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PERSATUAN GEOLOGI MALAYSIA
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The aim of the Geological Society of Malaysia is to promote the advancement of geological sciences particularly in Malaysia and nearby areas. Anyone interested in becoming a member of the Society should obtain the necessary forms from the Hon. Secretary.

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GEOLOGICAL NOTES

The relationship between the disposition of primary tungsten deposits in Selangor and Negri Sembilan (Peninsular Malaysia) and the tungsten distribution pattern in the associated granites

C.H. Yeap, Associated Mines (M) Sdn. Bhd., Kuala Lumpur
K.F.G. Hosking, Jabatan Geologi, Universiti Malaya

Introduction

The object of this note is to record the findings of an investigation that was carried out in order to discover if there was any recognizable relationship between the disposition of the primary tungsten deposits of Selangor and Negri Sembilan and the nature of the tungsten dispersion pattern in the neighbouring granites. The desire to search for a recognizable relationship was prompted by the fact that were one discovered it might provide the basis of a further aid to the search for tungsten deposits both in Peninsular Malaysia and throughout the whole of the Tin/Tungsten Belt of Southeast Asia of which Peninsular Malaysia is a part.

General geological character of the study area (Fig. 1)

For present purposes it is sufficient to note that the study area consists, essentially, of meta-sediments, that vary in age from Silurian to Devonian, and have been invaded by granites which are probably mainly of Triassic age, but which may contain minor Upper Carboniferous and/or Upper Cretaceous elements. These granites, which are responsible for much of the high ground of the area, are locally fringed by marble.

Primary deposits, containing wolframite with or without scheelite, occur in both the granites and the granite-invaded rocks, whilst hard-rock deposits containing only scheelite are restricted to the marble. Beyond reasonable doubt all the known tungsten deposits of the area developed near granite contacts, but in certain instances direct evidence in support of this has been eliminated by denudation.

All the known primary tungsten deposits are small, and with the exception of those at Titi, their tungsten content has never been exploited. Denudation, however, has released tungsten minerals from these deposits and permitted them to report in the dominantly stanniferous placers which occupy many of the valleys and cover extensive areas of the lowlands. The tungsten content of these placers has received but scant attention because it is generally too low to be of economic interest. However, in the past scheelite was recovered, as a profitable by-product, from the Sungei Way placers and also from some situated to the southeast of Ampang (Jones, 1925, p. 199).

Classification of the tungsten deposits in the study area

The tungsten deposits in question may be provisionally classified as follows:-

(1) Skarn deposits

(i) Stratabound types. These occur in the marble, for example, in the Templer Park area, the Melor Syndicate Mine (Sungei Way) and in mines in the vicinity of Kampung Pandan. They may be boudinaged and otherwise deformed, and they may contain, in addition to scheelite, such species as malayaite, grossularite, diopside and vesuvianite.

(ii) Vein types. These are comparatively rare, but a small one, consisting of grossularite, diopside, calcite and scheelite and cutting the marble of Sungei Besi Mine has been described (S.C. Chan, 1970).

(2) Mineralogically simple, generally small, early hydrothermal veins

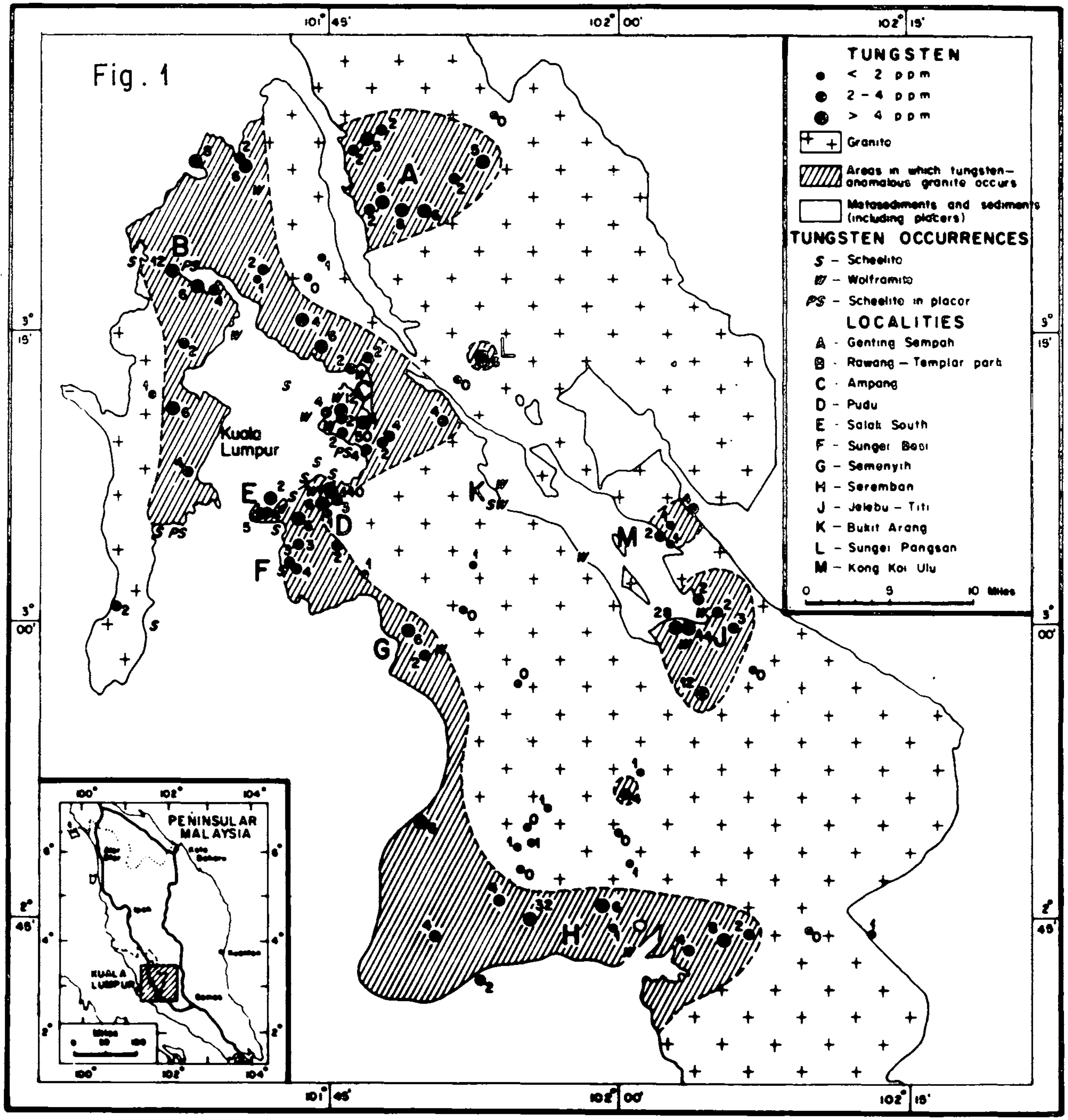
These occur in the metasediments and in the granites. At Ulu Langat, for example, small, greisen-bordered veins in the granite consist, essentially, of tourmaline, quartz, cassiterite, wolframite, and scheelite.

