THE JOURNAL
of the
Association of Surveyors
of Papua New Guinea

Vol. II JULY 1982 No. 2

ROLL OF PAST PRESIDENTS

1960-62	C.W. Sparkes - Carroll	1971-72	K.St.C. Matheson
1962-64	R.G. Matheson	1972-73	M.J. Larmer
1964-65	O.G.G. Dent	1973-74	J.J. Garrett
1965-66	T.W. Richards	1974-75	B.J. Mennis
1966-67	J.C. Williams	1975-76	J.J. Tierney
1967-69	T.C. Jackson	1976-77	A. Bale
1969-70	T.W. Williams	1977-78	F. Posanau
1970-71	J.C. Macartney	1978-Present	S. Low

Please address all communications to the:

Hon. Secretary
Association of Surveyors of Papua New Guinea
P.O. BOX 1422
BOROKO.

The Journal of The Association of Surveyors of Papua New Guinea.

Vol II July 1982 Number 2

Editor
D.J.McNEE

Manager
M.J. LARMER

Sub Editor
T.M. NACINO

Contents

1. Peopling of the Pacific Part 1 — 2-17
P.S. Bellwood

2. Minutes of 141 Council Meeting 14th May 1982. — 18-21

3. Aubrey Baker Scholarships — 22-24

4. Adjusted Traverse Areas On small Electronic Calculator — 25-27
S.J. Braughton

5. Multi-Functional Close Program — 28-32
D.J.McNee

6. Notes on Use of Terrestrial Photogrammetry in P.N.G. Part 2 — 33-48
M. Zeman

THE PEOPLING OF THE PACIFIC

It began 40,000 years ago with the first known ocean voyages. How Melanesia, Micronesia and Polynesia were colonized later is suggested by linguistic, genetic and archaeological evidence.

by P.S. Bellwood

The peopling of the Pacific was the greatest feat of maritime colonization in human history. If one begins at the beginning and chooses to trace all the movements of its major actors, the record spans perhaps two million years in time and extends beyond the Pacific proper as far west as Madagascar and as far north as mainland China above the Tropic of Cancer. Its main arena, however, consists of the islands of South east Asia, the subcontinent of Australia and its island neighbors, and the great ocean reaches of what today are called Melanesia, Micronesia and Polynesia. Its first maritime phase was well under way 40,000 years ago. By then certain hunter-gatherers had managed to cross a minimum of 70 kilometers of open water to settle in Australia and New Guinea.

Long before the region was known to Europeans it was settled by diverse populations that have maintained their diversity down to the present day. It is impossible to explain this diversity purely on the basis of today's physical, cultural and linguistic patterns, hence the confusion of hypotheses that have proliferated until recently. Advances in archaeology, physical anthropology and comparatice linguistics, mainly over the past three decades, now make possible a fresh assessment of the problem. Here I shall present this modern view. It is to some extent my own and one that not all scholars will support. It is, however, at least simple and logical and can be subjected to constant review as new data come to the fore.

To begin, consider the geography of the main arena. With the exception of New Zealand and the southern half of Australia it is a tropical area. On the west the large islands of Borneo, Sumatra and Java lie together on the shallow Sunda Shelf. At times of low sea level during the great continental glaciations of the Pleistocene these islands not only were joined together but also were connected to the mainland of Asia, thereby forming an even larger land mass that has been named Sundaland. The eastern frontier of Sundaland is delimited by the biogeographical divide called Huxley's Line, a variation on a better-known divide, Wallace's Line.

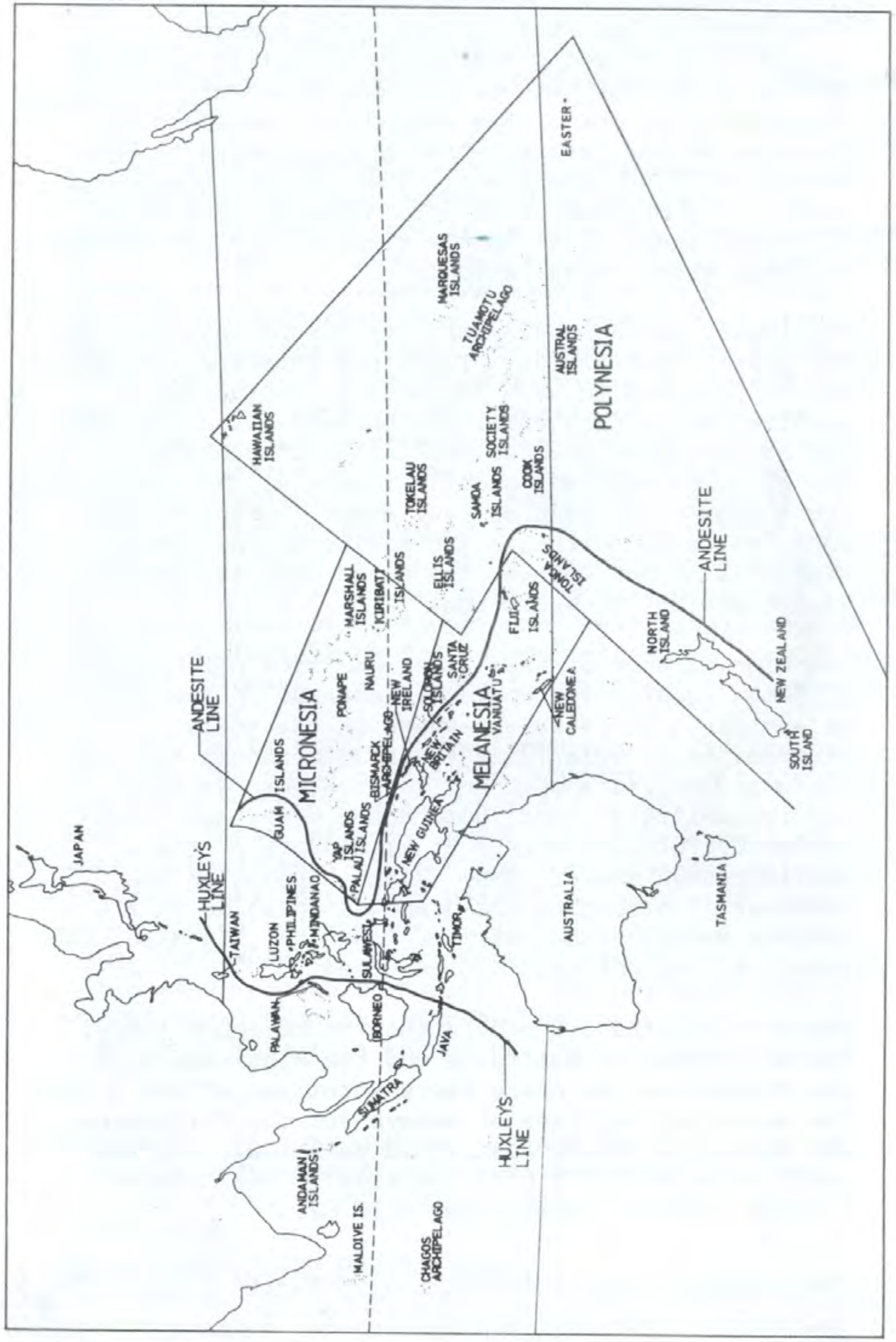
The flora and fauna on opposite sides of this frontier differ markedly from each other. To the east, in the Philippine and eastern Indonesian biogeographical zones, plant and animal life is less diverse and cosmopolitan than it is in Sundaland. Indeed, Sulawesi and the Lesser Sunda Islands in eastern Indonesia have definitely not been linked with Sundaland since at least Lowe Pleistocene times, more than a million years ago. The same may be true for the Philippines.

East of this area lie Australia and New Guinea, connected by the shallow Sahul Shelf, which was also dry land at times of Pleistocene low sea level. Here the mammalian fauna includes two primitive forms-monotremes and marsupials-that have been evolving in isolation within Sahulland since continental drift separated the area from Antarctica more than 50 million years ago in Eocene times. It is true that certain marsupials managed to reach eastern Indonesia, perhaps before man first arrived there. It is also true that such advanced mammals as rats and bats reached Australia and New Guinea from Asia. Nevertheless, the basic biogeographical differences between Sahulland and its neighbors imply a high degree of isolation for Sahulland. The deep seas of eastern Indonesia have probably never been bridged.

East of New Guinea lies Oceania, first the large and close-set "black" islands of Melanesia and then the increasingly fragmented island worlds of Micronesia (meaning "small islands") and Polynesia ("many islands") that lie across the Andesite Line. (Andesite, a volcanic rock, is characteristic of the great offshore arc of active volcanism around the rim of the Pacific basin). The islands west of the line are large and geologically complex and exhibit such features as sedimentary rocks and mature rive valleys. Beyond Fiji (and New Zeland, far to the south) these features are not know, the islands of Micronesa and Polynesia are small, jagged volcanic formations or coral atolls built on mountains long submerged. Many of these islands are ranged in chains. Nevertheless, they tend to be small, isolated and impoverished in their flora and fauna. To cite one example, in order to develop the elaborate societies that greeted Captain James Cook in the 18th century the immigrants who settled in Polynesia had to bring all their domestic animals and major food plants with them on their migration eastward.

At some time between one and two million years ago man first entered the western margin of this vast and empty area. The migrants were populations of Homo erectus, their remains have been found in central and eastern Java in geological formations of the Lower and Middle Pleistocene. Recently a few simple stone tools have been discovered in associated formations. So far there is no proof of the frequent assertion that these same early representatives of man reached either the Philippines or eastern Indonesia. Faunal evidence suggests the strong possibility that Sulawesi was connected to Borneo by a land bridge in Lower Pleistocene times, but as yet there is no definite evidence that Homo erectus was able to take advantage of it to migrate farther eastward.

