due.

This statement is made in accordance with a resolution of the council and is signed for and behalf of the Council by:

President ....
[Original signed by P.A. Williams (President)]
Acting Hon. Treasurer ....
[Original signed by P.R. Evans]

Dated this 28th day of March 2001

The Royal Society of New South Wales
Independent Audit Report to Members

SCOPE

I have audited the financial statements, being the Statement of Income and Expenditure, Balance Sheet and Notes to and forming part of the financial statements of The Royal Society of New South Wales for the year ended 31 December 2000. The Council is responsible for the financial statements. I have conducted an independent audit of these financial statements in order to express an opinion on them to members.

My audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance as to whether the financial statement are free of material misstatement. My procedures included examination on a test basis of evidence supporting the amounts and other disclosures in the financial statements and the valuation of accounting policies and significant estimates. These procedures have been undertaken to form an opinion as to whether, in all material respects, the financial statements are presented fairly in accordance with Australian Accounting standards and other professional reporting requirements so as to present a view which is consistent with my understanding of the Society's position and the results of its operations.

The audit opinion expressed in this report has been formed on the above basis.

AUDIT OPINION

In my opinion, the financial statements present fairly in accordance with Australian Accounting Standards and other mandatory reporting requirements the financial position of The Royal Society of New South Wales as at 31 December 2000 and the results of its operation for the year then ended.

[Original Signed by Mr B.E. Holden on 28 day of march 2001]

B.E. Holden FCA
Chartered Accountant
Chatswood

NOTICE TO AUTHORS

Manuscripts should be addressed to The Honorary Secretary, Royal Society of New South Wales, PO Box 1525, Macquarie Centre, NSW 2113. Manuscripts submitted by a non-member (through a member) will be reviewed by the Hon. Editor, in consultation with the Editorial Board, to decide whether the paper will be further considered for publication in the Journal.

Manuscripts are subjected to peer review by an independant referee. In the event of initial rejection, manuscripts may be sent to two other referees.

Papers, other than those specially invited by the Editorial Board on behalf of Council, will only be considered if the content is substantially new material which has not been published previously, has not been submitted concurrently elsewhere nor is likely to be published substantially in the same form elsewhere. Well-known work and experimental procedure should be referred to only briefly, and extensive reviews and historical surveys should, as a rule, be avoided. Letters to the Editor and short notes may also be submitted for publication.

Three, single sided, typed copies of the manuscript (double spacing) should be submitted on A4 paper.

Spelling should conform with "The Concise Oxford Dictionary" or "The Macquarie Dictionary". The Systéme International d'Unites (SI) is to be used, with the abbreviations and symbols set out in Australian Standard AS1000.

All stratigaphic names must conform with the International Stratigraphic Guide and new names must first be cleared with the Central Register of Australian Stratigraphic Names, Australian Geological Survey Organisation, Canberra, ACT 2601, Australia. The codes of Botanical and Zoological Nomenclature must also be adhered to as necessary.

The Abstract should be brief and informative.

Tables and Illustrations should be in the form and size intended for insertion in the master manuscript - 150 mm x 200 mm. If this is not readily possible then an indication of the required reduction (such as 'reduce to 1/2 size') must be clearly stated. Half-tone illustrations (photographs) should be included only when essential and should be presented on glossy paper.

Maps, diagrams and graphs should generally not be larger than a single page. However, larger figures may be split and printed across two opposite pages. The scale of maps or diagrams must be given in bar form.

Half-tone ilustrations should be included only when essential and should be presented on glossy paper.

All tables and illustrations should be numbered consecutively with Arabic numerals in a single sequence and each must have a caption.

References are to be cited in the text by giving the author's name and year of publication. References in the Reference List should be listed alphabetically by author and then chronologically by date. Titles of journals should be cited in full - not abbreviated.

MASTER MANUSCRIPT FOR PRINTING

The journal is printed from master pages prepared by the LaTeXtypesetting program. When a paper has been accepted for publication, the author(s) will be supplied with a guide to acceptable electronic format for the submission of the revised manuscript. Galley proofs will be provided to authors for final checking prior to publication.

REPRINTS

An author who is a member of the Society will receive a number of reprints of their paper free. Authors who are not a members of the Society may purchase reprints.

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Vol. 134 Parts 1 and 2

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