The Titi deposits, which are characterised by the presence of much arsenopyrite, in addition to cassiterite and wolframite, are somewhat exceptional members of this class in that Jones (1925, p. 204) speaks of them as lodes, and by so doing indicates that they are rather wide and probably structurally quite complex.

(3) Xenothermal Veins

Typical examples are found in the marble in the opencast mines near Kampung Pandan. The veins, that are up to a few inches in width, contain an impressive assemblage of minerals which include sericite, fluorite, cassiterite, wolframite, scheelite, and sulphides of tin, copper, iron, lead and zinc.

Fig. 1


TUNGSTEN
< 2 ppm
2 - 4 ppm
> 4 ppm
Granite
Areas in which tungsten-anomalous granite occurs
Metasediments and sediments (including placers)
TUNGSTEN OCCURRENCES
S - Scheelite
W - Wolframite
PS - Scheelite in placer
LOCALITIES
A - Genting Sempah
B - Rawang - Templer park
C - Ampang
D - Pudu
E - Salak South
F - Sungei Besi
G - Semenyih
H - Seremban
J - Jelebu - Titi
K - Bukit Arang
L - Sungei Pangsan
M - Kong Koi Ulu
0 5 10 Miles
101° 45'
102° 00'
102° 15'
3° 15'
3° 00'
2° 45'
Kuala Lumpur
A
B
C
D
E
F
G
H
J
K
L
M
PENINSULAR MALAYSIA
KUALA LUMPUR
100°
102°
104°
6°
4°
2°
Miles
0 50 100

(4) Tungsten-bearing placers

As these have been mentioned earlier it is only necessary to add here that eluvial, colluvial, and alluvial types are known in the study area.

The collection, preparation and analysis of the samples of granite

Sample collection: Largely because of deep secular weathering natural exposures of 'fresh' granite are very rare in the study area, hence, of necessity, sample collection was confined to man-made exposures along roads and in quarries.

Initially, attempts were made to collect suitable material at intervals of 2 miles along the roads, but this had to be abandoned because of the erratic distribution of exposures of 'fresh' granite.

Sample preparation: To obtain a statistically and otherwise satisfactory fraction for analysis each sample of c. 20 lbs., was reduced to pieces, each 1 to 2 inches in length, by means of a 10 lb. hammer. Stained or obviously altered portions were then chipped off and discarded. The remainder was reduced in a jaw crusher, to pieces c. ⅛th-inch in length, and these were then passed through a riffle splitter which yielded a fraction, of about 200 g. This fraction was next reduced to a fine powder in a Tema mill, and from it representative portions for analysis were obtained by the cone and quartering method. Throughout the whole operation precautions were taken to prevent contamination.

Analysis: Tungsten was determined colorimetrically by Stanton's (1966, pp. 86-7) dithiol method, but 0.5 g of sample was used instead of the recommended 0.25 g.

In order to establish the precision of the method three powdered granites were selected whose tungsten contents had been routinely determined. The tungsten content of two of them was low whilst that of the third was high.

The tungsten content of each of the ten representative samples from each of the three granites was then determined by Stanton's method of analysis, and from the results the data in the table below were calculated.

Sample No.	Mean value (ppm W)	Standard Deviation	Coefficient of variation
YH 76	1.0	0.47	47
YH 82	2.7	0.67	25
YH 118	150.0	10.54	7

The above results demonstrated that when analysing samples containing c. 1 ppm tungsten the coefficient of variation is rather high (approaching 50 percent) but that as the tungsten content increases the spread of values decreases markedly, so that when the sample contains c. 2.7 ppm tungsten the coefficient of variation is only 25 percent. One can conclude, therefore, that as far as the present study is concerned Stanton's method is quite adequate, as no serious errors in the final conclusions can accrue as a result of the fact that the results of analysing samples containing low concentrations of tungsten (of the order of 1 ppm) may differ by about 0.5 ppm from the true values.

That the Tema mill did not introduce tungsten contamination was proved by the fact that quartz ground in it and subsequently analysed according to Stanton's method contained no detectable tungsten.

Analysis of the results

Inspection of Fig. 1, on which the geochemical results and all the tungsten deposits in the area, that are known to the writers, have been plotted, provides the following data:-

(i) Granites that are in the vicinity of hard-rock tungsten deposits commonly provide samples that contain 4 or more ppm tungsten, but they may also yield some samples in which the tungsten content is less than 4 ppm. This means that from the point of view of the searchers for hard-rock tungsten deposits that the tungsten content of a single sample of granite may only have some significance if it is 4 or more ppm. Here it is pertinent to remark that Beus (1969) concludes that if half of the granite samples (assuming a statistically satisfactory number has been taken) from a given mass contains 4 or more ppm tungsten then it is probable that tungsten deposits will be associated with it (see Table 1). The writers' overall results lend support to Beus' view.

Table 1. Geochemical criteria for determination of parent granites of tungsten (after A.A. Beus 1969, p. 74)

Types of deposits and main ore component	Indicatory element and number of samples used in study ( )	Average abundance (ppm)		Contents (ppm) selected as criteria	Probability of the indicatory value in sample population	
		In ore-bearing granites	In barren granites		In ore-bearing parent granites	In barren granites
Tungsten deposits in quartz veins & greisens (Based on Altai and Transbaikalia regions)	W(40)	5 ± 1	2 ± 0.3	4 and more	0.50 and more	0.03 and less

That the granite adjacent to some of the known tungsten deposits in the study area is only represented by a single sample is because of the difficulty of obtaining acceptable samples.

One can also conclude that the very low tungsten content of isolated granite samples collected from well inside the contact cannot be taken to mean that no tungsten deposits occur there. Although when one remembers the penchant tungsten deposits have for granite/invaded rock contacts it is unlikely that tungsten deposits occur well inside the original contact. In spite of this there may be tungsten deposits reasonably far inside the present contact in the vicinity of points L and to the N.N.W. of point H. Should such deposits exist it is probable that they will be small and of no economic interest, and that they developed near a contact that has since been eliminated by denudation.

(ii) At area A a cluster of tungsten-anomalous granite samples has been collected, and in the vicinity of the granite/limestone contact one might expect tungsten deposits, yet the writers do not know of any there. The area might be worth investigating, but, as noted earlier, in the whole area only at Titi was the tungsten content of the deposits of any importance, and by present day standards it would rank as a very modest one, so it is unlikely that in area A a tungsten bonanza awaits discovery.

(iii) All types of 'hard-rock' tungsten deposits noted in the classification provided earlier have tungsten-anomalous granite closely associated with them in the study area.