The most recent fossil traces of Homo erectus in Sundaland may date back about 300,000 years. Thereafter information is virtually absent until about 40,000 years ago.



Then populations of hunter-gatherers, who must have flourished in Indonesia at the time, somehow succeeded in crossing deep water to settle in empty Australia and New Guinea. Perhaps their entry coincided with one of the periods of the lowest Pleistocene sea levels, which are now known to have been some 55,000 years ago. Even so, the immigrants still had a minimum of 70 kilometers of open water to cross, their claim to the title of the first ocean voyagers seems unchallengable.

Physically these people were the direct ancestors of the modern Australoids. Their own ancestry, in turn, can be presumed to have included a combination of genetic inputs from mainland Southeast Asia and from the earlier Homo erectus population of Sundaland. The clearest archaeological evidence of their arrival comes from sites such as Lake Mungo In Western New South Wales in Australia and Kosipe in the Papuan highlands of New Guinea; the sites date to between 35,000 and 25,000 years ago.

The significance of this first maritime colonization in human prehistory should be assessed in the ligh of similar activities elsewhere in the world. For example, major islands in the Mediterranean such as Crete and Cyprus appear not to have been settled before Neolithic times, some 8,000 years ago, even though Cyprus lies within 80 kilometers of the Mediterranean shore. Some island-hopping in the interest of procuring obsidian was going on in the eastern Mediterranean earlier than that, in Mesolithic times, but no colonization resulted.

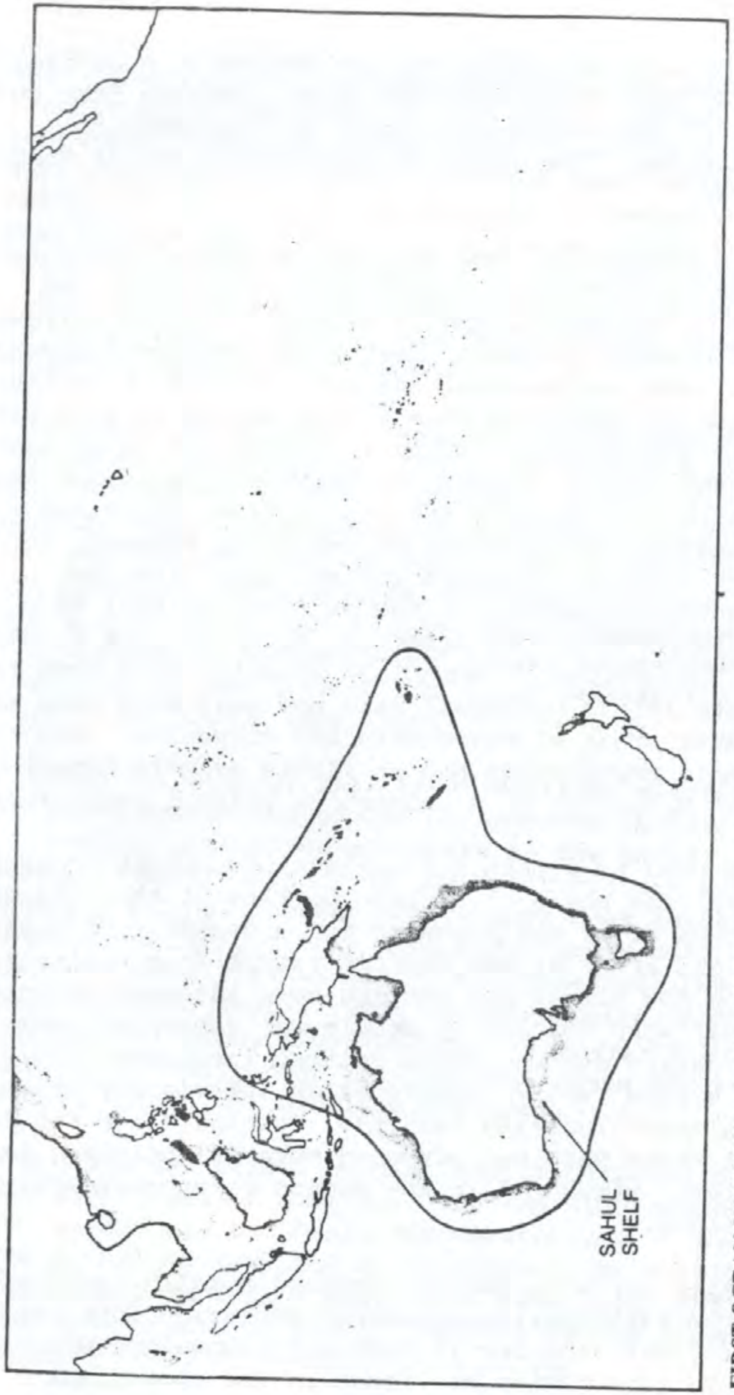
Where are Australoid populations to be found today? The Aborigines of Australia and the Highlanders of New Guinea are the basic representatives of the group. The so-called Negritos of Malaya and the Philippines are almost certainly Australoid relatives, and the isolated pocket of similar peoples in the Andaman islands north of Sumatra may also be.

The people of Melanesia too are basically Australoid, but they show a genetic complexity stemming from both ancestral and recent Polynesian and Micronesian penetrations. The last two populations are of Mongoloid affinity.

In this connection some physical anthropologists are unhappy when the term Mongoloid is applied to the people of Polynesia, and it is true that the Polynesians do not present a classic East Asian Mongoloid appearance. Indeed, many Polynesians and many peoples of southern and eastern Indonesia show a high degree of Australoid genetic inheritance. This, of course, is to be expected, given the earlier Australoid dominance in island Southeast Asia. To my mind the Indonesians, Filipinos, Micronesians and Polynesians owe their ancestry to complex patterns of migration and gene flow that originated ultimately on the mainland of East Asia, possibly north of the Tropics. With the past 6,000 years these populations of Mongoloid ancestry have come to dominate island Southeast Asia and have gone onto settle the empty areas of Micronesia and Polynesia. Why the Mongoloid populations had so little genetic impact on much of Melanesia is a subject to which I shall return.

Having come to within six millenniums of the present we enter the phase of Pacific settlement that has been the focus of my own research for a decade. In this phase all areas of the Pacific (apart from Australia, most of New Guinea and perhaps some adjacent Melanesian islands) were settled by people who subsisted largely by gardening and who spoke related languages within a large single family: Austronesian (previously known as the Malayo-Polynesian family). Putting aside for the moment these peoples' advanced material culture, the linguistic situation in the region is approximately as follows.

Australia for some reason remained totally isolated from the Austronesian-speakers' expansion into the Pacific, with the result that only languages unrelated to this family are found in the aboriginal population of the subcontinent.



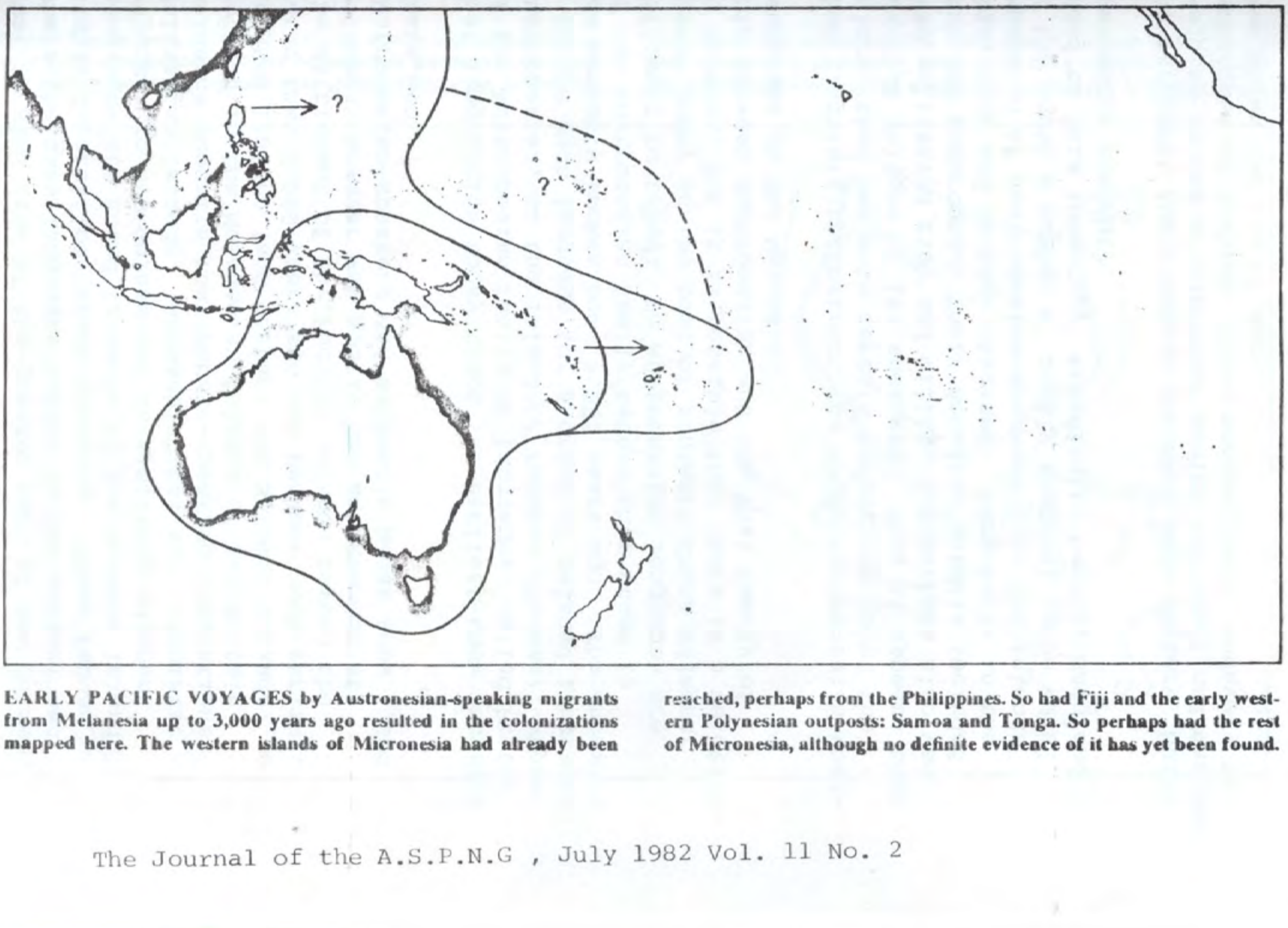
FIRST OCEAN VOYAGES of perhaps 40,000 years ago carried the ancestors of today's Australoids from Sundaland to Australia and New Guinea, then perhaps a single expanse named Sahulland. The Negritos of the Philippines, Malaya and the Andaman Islands (*light color*) are Australoid relatives. So are the Melanesians (*dark color*), who colonized the islands eastward to Fiji at least 3,500 years ago.