(iv) Primarily because of the granite from the areas which have been comparatively well-sampled contain widely differing, and not infrequently quite high concentrations of tungsten, it is though that the pattern is largely due to deposition of the element during those times when primary tungsten deposits were developing. Elsewhere, one of us (Hosking, 1973) has given cogent reasons for believing that whilst some of the primary tungsten deposits of the study area, such as the vein types that were impounded in the granite by the limestone, are probably of Upper Triassic age, others, but particularly the xenothermal ones in the limestone, are probably of Upper Cretaceous age. If this view is correct it follows that some tungsten anomalies in the granite may be of Triassic age, some of Upper Cretaceous age, and some may contain elements of both ages.

(v) The distribution of the sampling points demonstrates the difficulty of using hard-rock geochemical aids to the search for mineral deposits in the humid tropics. It has also to be remembered that the density of roads and mines in the study area makes this one of the easier ones to investigate. In many parts of the Tin/Tungsten Belt of Southeast Asia it would be far more difficult to carry out such a study. So, it can be concluded that in those parts of Southeast Asia, whose topography is similar to that of the study area, geochemical exploration involving the analysis of stream sediments and of soils collected on spurs and ridges is likely to be rather easier and far more remunerative.

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Cross bedding in sandstones of probable Carboniferous age at Tanjung Gelang, Pahang

Peter H. Stauffer, Jabatan Geologi, Universiti Malaya

A sequence of alternating sandstones and mudstones is well exposed at Tanjung Gelang, a prominent rocky headland about 15 km north of Kuantan, Pahang (Fig.'s 1, 2). These rocks, which are hardened and perhaps slightly metamorphosed, but which still show their sedimentary feactures clearly, are undated but generally thought to be late Palaeozoic, most likely Carboniferous in age. They are shown as Upper Palaeozoic on the Geological Society of Malaysia's 1:1 000 000 geological map (Gobbett, 1972).

During a field trip with the Third Year Geology Class of the Universiti Malaya last August, I took the opportunity to examine the rocks of Tanjung Gelang and to measure the cross bedding in the sandstones. I measured some 20 sets of medium-scale cross bedding (generally 20-50 cm thick), and restored the foreset orientations by rotating the main bedding to horizontal about its strike on a stereonet. Figure 3a shows the resulting distribution of foreset dip directions - an apparently complete spread through 360°.

The strike of the rocks varies considerably from place to place at Tanjung Gelang (Fig. 2), especially between the north side, where it is generally about 330° with topside to the west (the four readings from the north side are identified on Figure 3) and the south side, where strike azimuths are mostly 70-90° with topside to the north. In order to see if these strike changes were secondarily imposed, all strikes were rotated to the same direction of 330° (thought to represent a typical regional strike), with topside to the west. The revised distribution of foreset dip directions is shown as Figure 3b. Note that it is now considerably more tightly grouped, and in particular that the north side and south side distributions are now essentially similar. This provides evidence that the structure of Tanjung Gelang resulted from differential rotation of the north and south sides about steeply plunging or vertical axes.

Environment of deposition and paleogeography: Sedimentary features in the rocks of Tanjung Gelang are suggestive of a shallow-water marine to possibly estuarine-deltaic environment of deposition. Beds are generally 5-60 cm thick, but some sandstones are as much as 4 m thick. The sandstones are sometimes quite coarse-grained, even conglomeratic, with poorly rounded pebbles as much as several cm across. Primary structures include abundant medium-scale cross bedding; numerous erosional, sand-filled channels with relief on the order of 50 cm and commonly cross-bedded internally; small-scale cross bedding, sometimes in a 'cross-hatch' pattern indicating oscillatory currents or wave action; and 'pillow'-like soft sediment deformation of the type described by Selley (1964), Shearman (1964), Hubert, et al. (1972), and Stauffer and Lee (1972) from deltaic and possible fluvial sandstones.

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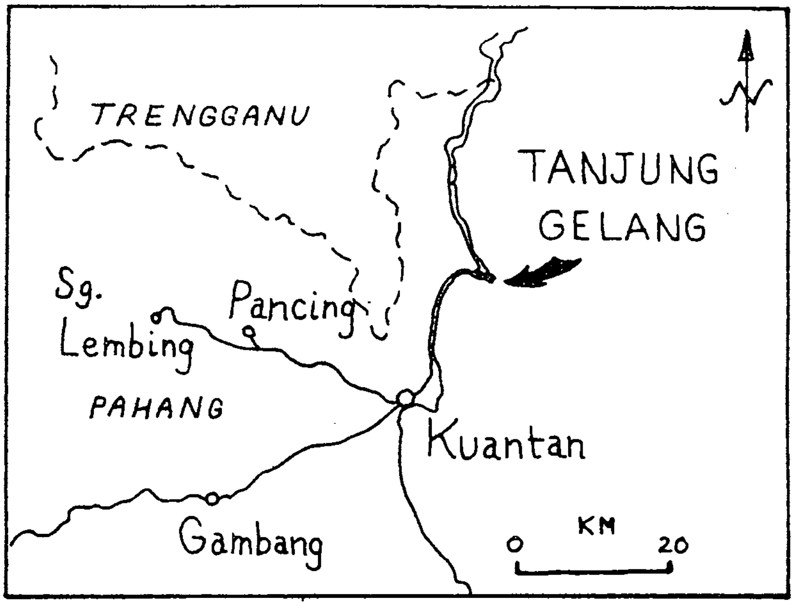

Fig. 1. Index map of localities mentioned in the text.

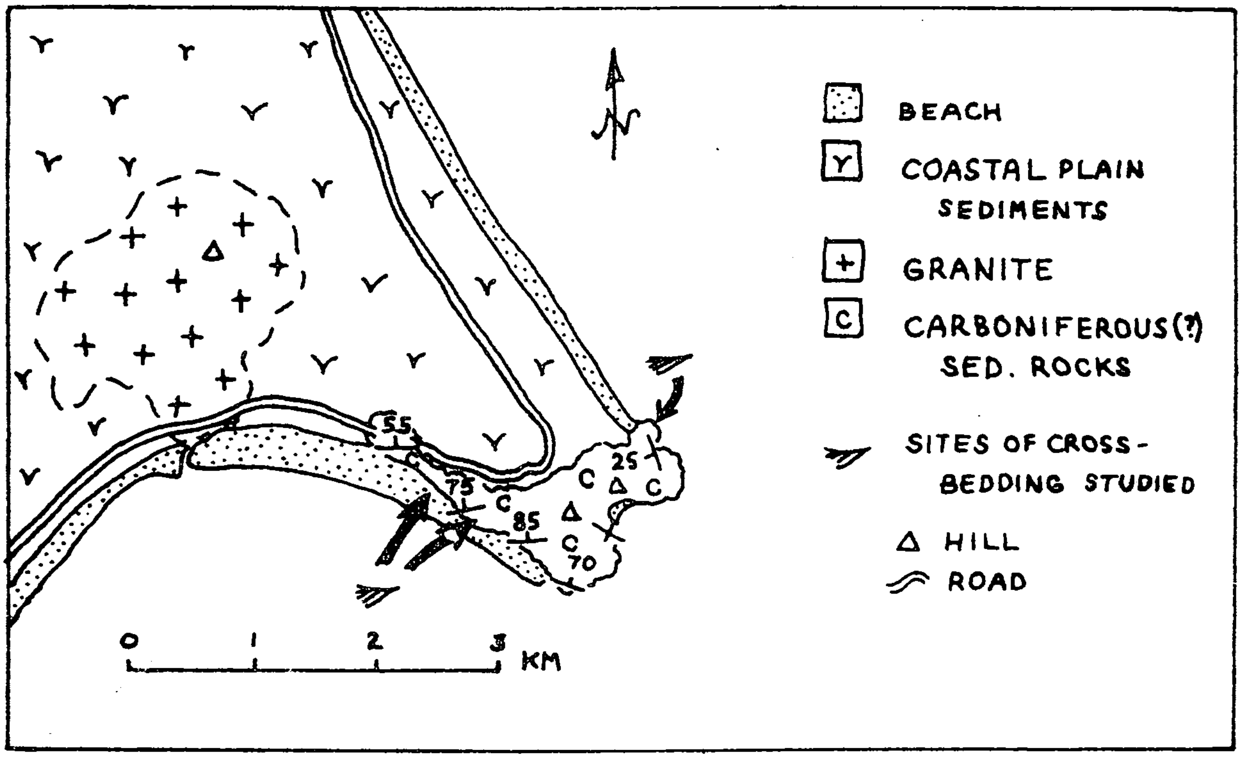

Fig. 2. General geology of Tanjung Gelang, Pahang. Mostly after Fitch (1951), with a few additions and annotations, including the locations of the measured cross bedding.

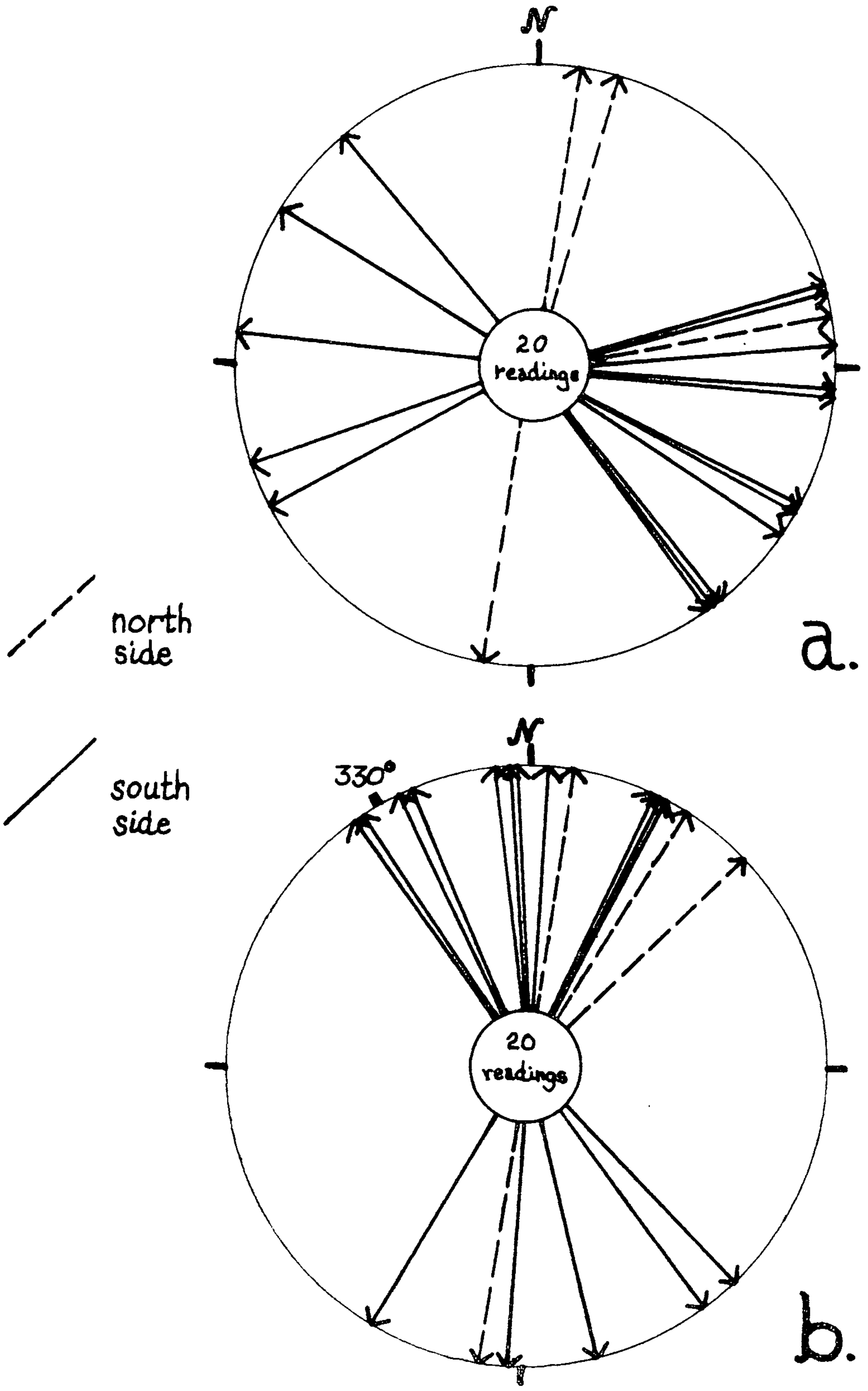

Fig. 3. Restored foreset dip azimuths of medium-scale cross bedding at Tanjung Gelang, Pahang. a. Restored by rotation about local strike. b. After 'correction' by rotating all strikes to 330°, considered a typical regional strike.

This 'pillow' structure is thought to be caused by fluidization in rapidly deposited loose sands. At Tanjung Gelang it is seen in some of the thickest sandstone beds.

The palaeocurrent pattern shown by the foreset dip directions (Fig. 3b) is consistent with a shallow marine or estuarine-deltaic origin. The pattern is bimodal, with two modes at nearly 180°, but the northward mode is much stronger. Most of the northward directions are from extensive and apparently tabular cross-bedded layers, while three of the six southward directions are from the sides of channels. The dominant northward trend is supported by the fact that pebbly beds were only seen at the south side, suggesting a decrease in grain size northward.

If these beds are estuarine-deltaic in origin, then a land source to the south is indicated. However, if one can assume that the rocks of Tanjung Gelang are Upper Palaeozoic and probably Carboniferous, then the facies relations to several nearby areas (Fig. 1) indicate offshore and deeper marine conditions to the west. The dated Carboniferous rocks in the Panching area are clearly marine shelf deposits, but as they include clean carbonates and the clastics are generally fine grained, they are probably of the outer shelf (Tan, 1972). Farther west, in the Sungai Lembing area, thinner-bedded and generally rather fine-grained clastics suggest more offshore conditions, and exposures to the south-west, west of Gambang (not dated but thought to be probably Carboniferous) show slump structures suggestive of a submarine slope (see Fig. 4.14 in Gobbett, 1973). If this implied palaeogeography is correct, then the palaeocurrent pattern at Tanjung Gelang might better be interpreted as representing marine currents mainly parallel to a north-south shoreline located to the east.