That is also true of the greater part of New Guinea, where the many languages belong to the ancient and highly diversified Papuan grouping. Other Papuan languages are found in parts of the Molucca Islands adjacent to New Guinea and in similarly adjacent Melanesian islands. Archaeological and linguistic evidence suggests that Papuan-speaking populations settled in the Melanesian islands of New Britain and New Ireland (and perhaps the Solomon Islands) no later than 6,000 years ago and perhaps much earlier. The settlement of the Pacific islands beyond the Solomons, however was solely the achievement of Austronesian-speakers and evidently began some 5,000 years ago.

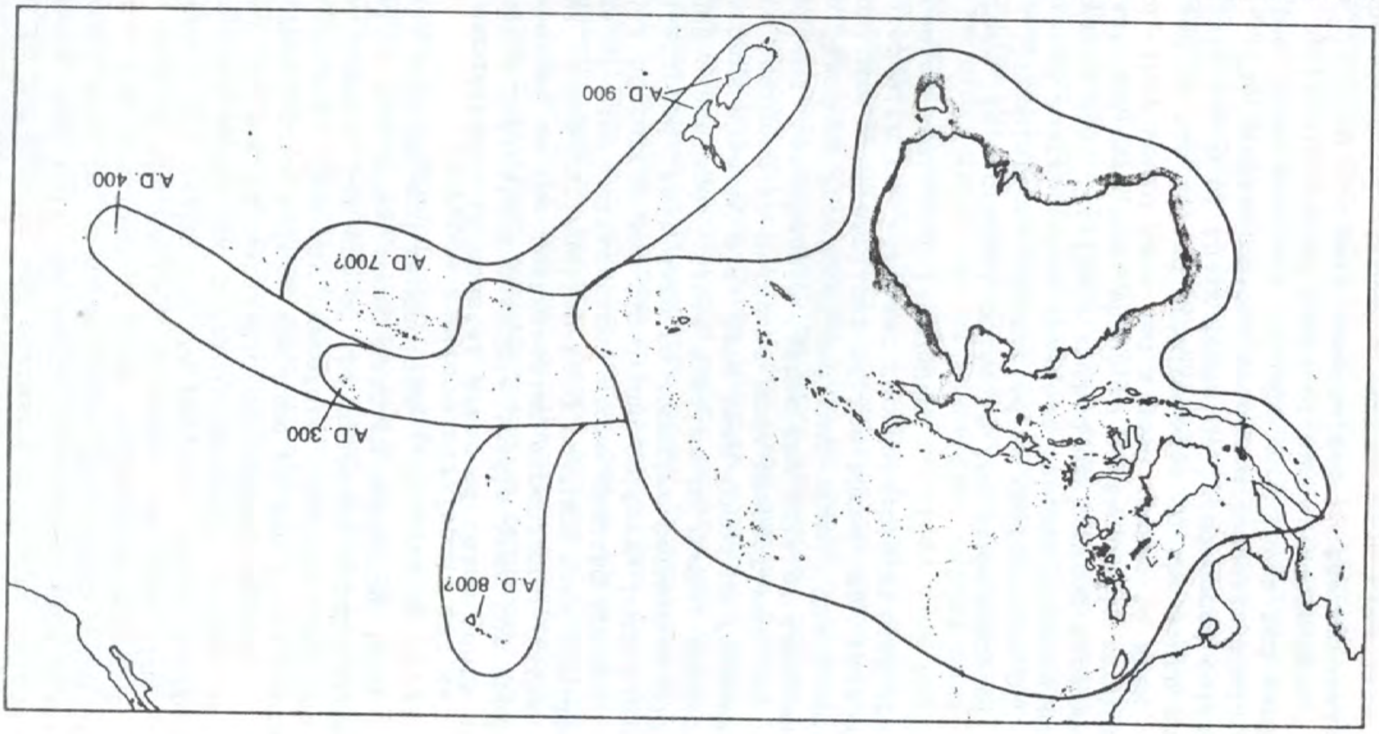
Most linguistics today trace the earliest-know ancestor of the Austronesian family of languages, called Proto-Austronesian, to the island of Formosa (Taiwan), where a single such language (or a group of related languages) was probably spoken some 6,000 years ago. The ancestry of the Austronesian family before that stage is difficult to trace. No Austronesian languages are spoken today on the cost of southern China adjacent to Formosa, but it is possible that there is a relationship between Austronesian and the Thai family of languages on the mainland.

When linguists reconstruct the Proto-Austronesian vocabulary, they can make certain deductions about the material culture of its speakers. Thus it appears that they cultivated rice and millet, and perhaps also yam, taro and sugarcane. Their domestic animals included pigs, dogs and perhaps chickens. Very early in the expansion of Austronesian-speakers into the islands to the south a number of purely tropical crops were added to this inventory: breadfruit, banana, sago and presumably coconut.

The earlierst Austronesian-speakers made pottery, built seagoing canoes of outrigger design and practiced various techniques of fishing. They are unlikely, however, to have known the use of metal.



EARLY PACIFIC VOYAGES by Austronesian-speaking migrants from Melanesia up to 3,000 years ago resulted in the colonizations mapped here. The western islands of Micronesia had already been reached, perhaps from the Philippines. So had Fiji and the early western Polynesian outposts: Samoa and Tonga. So perhaps had the rest of Micronesia, although no definite evidence of it has yet been found.



FINAL POLYNESIAN PUSH, starting early in the first millennium A.D., advanced eastward against prevailing winds and currents from the Tonga-Samoa area 3,500 kilometers to the Marquesas Islands, which were settled in about A.D. 300. Remote Easter Island was colonized perhaps a century later, and within another 500 years so were central Polynesia, the Hawaiian Islands and New Zealand.

Hence the enormous geographical expansion of the Austronesian-speakers over the following milenniums westward to Madagascar and eastward to Easter Island, places more than half the earth's circumference apart was accomplished by an essentially Neolithic group of cultures. The practice of rice cultivation was not carried east of the Mariana Islands. At some time later than 3,000 years ago the peoples island Southeast Asia acquired metal and possibly domestic cattle as well, but the use of metal did not extend beyond western New Guinea before the time of the first contact with Europeans. One may therefore conclude that the original impetus for one of the greatest colonizations achieved by man arose among peoples supported by a Neolithic economy and technology.

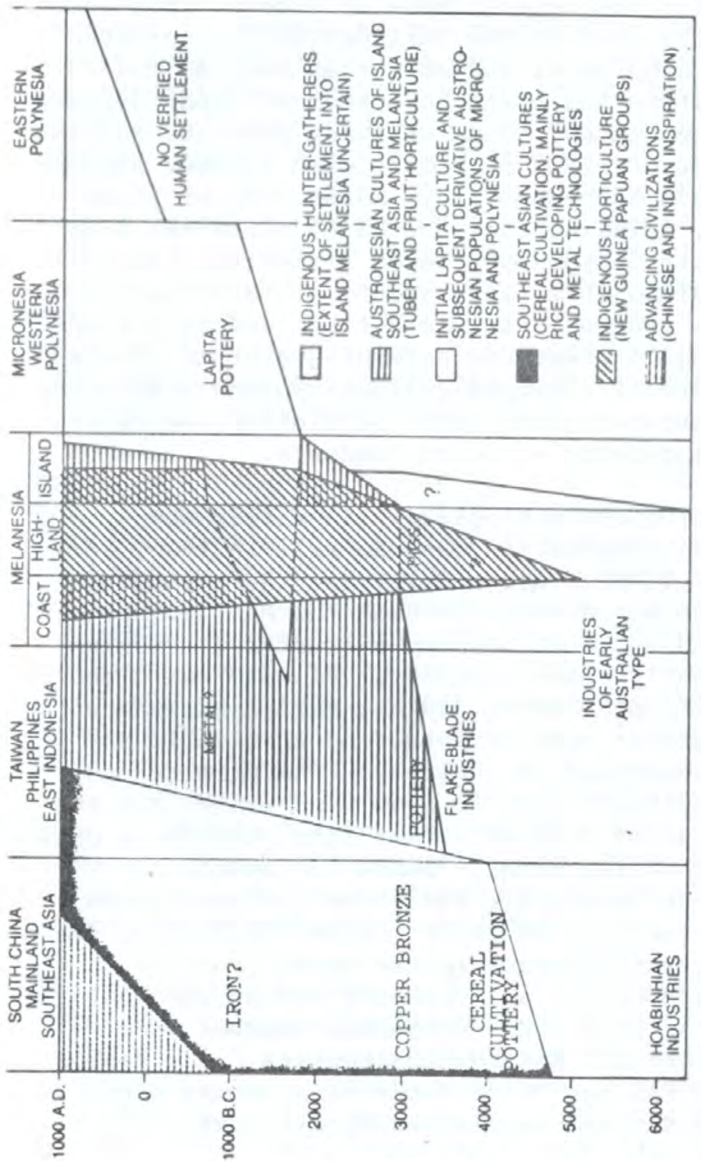
Recent excavations in coastal areas of China south of the Yangtze indicate a possible cradle area for what later emerged as the Austronesian expansion. Sites assigned to the Ch'ing-lien-kang culture have yielded evidence of rice cultivation, stone reaping knives, the bones of cattle and pigs, and pottery, both plain and red-slipped, that date to sometime between 6,000 and 5,000 years ago. Sites similar to these, some of them perhaps equally old, have been found on Formosa. They are assigned to cultures know respectively as Ta-p'enk'eng, Lungshanoid (after the site of Lung-shan-chen in Shandong Province) and Yuan-shan. The Ta-p'en-K'eng culture, the earliest of the three, may reasonably be equated with the earliest recognizable stages of the Austronesian family of languages.

Here, then, is a crucial point in the prehistory of the Pacific. Populations identified as cultivators of cereals and Austronesian-speakers reached Formosa about 6,000 years ago. If their method of growing rice was the slash-and-burn one, which is particularly prodigal of land, they would have had a good reason to seek more land in the island archipelagos to the south that lay within reach of their technically advanced outrigger canoes. The archaeological evidence suggests that at this time those southern islands were inhabited exclusively by thinly-spread bands of hunter-gatherers, who in the long run were overwhelmed by the expansion from the north.

Little evidence is available at present from Java and Sumatra, but in the Philippines, in northern Borneo, in Sulawesi and as far as east as Timor rock shelters and caves have yielded clear archaeological sequences. Some of these show the sudden appearance of plain or red-slipped pottery between 5,500 and 4,500 years ago. Adzes made of stone shaped by grinding that are quite different from the simpler indigenous flaked stone tools also appear, although in less secure archaeological contexts. There is little alternative at present but to regard these new assemblages of artifacts as a record of a marked cultural change associated with an expanding Neolithic population, exactly as the linguistic evidence suggests.

By combining archaeological, linguistic and ecological information one can fill in the picture a little more. First, as the expanding population moved south through the Philippines, Borneo and Sulawesi its members entered a region of constantly humid equatorial climate where the early cultivated rices did not thrive and where land clearance without metal and a reliable dry season became more difficult. (The peoples of island Southeast Asia do grow rice today, but the practice seems to have spread into many areas only in recent millenniums). Hence the newcomers' cereal crops gradually diminished in importance and were replaced as major sources of food by the tree fruits indigenous to the south (such as breadfruit, banana and coconut) and by sago-palm starch. Although the indigenous peoples were huntergatherers, not horticulturists, they probably exploited the same wide foodstuffs, along with wild taro and some varieties of wild yam.

Pigs, dogs and chickens appear to have adapted successfully to the southern environment. Indeed native wild pigs are found today in both the Philippines and Sulawesi. Cattle if the colonists attempted to transport them, did not thrive, archaeological sites of this period in island Southeast Asia hold no cattle bones.



AUSTRONESIAN MOVEMENT into the Pacific is plotted in relation to advances in material culture in five regions: mainland Southeast Asia and southern China; Taiwan, the Philippines and eastern Indonesia; Melanesia; Micronesia and western Polynesia, and finally eastern Polynesia. Until some 7,000 years ago from the Asian mainland to Melanesia most tools were of flaked stone rather than ground stone, and their users were indigenous hunter-gatherers. On the mainland soon thereafter farming and pottery appeared; metallurgy was known by 5,000 to 4,000 years ago and iron by about 3,000 years ago, long before Indian and Chinese civilization began to affect the area. The Neolithic arts of pottery and horticulture also appeared in Taiwan, the Philippines and eastern Indonesia between 6,000 and 4,500 years ago and spread to Melanesia. There, beginning in highland New Guinea, an indigenous form of horticulture had arisen perhaps even earlier. The Austronesians, facing cultural equals, could not displace or absorb the Melanesians as they had the hunter-gatherers of the Philippines and eastern Indonesia. Instead, beginning less than 4,000 years ago, they spread into unpopulated western Micronesia and from island Melanesia into eastern Micronesia and western Polynesia. The colonization was marked by the appearance of a distinctive pottery: Lapita ware. Finally, early in the Christian Era, when the Austronesian colonists had evolved most attributes of Polynesian culture, they began their greatest maritime venture, settling the Marquesas, Easter Island, central Polynesia, the Hawaiian Islands and New Zealand.

As a result when the Austronesian colonists went on to settle the Pacific, their eccnomy was based almost entirely on tubers and fruits and included neither major cereal plants nor herbivorous animals.

By some 4,500 years ago Austronesian peoples had been expanding into the equatoria islands of eastern Indonesia for about a millennium. This expansion which ultimately encompassed the whole of island South East Asia, can be compared to the expansion of Neolithic societies into Mesolithic Europe. The economy of the expanding population had undergone basic changes with respect to food plants, and the colonists themselves had doubtless come in wide contact with indigenous Australoid hunter-gatherers of the region. One may suspect that as a result interbreeding many of these Austronesian-speaking colonists had become genetically intermediate between the classical Mongoloid and Australoid norms. Even when allowance is made for a constant Mongoloid gene flow from the north up to the present day, one can still see, moving south from the Philippines to Java or the Moluccas, a gradual increase in the Australoid genetic inheritance. One may perhaps also infer that many of the Austronesian-speaking colonists in eastern Indonesia some 5,000 years ago would have resembled the more recent Polynesians. It must be admitted, however, that human skeletal remains in support of this view have not yet been uncovered.

Continued in Volume II NO. 3.

MINUTES OF THE 141 COUNCIL MEETING HELD IN PORT MORESBY ON THE 14TH MAY 1982.

PRESENT:	S. Low	President
	J. Sipuman	Secretary/Treasurer
	B. Mennis	Counsellor
	D. McNee	Counsellor
	G. Wai	Counsellor

ABSENT:	F. Posanau
	C. Polume
	C. Bassett
	S. Palanga

The meeting commenced at 4.30 pm at Low and Associates Office.

1.0 MATTERS ARISING FROM PREVIOUS MEETING

It was pointed out during the last meeting that certain members of the Association were not making any effort to pay the amount owing to the Association over the past couple of years.
Brian Mennis moved that these members whose names appear below must be given a further notice and if fail to pay the required amount by the 31st of May 1982 should be 'Struck-off' from the register.

Seconder: Des McNee.

Members:

L. Tabua	A. Waisale
A. Adoremus	K. Pochapon
A. Dion	R. Gurao
P. English	Capt. Pearson
R. Sioni	M. Popeu
P. Nama	J. Junt
P. Breria	K. Blaik
D. Forster	

2.0 APPLICATION FOR MEMBERSHIP

There was no new application to be considered however, application forms were sent to Mr Gonzales and Mr. Dwyer. Both had been requested to send their application forms to the President at the Port Moresby address if nearing the 14th of May.

3.0 SUBSCRIPTION FEE

The following members sent in their subscription fee:

G.F.B. VcVeagh	K16.
B. Huntington	K30.
G. Arman	$44 (US)
S. Palanga	K30.
C. Bassett (T/Sheet)	K10.
D.M. Swift	K15.
R. Moody	K30.
M.J.Larmer (T/Sheet)	K110.
T.W. Richards	K30.
Alexander Miller	K30.
Terry Lester	K30.
C. Polume	K60.
M. Hurburgh	K60.
G. Cross	K30.
D.M.B. Randle	K30.
M. Day	K15.
F. Pratt	K30.
M.J. Larmer	K30.
Gairo Wai	K30.
Selan Pambuai	K30.
Kila Ranu	K30.
Mela Popeu	K30.
J.M. Wolfe	K15.
Brian Mennis	K30.
Colin Hard	K15

Ian Van Ass	K15.	
Daniel Fitzhenry	K15.	
Graeme Arman	K15.	(1982)
Graeme Arman	K15.	(1983)
Peter Jolley	K15.	
Noel Sharp	K15.	
Graeme Sparks-Carroll	$15.	

4.0 CORRESPONDENCE BUSINESS ARISING

Mr Gouzales requested application form to join the ASPNG.

Letter from Remote Sensing Symposium to be held in Germany.

Mr Dwyer, application for membership.

G.F. McVeagh - Change address.

Set out application forms to both applicants.

Notified Mark Zorro and Nicholas Matui that the applications were successful while Steve Konena and S. Madu were not successful on the grounds that no certificate accompanied the form.

J.C. Macartney - sent receipt.

Mr R. Pratt enquired of 1981 Sub/Fee which was paid and deposited but not recorded in the register.

Mrs H. Pike - letter of sympathy to her late husband.

5.0 CONGRESS

Brian Mennis reported that everything is running smoothly as planned. The only matter yet to finalize will be the Opening Address which will be sorted out when the new Prime Minister is elected.

6.0 OTHER BUSINESS

Castle Membership - It was suggested that we pay the amount owing to castle for the membership.

Journal - Des McNee reported that the next issue will be out within two weeks time, while the third issue will be distributed during congress.

Scale of fee - after the council had gone through the submission from M. Larmer and C. Bassett, the President will compile the final draft of the scale of fees.

JERRY SIPUMAN
SECRETARY

Editors Note:

The following have since the 14th May paid their subscription fees:-
L. Tabua
P. Breria
A. Gurao
D. Forster
M. Popeu

12 Great George Street,
Parliament Square,
London SW1P 3AD

Tel: 01-222 7000
Telex: 915443

AUBREY BARKER SCHOLARSHIPS

Conditions relating to Awards

The Trustees of the Aubrey Barker Fund invite applications from suitably qualified persons for the award of scholarships as described below.