These questions are of some interest in view of recent suggestions (Mitchell, 1975; Hutchison, 1975) that eastern Malaya represents a distinct, possibly continental fragment which may have been separated from western Malaya by an oceanic basin during Palaeozoic. The paleaogeography inferred above is consistent with this idea.

This note has benefitted from the comments and suggestions of N.S. Haile on the original draft.

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A procedure for computing the lattice constants of some crystal systems

S.H. Chan, Jabatan Geologi, Universiti Malaya

Introduction

The lattice constants (a, b, and c) of the cubic, tetragonal, and orthorhombic systems are related by the general equation,

$$(1/d^2) = (h^2/a^2) + (k^2/b^2) + (l^2/c^2), \qquad (i)$$

while in the hexagonal system they are related by the equation,

$$(1/d^2) = [4(h^2 + hk + k^2)/3a^2] + (l^2/c^2) \qquad (2)$$

(Azaroff and Buerger, 1958; Hutchison, 1974). In these equations hkl are the Miller indices of the lattice planes and d is the inter planar spacing. The problem of interest to us is that in a given experiment using the technique of X-ray powder diffraction a set $\{d_i\}$ of the values of the interplanar spacing is obtained corresponding to a set $\{h_i, k_i, l_i\}$ of the Miller indices, where $i = 1, 2, \ldots, N$, and it is desired to estimate the lattice constants a, b, and c which provide the best fit to the observed experimental data. At first sight it appears that a, b, and c can easily be calculated by direct substitution of the observed data into equation (1) or (2). However, this procedure of direct substitution will lead to a set of nonlinear equations which are very difficult to solve. Although there are many techniques available for the solution of system of nonlinear equations (e.g., see Ralston, 1965) we shall not employ such techniques for solving our problem. It will be shown in the following that by employing some simple transformations both equations (1) and (2) can be reduced to a linear equation containing the unknown parameters which can then be computed by means of the method of least-squares.

In this paper the method for solving equations (1) and (2) will first be presented. This is followed by a discussion on the computational aspects of the problem. For the benefit of readers who have access to a digital computer a FORTRAN program for carrying out the actual computations is included in the Appendix.

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Method of solution

In the following discussions attention will be confined to the solution of equation (1) only. The reason is that as is evident from the derivations to be presented equation (2) is exactly of the same form as equation (1). Hence all remarks concerning the solution of equation (1) apply equally well to equation (2).

In order to solve equation (1) we make the following changes of variables:

$$D = 1/d^2 \; , \quad x_1 = h^2 \; , \quad x_2 = k^2 \; , \quad x_3 = 1^2$$

$$F_1 = 1/a^2 \; , \quad F_2 = 1/b^2 \; , \quad \text{and} \quad F_3 = 1/c^2 \; .$$

It is obvious that in terms of the new varables equation (1) can be rewritten as

$$D = F_1 X_1 + F_2 X_2 + F_3 X_3 \qquad (3)$$

which is a linear equation with three unknown parameters, namely F_1, F_2, and F_3. Thus our problem of estimating the lattice constants a, b, and c has been reduced to one involving the fitting of a hyperplane as defined by equation (3) in a four-dimensional space to an observed set of data, namely

$$\{D_i, \; x_{i1}, \; x_{i2}, \; x_{i3}\} \quad , \qquad i = 1, 2, \ldots\ldots N.$$

Note that the subscript i denotes the ith measurement of any one of the observables. It should be clear that by now that equation (2) can similarly be transformed into a linear equation, except that in this case there are only two unknown parameters.

One way of solving for the unknowns in equation (3) is to employ the method of least-squares. The unknown parameters thus obtained will be optimal in the sense that the mean square errors will be minimum. Since the theory of least-squares is well described in the literature on numerical analysis (e.g., see Conte and de Boor, 1972; Ralston, 1965) we shall outline only those points which are pertinent to our discussion here and readers are referred to the cited references for more details on the theory of least-squares.

The least-squares solution of equation (3) leads to the following normal equations:

$$\begin{aligned}
F_1\Sigma X_{i1}^2 &+ F_2\Sigma X_{i1}X_{i2} &+ F_3\Sigma X_{i1}X_{i3} &= \Sigma X_{i1}D_i \\
F_1\Sigma X_{i1}X_{i2} &+ F_2\Sigma X_{i2}^2 &+ F_3\Sigma X_{i2}X_{i3} &= \Sigma X_{i2}D_i \\
F_1\Sigma X_{i1}X_{i3} &+ F_2\Sigma X_{i2}X_{i3} &+ F_3\Sigma X_{i3}^2 &= \Sigma X_{i3}D_i
\end{aligned} \qquad (4)$$

Or, in matrix notation, equation (4) can be written as

$$E\,F = G \qquad (4a)$$

where

$$E = \begin{bmatrix} \Sigma X_{i1}^2 & \Sigma X_{i1}X_{i2} & \Sigma X_{i1}X_{i3} \\ \Sigma X_{i1}X_{i2} & \Sigma X_{i2}^2 & \Sigma X_{i2}X_{i3} \\ \Sigma X_{i1}X_{i3} & \Sigma X_{i2}X_{i3} & \Sigma X_{i3} \end{bmatrix}$$

$$F = \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} \qquad \text{and} \qquad G = \begin{bmatrix} \Sigma X_{i1}D_i \\ \Sigma X_{i2}D_i \\ \Sigma X_{i3}D_i \end{bmatrix}$$

Note that all the summations in the above expressions are performed over the index i. From the normal equations we can solve for the unknown parameters F_1, F_2, and F_3. Using equation (4a) we observe that the solution is given by

$$F = E^{-1}G \qquad (5)$$

where E^{-1} is the inverse of the matrix E. Once the solution vector F is determined the reciprocals of its elements will be the desired values of the lattice constants.

Computational Details

The computation of the solution vector F is most conveniently carried out on a digital computer. The writer has developed a FORTRAN program for handling both equations (1) and (2). This computer program is presented in Appendix I. An outline of the computational procedure is given in the flow chart shown in Figure 1.

The input data to the computer program consists of a Nx4 matrix, known as DATA, N being the number of sets of hkl values together with the corresponding values of d. Each row of DATA is made up of a set of hkld values. Thus the jth row of DATA will be of the form

$$\{h_j,\ k_j,\ l_j,\ d_j\} \quad ,$$

which will be punched on a single input data card. In addition there are two other input quantities, namely NC and M. NC specifies the number of parameters to be estimated; it is set equal to 2 if the crystal belongs to the hexagonal system and equal to 3 for other systems. M represents the number of sets of the matrix DATA.