The Trust Fund has been established by the Commonwealth Association of Surveying and Land Economy for the purpose of promoting the study of land surveying, quantity surveying and land economy, and the acquisition and dissemination of knowledge and skill in those disciplines, particularly in developing countries of the Commonwealth.

The Trustees aim to assist further studies by candidates who have had at least two years experience after qualifying and who would be likely to make a contribution to the advancement of knowledge and skills in the candidiates' own country as well as benefiting from the opportunity for further study or research. Applicants for an Award must be nationals of, and domiciled in, one of the Commonwealth countries (other than Australia, Canada, Hong Kong, New Zealand or the United Kingdom). They must be qualified in one of the three disciplines mentioned above; they should not be more than 35 years of age at the time of applying for an Award; and they should not previously have undertaken a course of study outside their own country.

It is comtemplated that successful candidates will use their Awards to travel to another Commonwealth country where faciltities exist for furthering their relevant studies.

Where such facilities exist in more than one country, the Trustees would expect candidates to select the course of study in the country nearest to their own, to save on travel costs and enable a larger proportion of each Award to be expended on tuition fees.

The amount of each Award will be determined by the Trustees, but will make a sizeable contribution towards the cost of tuition fees and accommodation during the academic year in which the course of study is to be undertaken. The Trustees hope that, wherever possible, a candidate will obtain paid employment during the vacation to help offset his living expenses; and the Trustees will, where necessary, assist candidates to find such employment.

Awards will be made conditional upon candidates obtaining places on courses acceptable to the Trustees. Applicants whom the Trustees consider eligible to receive Awards will be so informed in time to enable them to apply for places on a mutually agreed course of study at the start of the ensuing academic year. The Trustees will give all appropriate assistance to any short listed candidate to obtain a place (including informing the relevant university or college that he is a candidate for an Aubrey Barker Award).

Each candidate will be required to enter into a undertaking (with such bond or guarantee that the Trustees may require) that he will complete the course of studies or research and, at the termination thereof, return to his or her own country. It is a prime purpose of the Awards that they should result in benefit to the developing countries of the Commonwealth and Awards will only be made to candidates who acknowledge this objective and enter into the guarantee required.

Applications should be made on the form attached to this notification, and a candidate must sign the declaration that he has read and acepts the conditions mentioned above.

Issued on behalf of the Trustees by

LONDON
July 1982

ROBERT STEEL
Honorary Secretary

Editors Note:

The application forms as mentioned above were not included with this letter. These forms can be obtained by writing direct to the above adress ~~onto~~ me and I'll forward the request on.

Any letters, articles or suggestions for the Journal should be sent to the editor at the address in the inside cover.

Adjusted Traverse Areas on small Electronic Calculators.

By S.J. Broughton

The following article is reprinted from the Australian Surveyor of December 1974 Vol. 26 No. 4. Mr S.J. Broughton. The author is a lecturer in the Department of Surveying, University of Queensland.

INTRODUCTION:

(a) Land surveyors, especially those undertaking cadastral instructions, are often required to adhere to specifications which necessitate an adjustment to observed quantities, but only for purposes of calculating derived quantities, such as areas. Certain statutory regulations (e.g. N.S.W) prescribe the manner of adjustment; others (e.g. Old.) require only that careful adjustment be made; most stipulate that unadjusted observed quantities appear on plans and summaries of surveys.

(b) When computing under such specifications, it is not necessary to retain a knowledge of each separate line (for subsequent adjustment once the misclosure is determined). The methods given below allow the calculation of an adjusted area within a close traverse, with almost no limit to the number of lines involved. They are applicable to many small electronic calculators now available, and should result in a considerable saving in core-usage on larger computers using other methods unnecessarily.

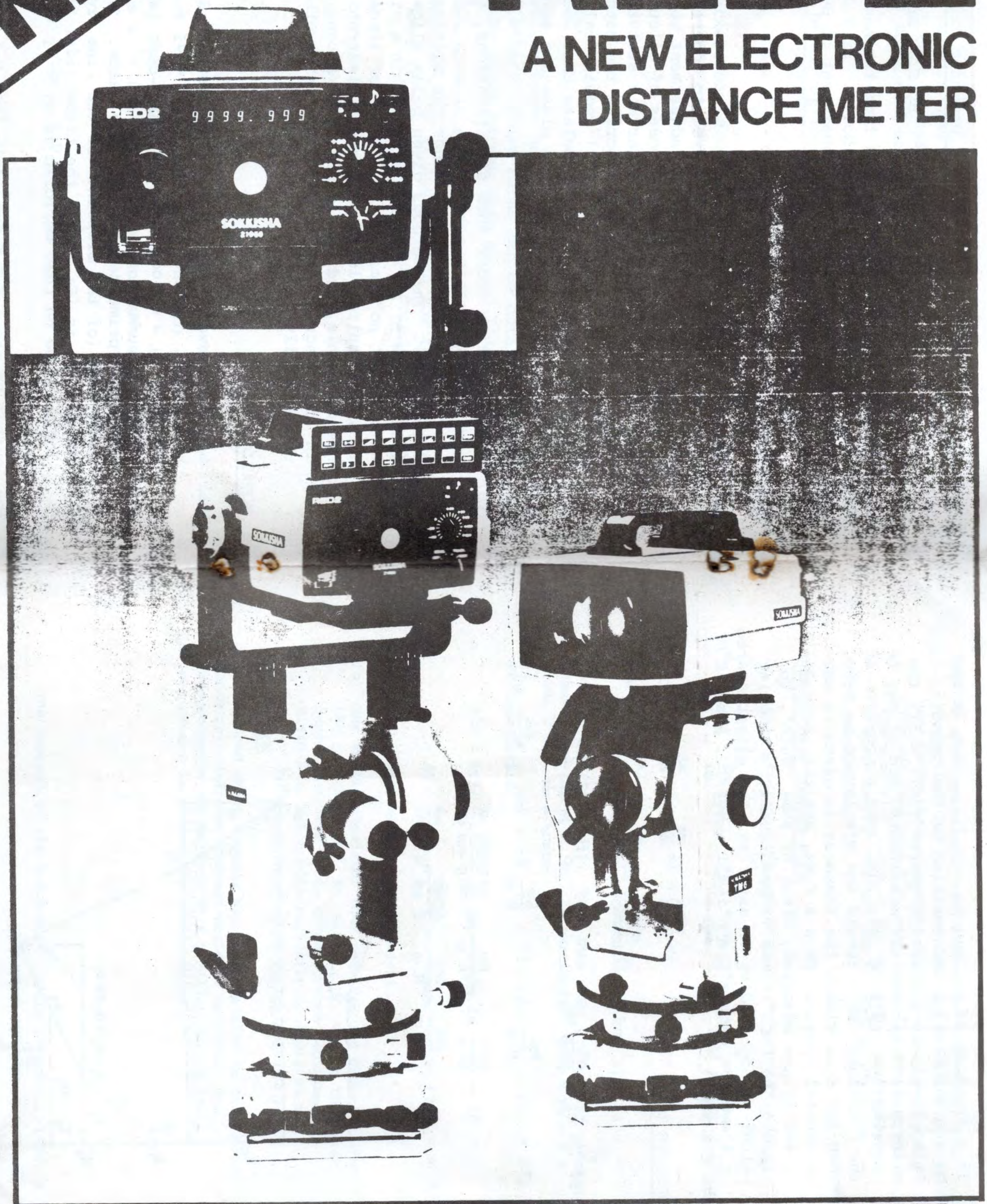
NOTATION

(a) Let the traverse line connecting stations S_i to S_{i+1} have bearing b_i, distance d_i, easting $e_i = d_i \sin b_i$, and northing $n_i = d_i \cos b_i$. Let upper-case letters denote continued summation, e.g. $E_i = e'_1 + e' + e'_2 + \ldots + e'$ where the prime denotes absolute value. Then the longitude (of the midpoint) of the line from the meridian through S_i is $(E_i - \frac{1}{2}e_i)$ the trapezoidal area subtended by the line on that meridian is $a_i = n_i (E_i - \frac{1}{2}e_i)$.

NEW

RED2

A NEW ELECTRONIC DISTANCE METER



SOKKISHA

THEODIST PTY LTD

(b) In a traverse of m lines (i = 1,2,..., m), Em and Nm are the easting and northing of the "missing-line" S_1 to S_{m+1}. In a closed traverse ($S_{m+1} = S_1$) the missing-line becomes the misclosure, and it may be required that this be less than some proportion of the "surround" Dm. Should the misclosure be zero, then the area within the traverse is given by Am. In general, however Em $\neq 0 \neq$ Nm, and the individual e_i and n_i are adjusted, often by some "Rule", to yield a "perfect" close mathematically. Denoting values so adjusted by an asterisk, the adjusted area is A^*m where each $a^*i = n^*i(E^*i - \frac{1}{2}e^*i)$. Also, $E^*m = 0 = N^*m$.

THEODOLITE RULE

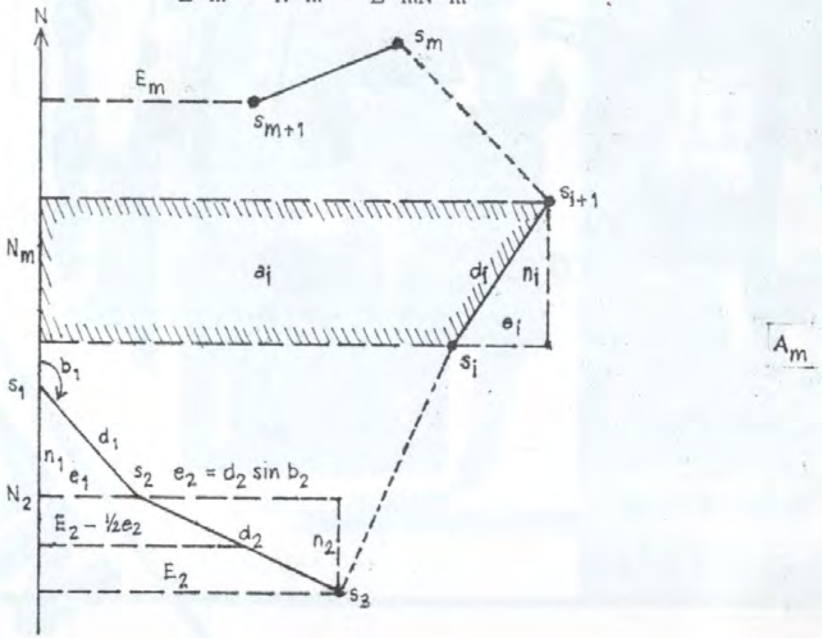
(a) The eastings and northins are adjusted so that:

$$e^*i = ei - \frac{ei}{E'm} Em \qquad n^*i = ni - \frac{ni}{N'm} Nm$$

$$a^*i = (ni - \frac{Nm}{N'm} ni)\,(Ei - \frac{Em}{E'm} Ei - \tfrac{1}{2}ei + \tfrac{1}{2}\frac{Em}{E'm} ei)$$

$$= ai - \frac{Em}{E'm} ai - \frac{Nm}{N'm} ai + \frac{EmNm}{E'mN'm} ai$$

$$A^*m = Am(1 - \frac{Em}{E'm} - \frac{Nm}{N'm} + \frac{EmNm}{E'mN'm})$$



(b) A small calculator with hard-wired functions, five "memories" (for the quantities Ai, Ei, Ni, E'i, N'i) and up to three "scratch" registers, may thus yield the adjusted area A^*m, with virtually no limit to the number of lines in the surround. In practice a sixth memory (for Di) may be used to yield the surround Dm.

BOWDITCH OR COMPASS RULE

(a) Here $e^*i = ei - \frac{di}{Dm} Em \qquad n^*i = ni - \frac{di}{Dm} Nm$

$$a^*i = ai - \frac{Em}{Dm} ni(Di - \tfrac{1}{2}di) - \frac{Nm}{Dm} di(Ei - \tfrac{1}{2}ei) + \frac{EmNm}{DmDm} di(Di - \tfrac{1}{2}di)$$

$$= ai - \frac{Em}{Dm} ui - \frac{Nm}{Dm} vi + \frac{EmNm}{DmDm} wi$$

$$A^*m = Am - \frac{Em}{Dm} Um - \frac{Nm}{Dm} Vm + \frac{EmNm}{DmDm} Wm$$

Let $v''i = ei(Di - \frac{1}{2}di)$. Then $EmDm = Vm + V''m$, with similar expressions for A, U, W. In particular, $DmDm = Wm + W''m = 2Wm$ - i.e. $Wm = \frac{1}{2}DmDm$.

We thus obtain:

$$A^*m = Am - \frac{Em}{Dm} Um - \frac{Em}{Dm} Vm + \tfrac{1}{2}EmNm$$

$$= Am - \frac{Em}{Dm} Um + \frac{Nm}{Dm} V''m - \tfrac{1}{2}EmNm$$

= etc, as may be convenient.

(b) The small calculator thus requires six memories (for the quantities Ai, Ei, Ni, Di, Ui, Vi, in the first expression) and up to three scratch registers to yield A^*m, again with virtually no limit to m.

CONCLUSION

It is hoped these methods may prove helpful to practising surveyors, and user comment would be welcome. The encouragement and help of Mr P.C.Miller during their development is gratefully acknowledged.

Multi-Functional Close Program for the HP41C.

by D.J. McNEE

INTRODUCTION:

All surveyors are obviously familiar with, close and misclose calculations, so much so that another article on the topic at this stage might seem a little boring. Please bear with me at least as far as finding our what the program does.

The program, I have found solves more than 90% of my survey calculations.

It produces:-

(a) Missing bearing and Distance.

(b) And Ratio of misclose.

(c) Two missing Distance close.

(d) Adjusted area.

FORMULA AND DETAILS.

The program algebraically sums the northings and eastings in the normal manner and computes and outputs the misclose in distance and bearing. It also accumulates the total distance so that a ratio of misclose can be computed.

When the figure contains two lines with known bearings and unknown distances. The program will calculate the unknowns using the formula.

$$D_1 = \frac{N \sin B_2 - E \cos B_2}{\sin (B_1 - B_2)}$$

where D_1 is the first missing distance B_1+B_2 are the 1st and 2nd missing bearings in order
N and E are the accumulated northings and eastings.

This formula is derived from simple geometry.

The area adjustment algorithm was developed by Mr Braughton described in the previous article.

$$\text{Adjusted area} = P - \frac{SE}{SD}\ Q - \frac{SN}{SD} - R + \frac{SE.SN}{SD.SD}\ .S$$

where
$P = (N.(SE^1 - \tfrac{1}{2}E))$
$Q = (N.(SD^1 - \tfrac{1}{2}D))$
$R = (D.(SE^1 - \tfrac{1}{2}E))$
$S = (D.(SD^1 - \tfrac{1}{2}D))$

SE and SN are the sum of the eastings and northings respectively.
SD is sum of the distances
E = easting of a line
N = northing of a line
SE^1 = sum of accumulated E.
SN^1 = sum of accumulated N
SD^1 = sum of accumulated Distances

The area computation is for a closed figure and the misclose must be within the required tolerance before computing the area.

INSTRUCTION	INPUT	KEY	OUTPUT	
			DISPLAY	PRINTER
1. Load Program, via card reader or manually.				
2. Fix 4 decimal places.				
3. Asign "Close" to say D				
4. Start program		D	0.0000	"Close Prg m"
5. Enter Bearing Bi	Deg.MMss	R/S	Deg.	Deg MMss
6. Enter Distance Di	Dist	R/S	i.0000	Dist
7. Calculator automatically returns to step 5				
8. To compute missing B/D and precision		A	Dist	
8a.		R/S	Brg.	Dist Bearing
8b.		R/S		Precis-ion
9. Calculator automatically returns to step 5.				
10. To compute the adjusted area		B		Area m^2
11. Calculator returns to step 5				
2 Missing Distances				
12. Follow steps 4 to 6 for all known B & D				
13. To calculate missing Distances		C	Brg 1	2 Mis.D
14. Enter 1st Bearing	DegMMss	R/S	Brg 2	BRG 1
15. Enter 2nd Bearing	DegMMss	R/S	Dist 1	BRG 2
16.		R/S	i	Dist 1
17. Calculator returns to step 5				Dist 2


```
01•LBL "CLOSE"
02 SF 12
03 "CLOSE PRGM"
04 FS? 21
05 PRA
06 0
07 STO 00
08 STO 01
09 STO 02
10 STO 03
11 STO 04
12 STO 05
13 STO 06
14 STO 07
15 CLΣ
16•LBL 00
17 RCL 16
18 STOF
19 CF 12
20 FS? 21
21 PRX
22 HR
23 STOP
24 FS? 21
25 PRX
26 ST+ 00
27 STO 01
28 P-R
29 STO 02
30 Σ+
31 LASTX
32 X<>Y
33 2
34 /
35 RCL 13
36 -
37 *
38 ST+ 04
39 LASTX
40 RCL 01
41 *
42 ST+ 05
43 RCL 02
44 RCL [illegible]
45 2
46 /
47 RCL 00
48 -
49 *
50 ST+ 06
51 LASTX
52 RCL 01
53 *
54 ST+ 07
55 FS? 21
56 ADV
57 GTO 00
58•LBL A
59 RCL 13
60 RCL 11
61 R-P
62 STOP
63 "MISCLOSE"
64 FS? 21
65 PRA
66 FS? 21
67 PRX
68 X<>Y
69 180
70 +
71 HMS
72 FS? 21
73 PRX
74 STOP
75 X<>Y
76 RCL 00
77 X<>Y
78 /
79 "PRECISION"
80 FS? 21
81 PRA
82 FS? 21
83 PRX
84 GTO 00
85•LBL B
86 RCL 06
87 RCL 13
88 *
89 RCL 00
90 /
91 ST- 04
92 RCL 05
93 RCL 11
94 *
95 RCL 00
96 /
97 ST- 04
98 RCL 13
99 RCL 11
100 *
101 RCL 07
102 *
103 RCL 00
104 X↑2
105 /
106 ST+ 04
107 RCL 04
108 ABS
109 "ADJ AREA. M"
110 FS? 21
111 PRA
112 FS? 21
113 PRX
114 GTO 00
115•LBL C
116 "2 MIS D."
117 FS? 21
118 PRA
119 "BRG.1"
120 FS? 21
121 ACA
122 PROMPT
123 FS? 21
124 ACX
125 ADV
126 HR
127 "BRG.2"
128 FS? 21
129 ACA
130 PROMPT
131 FS? 21
132 ACX
133 ADV
134 ADV
135 HR
136 STO 03
137 SIN
138 RCL 11
139 *
140 RCL 13
141 RCL 03
142 COS
143 *
144 -
145 X<>Y
146 RCL 03
147 -
148 SIN
149 /
150 FS? 21
151 PRX
152 STOP
153 P-R
154 Σ+
155 RCL 13
156 RCL 11
157 R-P
158 FS? 21
159 PRX
160 GTO 00
161 END
```

NOTES:

1. The calculator must be in "User" mode and will function with or without the printer.

2. Bearings are input in the usual degrees, minutes and seconds format, as is the output.

3. The bearing answer after step 8a is in the same cyclic direction as the close figure, that is from the end to the beginning.