The actual computation starts with the formation of the matrices E and G. It can be shown that

$$E = X^T X$$

where

$$X = \begin{bmatrix} X_{11} & X_{12} & X_{13} \\ X_{21} & X_{22} & X_{23} \\ X_{31} & X_{32} & X_{33} \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ X_{N_1} & X_{N_2} & X_{N_3} \end{bmatrix}$$

and
$$G = X^T D$$

where
$$D = \begin{bmatrix} D_1 \\ D_2 \\ D_3 \\ \cdot \\ \cdot \\ \cdot \\ D_N \end{bmatrix}$$

Note that X^T denotes the transpose of the matrix X. In the computer program the matrix X is calculated from the first three columns of DATA while the vector D is derived from the last column of this matrix.

Once the matrices E and G are formed the next step is to calculate the solution vector F, that is, to solve the normal equations. This is achieved by means of a subroutine program MIN which is based on the Gauss elimination method of solving a system of linear equations. It may be noted that subroutine packages for solving a system of linear equation are readily available at practically all computer centres. One can always select a subroutine best suited to his own problem.

Finally, when F is determined the lattice constants a, b, and c are calculated by means of the square root function subprogram.

Concluding Remarks

In this paper we have presented a procedure for estimating the lattice constants of crystals belonging to the cubic, tetragonal, orthorhombic, or hexagonal system when different sets of hkld values are provided. The procedure is based on linear least-squares theory.

It is important to realise that although we have referred to the use of digital computer for the implementation of the computational procedure this does not imply that we must always carried out the computations on a digital computer only. In actual fact, the solution of the normal equations which involve at the most three unknowns only can readily be achieved by means of an electronic calculator. Of course when one has to handle many different sets of data the digital computer has the obvious advantage of high speed over the electronic calculator. Under this circumstance computation by means of an electronic calculator can be very boring and tedious.

Acknowledgement

The writer would like to thank Dr C.S. Hutchison for bringing him to the attention of this problem and also for some helpful discussions.

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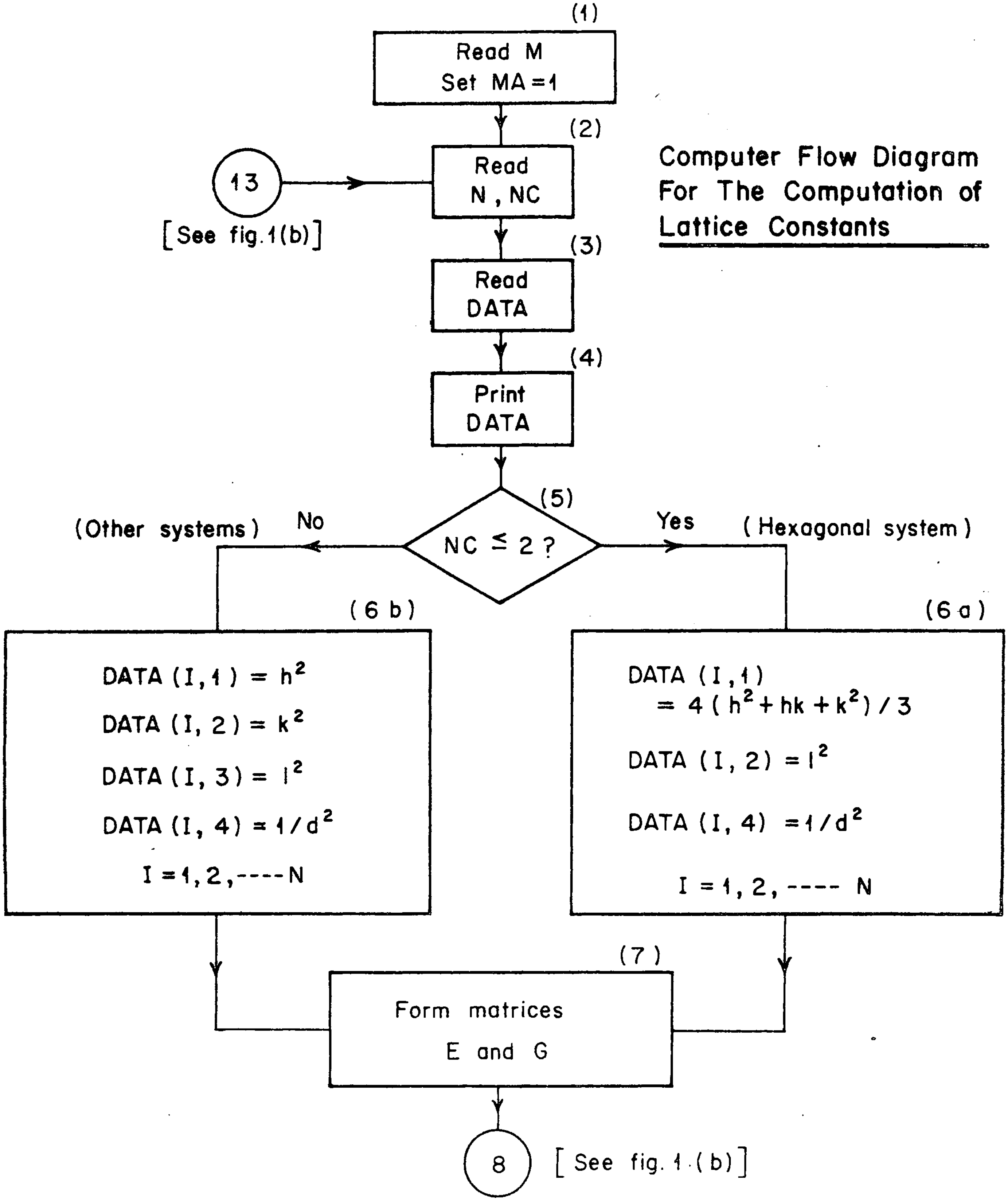

Computer Flow Diagram For The Computation of Lattice Constants

Fig. 1 (a)