4. The length of the misclose is the first output.

5. When the printer is not attached the adjusted area and the precision figure is in the Y stack, thus press X $\rightleftarrows$ Y to view the answer on the display.

Did this journal find you at your

CURRENT ADDRESS.

The Association is at present attempting to upgrade our records. The adress on the envelope is on our records as being current. If this is not correct please notify the secretary.

NOTE: The Association of Surveyors of Papua New Guinea now has an official address. It is

P.O. BOX 1422
BOROKO, NATIONAL CAPITAL DISTRICT

All mail to the Association should be addressed to this box. The Secretary will then pass on your letter to the person involved, President, Editor etc.

NOTES ON THE USE OF TERRESTRIAL PHOTOGRAMMETRY IN PAPUA NEW GUINEA - 2.

by M. Zeman, Dip. Surv. Czech, Assoc. Dip. Cart., Grad Dip TP (S.A.I.T.), lecturer, PNGUT.

3.0 TERRESTRIAL PHOTOGRAMMETRIC SURVEY FEASIBILITY

It is imperative that the prospective user is made fully aware of factors governing terrestrial photogrammetry application. The major factors which must be considered when planning terrestrial photogrammetric survey are:

- the desired end product
- the desired end product accuracy specifications.
- the availability of instrumentation in both, the data acquisition and data evaluation phases
- the terrain character (topography, vegetation, accessibility)
- completion schedule
- available funds

All of the above factors are inter-related and need to be treated as such. Thus for instance the availability of instrumentation in both, the data acquisition and data evaluation phases will not only influence the accuracy of the desired end product but in many cases the desired end product particular form. On the other hand the desired end product accuracy specifications may demand an employment of a particular method which can be proceeded with only if certain instrumentation is at the project executioner's disposal. The above factors must therefore be carefully considered during the planning phase of a particular project.

In the following these factors governing terrestrial photogrammetry application and thus affecting the ultimate success or failure of terrestrial photogrammetric survey will be briefly discussed.

3.1 The desired end product and its accuracy

In the specific approach to the use of terrestrial photogrammetry techniques it is essential to defind the method itself in terms that are meaningful to the client who in majority of cases may not be conversant with its potential or with its accuracy.

There are two aspects of a terrestrial photogrammetric survey and for that matter any type of survey that must be well-defined before any work starts if the survey is to be successful. These are firstly, the desired end product form i.e. the way in which the survey results are to be presented and secondly, the desired end project accuracy. If these aspects are not properly defined the survey outcome is not likely to be completely succesful.

It is the client's obligation to ascertain in unequivocal terms what information is required and how it will be used. Specifications drawn up for earlier jobs may not be applicable since nearly every mapping project is different and has different uses for the end product. No two object situations are exactly alike.

The survey executioner on the other hand has the responsibility to discuss with the client the form of data presentation together with accuracy. If necessary the survey executioner should question the client's assessment of the accuracies required. While it is true that a high degree of accuracy can be easily attained by the use of terrestrial photogrammetry the increase in accuracy is at the expense of overlap areas. Thus accuracy to a large extent determines costs of a mapping project. For instance a plan featuring 1 metre contour interval would be nearly twice as costly as the one featuring 2 metres contour interval all other parameters being equal.

For this very reason the desired end product is often a compromise between the client or Survey commissioner's original demands and the survey executioner's advice. The overriding consideration should always be the purpose for which a plan is produced. It is the author experience that the client often asks for a product that is entirely within the capabilities of terrestrial photogrammetric system yet somewhat redundant regarding the accuracy specifications. In this context the maintenance of a close liaison between the survey executioner and the client cannot be overemphasized. The application of a particular terrestrial photogrammetric procedure can be successfully made only if the two basic requirements outlined above are met specifically that the desired end product and its accuracy specifications are well defined and understood by both, the survey executioner and the client.

3.2 The availability of instrumentation

A number of instruments for both the data acquisition and data evaluation phase are available designed specifically for various requirements of terrestrial photogrammetry.

3.2.1 Data acquisition instrumentation

Metric cameras used for data acquisition in terrestrial photogrammetry are of two types, namely <u>single metric cameras</u> or <u>phototheodolites</u>, and <u>stereometric cameras</u>. Metric camera can be defined as the camera with a known orientation. Such camera is manufactured specially for photogrammetric applications, the stability of the orientation elements guaranteed over a long period and distortion minimized.

TABLE 1 - CHARACTERISTICS OF SINGLE METRIC CAMERAS

Manufacturer	Type	Focal length (mm)	Image Format (mm)	Aperture	Total depth of field	Photo-graphic material	Tilt range of camera axis & No. of interme-diate tilt stops
WILD (Heerbrugg)	P31 (S.W.A)	45	92 x 118	f/56 - f/22	f/56:3.6 m - ∞ f/22:1.5 m - ∞	Glass plates cut film	0 - ± 30° (3) and + 90°
	P31 (W.A.)	100	83 x 117	f/8 - f/22	f/8: 12.4 m - ∞ f/22: 6.6 m - ∞		
	P31 (N.A.)	200	83 x 116		f/9: 26m - 53m f/22:18m - 640m		
	P32	64	60 x 80		f/8: 7.3m - ∞ f/22: 33m - ∞	Glass plates cut film, roll film	0 - ± 40° continuous
ZEISS (Oberkochen)	TMK 6	60	80 x 100	f/11	f/11: 5m - ∞	Glass plates	0 - ± 90° (2)
	TMK 12	120		f/8 - f/16	f/8: 22m - ∞ f/16: 14m - ∞		
ZEISS (Jena)	UMK 10/1318N	99	120 x 165	f/8 - f/32	1.4m - 4.2m	Glass plates or 190 mm roll film flatness achieved by suction.	- 30° - + 90° (7)
	UMK 10/1318F				3.6m - ∞		

Single metric camera consists essentially of two main parts, a camera support or mount which can be attached to a tripod and a survey camera equipped for setting out the elements of exterior orientation in particular the direction of the camera's optical axis with respect to a base, and tilting the camera by predetermined angles.

Table 1 contains information on the main characteristics of some of the currently available metric cameras designed for topographic mapping. Of the many available only the ones made by the major European photogrammetric manufacturing companies are included. The table was compiled using respective manufacturers instruction manuals and references (1), (2), (3) and (4). Detailed descriptions will not be given since there are extensive explanations in the references quoted. The resurgence of terrestrial photogrammetry in general and its non-topographic mode in particular has been reflected in the characteristics of modern data acquisition instrumentation featured in Table 1. The cameras listed have a number of features which greatly increase their adaptability to different situations. This development may be characterised by:

- the inclusion of the high precision optics

  All lenses available for instance in the Wild cameras have extremely small radial distortion (± 4 μm maximum), and high resolution. They are also corrected for the visible and near infrared regions of the spectrum.

the possibility of modifying the cameras principal distances in order to widen their focussing ranges.

Thus for instance the Wild P31 camera which has otherwise a fixed focus of 25 metres can be focussed by the user also to 7, 2.5, 2.1, 1.8, 1.6 and 1.4 metres with the adapter rings inserted between the lens and the camera body. It is worth noting that the high accuracy of interior orientation is maintained when adapter rings are interchanged. On the Zeiss TMK 6 the focussing on different object distances is accomplished through the use of close-up lenses attached to the camera.

the increased control over photography

Most of the modern cameras listed in Table 1 have available aperture settings f/8, f/11, f/16 and f/22. Fixed aperture setting as featured on the Zeiss TMK 6 seems to be an exception. Shutter speeds as fast as 1/500 second are provided. Other features common to most cameras listed include the possibility of exposures in both, horizontal and vertical format and also the possibility of using various types of photographic material in addition to standard glass plates.

the use of two single cameras on special base bars

Such system combines the merits of stereometric camera with configuration possibilities of that of a single camera. Wild uses two P32 cameras on a base bar enabling different base lengths and various configurations of camera axes in relation to camera base. Zeiss (Jena) uses two UMK 10/1318 N single cameras in its IMK 10/1218 system.

It is worth mentioning here that to the author's knowledge there is only one camera in Papua New Guinea namely the Wild P32 with the Department of Works and Supply, Port Moresby, currently on loan to Department of Surveying, PNG University of Technology. The camera has been since used in a number of terrestrial photogrammetric surveys executed by the Department of Surveying including both, the topographic and non-topographic applications. The author intends to present a paper describing a terrestrial photogrammetric survey of the proposed Ok Menga hydro-electric power dam site (Ok Tedi mining Project) at the 17th ASPNG Survey Congress.

3.22 Data evaluation instrumentation

Although there are three alternatives for evaluation namely analogue, analytical and semi-analytical only the analogue instrumentation will be discussed since this approach is mostly likely to be adopted in topographic application.

Analogue instruments used in terrestrial photogrammetry may be divided into three groups namely the normal case plotters, universal first order plotters and topographic plotters.

Normal case group plotters includes the stereoplotters designed specifically for terrestrial photogrammetry, in general for the normal case and hence the term normal case plotters. Table 2 contains main characteristics of some of them. Once again, of the many available only the ones made by the major European photogrammetric manufacturers are included. The stereoplotters listed have been designed specifically to evaluate the normal case photography taken by stereometric cameras. They will accommodate also the photography obtained by single metric cameras provided the camera axes were parallel to each other, that is the normal case and the parallel averted case.