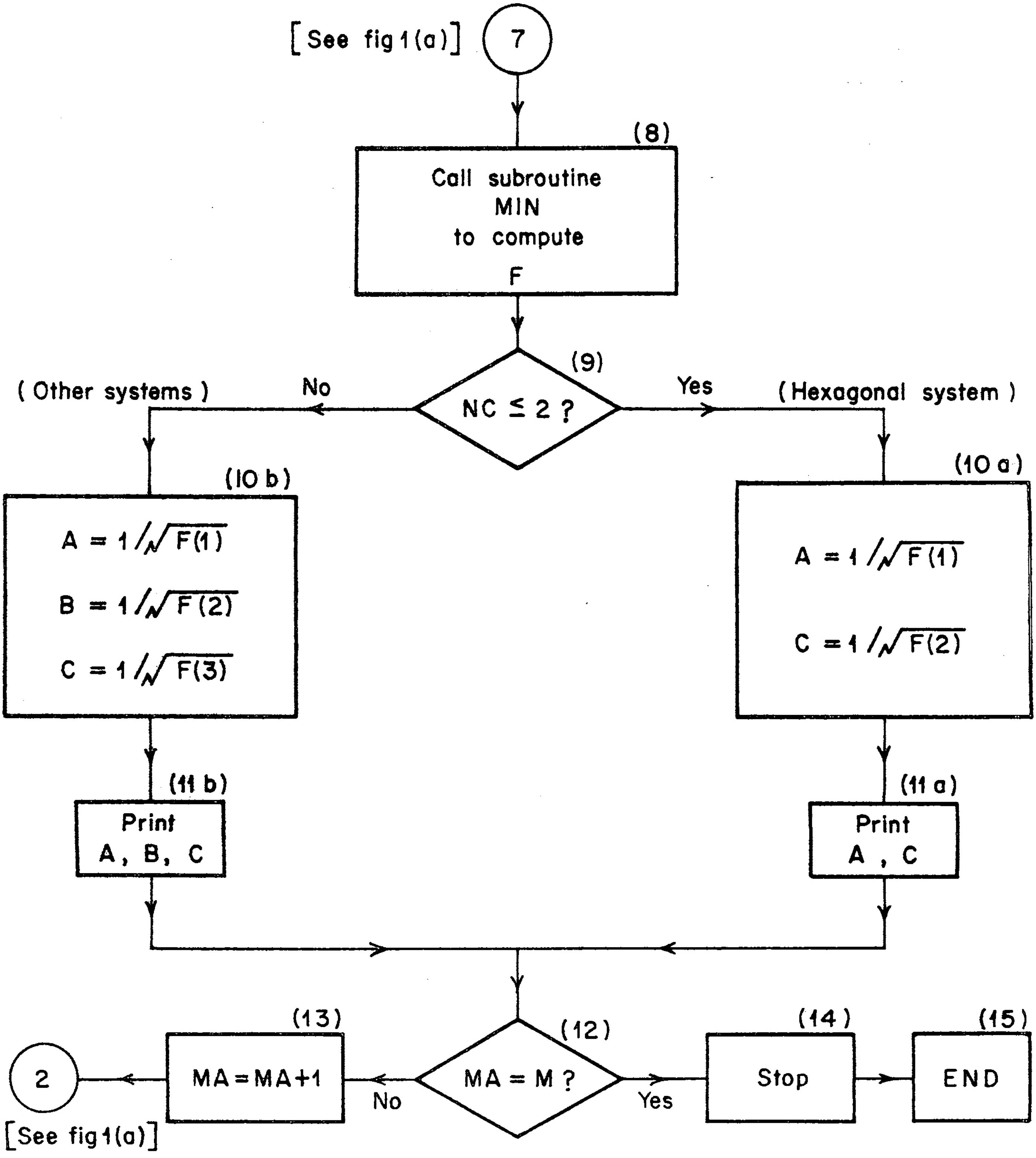
[See fig 1(a)]
7
(8)
Call subroutine MIN to compute F
(9)
NC ≤ 2 ?
No
Yes
(Other systems)
(Hexagonal system)
(10 b)
A = 1/√F(1)
B = 1/√F(2)
C = 1/√F(3)
(10 a)
A = 1/√F(1)
C = 1/√F(2)
(11 b)
Print A, B, C
(11 a)
Print A , C
(12)
MA = M ?
No
Yes
(13)
MA=MA+1
2
[See fig 1(a)]
(14)
Stop
(15)
END

Fig. 1 (b)

Appendix I

```
C     PROGRAM FOR COMPUTING LATTICE CONSTANTS OF CRYSTALS
C     IN CUBIC, TETRAGONAL, ORTHORHOMBIC,
C     OR HEXAGONAL SYSTEM
C
C     INPUT DATA
C                   MILLER INDICES AND D-SPACING (THESE ARE STORED
C                          COLUMNWISE IN DATA)
C                   NC = NUMBER OF UNKNOWN PARAMETERS ( NC = 2
C                          FOR HEXAGONAL SYSTEM, NC = 3 FOR OTHER
C                          SYSTEMS )
C                   M  = NUMBER OF SETS OF DATA
C                   N  = NUMBER OF ROWS IN DATA
C
C
      DIMENSION DATA(50,4), E(3,3), F(3), G(3)
C
C
      READ(2,1) M
    1 FORMAT ( I2 )
C
C
  100 READ(2,2) N, NC
    2 FORMAT ( I2, 5X, I1 )
C
C     READ IN DATA
C
      DO 3 I = 1,N
      READ(2,4) ( DATA(I,J) , J = 1,4 )
    4 FORMAT ( 3(F5.1), F10.5 )
    3 CONTINUE
C
C     PRINT DATA, N, AND NC
C
      WRITE(5,5) N, NC
    5 FORMAT ( 1H1, 20X, 'N =', I2, 5X, 'NC =', I1,// )
C
C
      WRITE(5,6)
    6 FORMAT ( 20X, 'H', 10X, 'K', 10X, 'L', 10X,'D', //)
C
C
      DO 7 I = 1,N
      WRITE(5,8) ( DATA(I,J), J = 1,4 )
    8 FORMAT ( 17X, F5.1,2(6X, F5.1), 6X, F10.5, //)
    7 CONTINUE
C
C     TEST WHETHER THE SYSTEM IS HEXGONAL
C
      IF ( NC - 2 ) 10, 10, 20
```

```
C
C      NC = 2    HEXAGONAL SYSTEM
C
   10 DO 11 I = 1,N
      DATA(I,1) = 4.* ( DATA(I,1)**2 + DATA(I,1)*DATA(I,2)
     1+ DATA(I,2)**2 ) / 3.
      DATA(I,2) = DATA(I,3) * DATA(I,3)
      DATA(I,4) = 1. / ( DATA(I,4) * DATA(I,4) )
   11 CONTINUE
C
      GO TO 50
C
C      NC = 3    OTHER SYSTEMS
C
   20 DO 21 I = 1,N
      DATA(I,4) = 1. / ( DATA(I,4) * DATA(I,4) )
      DO 22 J = 1,NC
      DATA(I,J) = DATA(I,J) * DATA(I,J)
   22 CONTINUE
   21 CONTINUE
C
      GO TO 50
C
C     FORM MATRICES E AND G
C
   50 DO 30 J = 1,NC
      JA = J
   31 SUM = 0.0
      DO 32 I = 1,N
      SUM = SUM + DATA(I,JA) * DATA(I,J)
   32 CONTINUE
      E(JA,J) = SUM
      E(J,JA) = E(JA,J)
      JA = JA + 1
      IF ( JA - NC`) 31, 31, 33
   33 JA = JA - JA
   30 CONTINUE
C
C
      DO 35 J = 1,NC
      SUM = 0.0
      DO 36 I = 1,N
      SUM = SUM + DATA(I,J) * DATA(I,4)
   36 CONTINUE
      G(J) = SUM
   35 CONTINUE
C
C     CALCULATE LATTICE CONSTANTS
C
      CALL MIN( E, G, NC, 1.0E-08)
C
```

```
C     TEST WHETHER THE SYSTEM IS HEXAGONAL
C
      IF( NC - 2 ) 40, 40, 60
C
C     NC = 2    HEXAGONAL SYSTEM
C
   40 F(1) = SQRT( G(1) )
      F(2) = SQRT( G(2) )
      A = 1. / F(1)
      C = 1. / F(2)
C
C     PRINT LATTICE CONSTANTS A AND C
C
      WRITE(5,41)
   41 FORMAT ( 20X, 'LATTICE CONSTANTS FOR HEXAGONAL SYSTEM',//
     1)
     WRITE(5,42) A, C
   42 FORMAT ( 20X, 'A =',F8.4, 5X, 'C =', F8.4 )
C
      GO TO 70
C
C
C     NC = 3     OTHER SYSTEMS
C
C
   60 F(1) = SQRT( G(1) )
      F(2) = SQRT( G(2) )
      F(3) = SQRT( G(3) )
      A = 1. / F(1)
      B = 1. / F(2)
      C = 1. / F(3)
C
C     PRINT LATTICE CONSTANTS A, B, AND C
C
      WRITE(5, 61)
   61 FORMAT ( 20X, 'LATTICE CONSTANTS FOR', /,
     125X, 'CUBIC SYSTEM IF A = B = C',/,
     225X, 'TETRAGONAL SYSTEM IF A = B',/,
     325X, 'ORTHORHOMBIC SYSTEM IF A,B,AND C ARE DIFFERENT'
     4,// )
C
      WRITE(5,62)A,B,C
   62 FORMAT ( 20X,'A =',F8.4, 5X, 'B =',F8.4, 5X, 'C =',
     1F8.4 )
C
C     TEST TO SEE IF THERE IS ANY MORE DATA
C
   70 IF( MA - M ) 80, 90, 90
   80 MA = MA + 1
      GO TO 100
   90 END
```

```
C     SUBROUTINE FOR SOLUTION OF NORMAL EQUATIONS
C
      SUBROUTINE MIN(EA, GA, NCA, ZERO)
C
      DIMENSION EA(3,3), GA(3)
C
      DO 200 LA = 1,NCA
      DIV = EA(LA,LA)
      IF ( ABS(DIV) - ZERO ) 299, 299, 201
C
  201 DO 210 LB = 1,NCA
      EA(LA,LB) = EA(LA,LB) / DIV
  210 CONTINUE
C
C
      GA(LA) = GA(LA) / DIV
C
      DO 212 LB = 1,NCA
      IF ( LA - LB ) 202, 212, 202
C
  202 RATIO = EA(LB,LA)
C
      DO 213 LC = 1,NCA
      EA(LB,LC) = EA(LB,LC) - RATIO * EA(LA,LC)
  213 CONTINUE
C
      GA(LB) = GA(LB) - RATIO * GA(LA)
C
  212 CONTINUE
  200 CONTINUE
      RETURN
  299 CALL EXIT
      END
```