TABLE 2 - CHARACTERISTICS OF THE NORMAL CASE PLOTTERS

Manufacturer	Type	Focal Length (mm)	Maximum format (mm)	Base Setting (mm)	Z Operating range area (mm)	Plotting table useable area (mm)	Tilt Range	Plotter to Plotting table gear ratios
WILD	A40 Autograph	54 - 100	92 - 125	0 - 40	40 - 500	700 x 700	±30°	0.4 - 4x
ZEISS (Jena)	Technocart	50 - 215	230 x 230	0 - 240	-240 to +240	600 x 600	±15° 30 45°	0.16 - 5x
ZEISS (Oberkochen)	Terragraph	52 - 67	90 - 120	0 - 50	60 - 610	500 x 500		0.5 - 8x

The plotting capabilities of these plotters can be further extended by an additional tilt correction device which enables evaluation of photography taken with inclined camera axes. This device is introduced between the plotter and the plotting table in order to keep the projection plans vertical or horizontal for tilted photography without the use of large tilts available only on the universal plotters.

Some rather old plotters belonging to universal groups, in particular Wild A5, A7 are exceptional in that they are capable of accommodating large tilts necessary for the optimum object cover (5). However they are in general imcompatible with modern data acquisition instrumentation listed in Table 1. Thus for instance neither of the above universal plotters would accommodate shorter focal lengths namely those of the Wild P32 and P31 super wide angle cameras. On the other hand modern plotters belonging to this group have restricted ranges for reconstructing the inclinations of a survey camera. Thus Wild A10, found in most photogrammetric establishments including Papua New Guinea has tilt ranges of only ± 5°.

The third group of analogue stereoplotters used for data evaluation in terrestrial photogrammetry includes topographic plotters. Although they have been designed primarily for aerial mapping purpose and accept photogrammetry. The typical example of this group is Zeiss (Jena) Topocart which had been used by the author in the evaluation of photography acquired by the Wild P32 camera for Ok Menga hydro-electric power dam site mapping project. The plotter is owned by the Dept. of Works & Supply, Port Moresby.

There are however certain limitations which will have to be taken into account whenever data evaluation is to be attempted on a topographic plooter. These are as follows:-

Inability of reconstructing larger inclinations of a survey camera.

The larger inclinations introduced in photographic data acquisition phase in order to increase the coverage are imcompatible with most topographic plotters basically conceived for aerial photography. Tilt ranges are usually restricted to $\pm 5^{\circ}$. The use of a rectifier can be made to reduce the tilts to acceptable levels, compatible with the tilt ranges of a plotter.

Inability of accommodation of a wide range of focal lengths characteristic of terrestrial survey cameras.

Zeiss (Jena) Topocart seems to be an exception in this regard with its focal length range of 50 - 215 mm. This inability of focal length accommodation can sometimes be overcome by enlarging the original negative until its focal length is acceptable to the plotter.

Inability of restitution of a depth range.

The Y - coordinate (depth) of terrestrial photogrammetry corresponds to Z - coordinate (elevation) of aerial mode. The depth range within the objects space in terrestrial photography usually exceeds considerably the elevation range encountered in aerial photography. Thus restrictions are imposed on the scale of model formed in the plotter.

Inability of the exact reconstruction of the interior orientation.

The carrier plates lack fiducial marks for various small formats encountered in terrestrial photography. This can be overcome by the use of grid plates for centering. Photogrammetric equipment manufacturers sometime supply the additional set of carrier plates as a optional accessory.

From the foregoing it is obvious that the instrumentation availability in both, the data acquisition and data evaluation phases and also its compatibility must be carefully considered in planning stages of a particular project. The prospective user should therefore be aware of the limitations enumerated earlier as they concern the data evaluation instrumentation. It is more than likely that the evaluation of survey photography will take place on instrumentation not specifically designed for the purpose.

3.3 Costs of a terrestrial photogrammetric survey.

The economics of terrestrial photogrammetry application and for that matter any methodology application can be divided into the parameters of costs and benefits, with the benefits more difficult to estimate satisfactorily than costs. Although the importance of the cost effectiveness is not denied by project executioner, in many cases cost parameters calculations take second place to technical aspects. This is reflected in terrestrial photogrammetric literature where there are very few contributions on this topic. Furthermore the value of these is limited to other potential users owing mainly to incomplete information regarding the basic cost standards adopted. As a consequence, in majority of cases it is not possible to fully utilize the given information in another setting.

A number of reasons can be given for this highly unsatisfactory situation.

First of all, not enough work has been done in the area of cost effectiveness by photogrammetric establishments.

This is especially true for government sponsored agencies. Production methods in these evolved over a period of time and often are being carried out as the "accepted procedures" without being subjected to a detailed cost effectiveness analysis. It could also be said that most government sponsored agencies are usually not very economics - minded. Often the particular mapping project is costed on its completion, not before. Academic institutions should also be mentioned here since they undertake a number of terrestrial photogrammetric projects.

Generally they are not concerned with costs aspects since they are not in production situation and often the project are executed or assistance given free of charge.

Secondly, the information concerning cost parameters available in individual organisations is not disseminated. Thus for instance, commercial establishments by necssity economics-minded are obviously reluctant to reveal information which might hamper their competitive situation.

Regardless whether government sponsored or commercial establishment is involved in a particular terrestrial photogrammetric project their approach to its costing would be similar and often the cost standards for aerial photogrammetric surveys is adopted.

Of the alternative methods available, the two which have become widely accepted are <u>the hourly rates or the area of the negative in cm^2</u>.

Hourly rates approach costs the particular mapping project by estimating the time requirements for the individual activities that constitute the photogrammetric survey and then applying a scale of rates.

These rates should take into account all direct and indirect cost elements incurred by an organisation in the execution of the survey. The cost elements depend in turn on the unique set of circumstances pertaining to the survey organisation and hence will they vary between different organisations. Time requirements in the hourly rate appraoch are the empirically derived data concerning personnel and equipment. They are established by a careful analysis of work carried out over long periods. They are often significantly influenced by various other factors difficult to assess and quantify such as the unique nature of the project area, the desired end product specifications and the method and instrumentation used.

The other most popular method of costing photogrammetric surveys is based on the area of the negative in cm^2 that can be plotted within a given time unit. Apart from being dependent on the skill and efficiency of personnel, stereoplotting in cm^2/time unit is to a considerable extent influenced by the same factors that significantly influence the time requirements in the hourly rates appraoch, the project area in particular. Thus the more irregular and complex the object situation is, the less stereoplotting will be done within time unit.

Attempt had been made by the author to cost a number of terrestrial photogrammetric projects using the hourly approach involving both the topographic and non-topographic applications of terrestrial photogrammetry (6). The findings indicate that the data evaluation phase is by far the biggest cost expenditure, representing approximately 70% of the total cost and that the levels of detail portrayal i.e. the contour interval in topographic application is the major factor affecting the cost. The importance of maintaining a close liaison between the survey executioner and the client cannot be overemphasised especially in the project design stage.

The desired end product form together with the desired contour interval and planimetric accuracy must be defined by the client as precisely as possible.

As regards the survey executioner, he should present the client not only with the total cost of the project in question but also with a detailed analysis of all the individual activities that constitute the survey. This approach would result in an optimal solution from both cost and performance viewpoints. The client would then be in a position to modify the requirements to suit his budget, for instance somewhat lower the accuracies initially required.

3.4 The advantages of a terrestrial photogrammetric survey.

In the following the summary of the main advantages is given. According to the circumstances of a particular survey some or all of these may be relevant while a considerable number of them apply to all terrestrial photogrammetry applications.

The most important advantage of terrestrial photogrammetric survey and at the same time the one which makes it superior to a conventional survey lies in the fact that the total effort of photogrammetric mensuration needed to provide the desired end product does not increase proportionally to the quantity of points necessary for an accurate description of the object situations. This especially true of an analogue approach with its capacity to provide a continuous flow of information. There is a definite limit to the density of network of points needed to achieve the comparable levels of the object situation portrayal by conventional means.

Unlike the conventional survey, techniques the terrestrial photogrammetric survey allows an effective separation of the data acquisition and data evaluation phases, this advantage elucidated by almost anyone exploring the validity of terrestrial photogrammetry application. The data acquisition phase is quickly completed and at relatively small expenditure. The data evaluation phase can then be executed by any future date.

The negatives constitue a permanent record of the object situation at a particular instant in time. They have all the attributes of archival type of documentation and providing control survey had been done at the time of photography acquisition, their evaluation is possible when convenient or perhaps when the funds are allocated for it. The enlarged survey photographs feature an enormous information density which can be exploited by other users for instance a geologist.

3.5 Conclusion.

While not a panacea for all mapping tasks terrestrial photogrammetry can fulfill in majority of cases demands of the survey commissioner provided that certain basic requirements discussed in these notes are met by the prospective user. He must not only know thoroughly the performing capacity of the terrestrial photogrammetric system but convey also this capacity to the client in terms that are significant to him so that a photogrammetric procedure best suited to a particular mapping task at hand can be chosen, its cost being commensurate with that of other methods serving the same purpose.

References:

1. Schlienger, R.: Wild Cameras for Terrestrial and Close Range Photogrammetry, I.S.P., Commission V, Ottawa Congress, 1972.

2. Schlienger, T.: Recent Improvements to the Terrestrial Cameras of Wild Heerbrugg, ASP Symposium on Close Range Photogrammetric Systems, 1975.

3. Voss, G.: The UMK 10/1318 Universal Photogrammetric Camera System, Surveying News, No.27, 1973.

4. Trager, H.: The Zeiss Instrument System for Close Range Photogrammetry ASP Symposium on Close Range Photogrammetric System, 1975.

5. Zeman, M.: Terrestrial Photogrammetric Survey of the Excavated Rockfill Quarry at the Little Para Dam, Engineering & Water Supply Department Newsletter, Adelaide 1980.

6. Zeman, M.: The Application of Terrestrial Photogrammetry to the Recording of Historic Properties, Unpublished Thesis, South Australia Institute of Technology, 1979.

All contributions to the Journal are welcome.