MEETINGS OF THE SOCIETY

D.A. Brown: Distribution of vertebrates and plate tectonics

Prof. D.A. Brown, head of the Geology Department, School of General Studies, Australian National University and also external examiner of the Department of Geology, University of Malaya gave the talk to the Society and Department of Geology, University of Malaya at 5 p.m. on 5 February 1976. About 60 people attended the talk. Below is an abstract of the talk written by Prof. Brown.

Abstract

Many reliable palaeomagnetic data have been obtained from the arid and subtropical redbed sequences that were deposited during the time span from the Late Carboniferous to the Triassic, that is, across the Palaeozoic-Mesozoic boundary. This time was also the heyday of the great labyrinthodont Amphibia and the rapidly developing Reptilia, represented at the present day by a few, mostly aberrant and terrestrial, but totally ectothermic groups, frogs, lizards, snakes, etc. Examination of the distribution of their fossil representatives (genera) indicates very clearly that it does not fit the distribution pattern of modern types in terms of present-day latitudes. If the distribution of the fossils is, however, plotted against palaeolatitudes, determined completely independently on the basis of palaeomagnetic measurements, the pattern, especially in the case of the late Palaeozoic Amphibia, takes on the appearance of a 'bell-shaped' clustering around the palaeotropics, and in every case examined, Triassic Amphibia, late Palaeozoic Reptilia, and Triassic Reptilia, there is a substantially better correlation with the palaeolatitude pattern than with that of the modern latitude network. It is suggested that the marked skewness in the reptile histograms reflecting the enormous abundance and diversity of the Beaufort (Upper Palaeozoic-Lower Triassic) faunas of South Africa and the West Uralian faunas of the U.S.S.R., may be the result of (a) previously undetected synonymies resulting from multiplication of generic names for individual growth stages, and (b) the early development of endothermic reptiles (Synapsida-Therapsida), as pointed out by Brink (1963), which gave them some independence from latitude control. Removal of the statistics for these possibly endothermic reptiles results in a substantial improvement - the correlation between the palaeontological and palaeomagnetic data.

In summary, there is strong evidence from this correlation between these two independent lines of approach, that the late Palaeozoic-Triassic vertebrate faunas were largely latitude-dependent and the results lend support to the theory of continental displacement, be it through plate tectonics, ocean-floor spreading, or global expansion.

G.S. Gibbons: The discovery of nickel in Western Australia

Dr Gibbons, Head of the Dept of Geology, New South Wales Institute of Technology, Australia and at present a Research Associate in the University of Malaya delivered the talk to about 20 members in the Lecture Hall, Dept of Geology, University of Malaya on 13 February 1976 at 5 p.m.

In this talk Dr Gibbons gave an account on the discovery of nickel in Western Australia and the exploration problems encountered. Some excellent slides of the geology of the area were also shown e.g. the occurrence of pillows of ultramafic flows. It was an informative and enjoyable talk.

C. Halls: Mineral deposits of the Grong Greenstone Belt, Central Norway

Dr C. Halls from Imperial College, London gave this talk to the Society in the University of Malaya on 24 February 1976 at 5 p.m. Unfortunately not many members turned up for this very interesting talk. In this talk, which was very well illustrated, Dr Halls gave a very detailed account of the structural history, metamorphism and metallogeny of the belt. An abstract of this talk will be published as soon as available from Dr Halls.

C. Halls: Subvolcanic tin deposits of Bolivia

This talk was given on 25 February 1976 at 5 p.m. in the same place mentioned above. Again not many members turned up for this excellent talk. In this talk Dr Halls spoke on the style and place of tin mineralization and the geothermometry of tin minerals. After the talk there was an interesting and lively discussion in spite of the poor attendance. An abstract of this talk for the Warta Geologi is also promised by Dr Halls.

NEWS OF THE SOCIETY

Resignation of the Hon. Secretary

Mr D. Krishnan has resigned as the Hon. Secretary on 9 January 1976. He has taken up an appointment with Exploration Logging Int. Inc. in Singapore and so will not be able to carry out the duties of the Hon. Secretary effectively. The Council thanked him for his services and directed Mr A.S. Gan, the Asst. Secretary to take over the duties of the Hon. Secretary till the next Council assumes office.

Resignation and cooption of Treasurer

Our efficient and diligent Treasurer, Mr G.H. Teh has resigned from the post on 9 January 1976. He has gone to Heidelberg University, West Germany to study for a doctorate degree. The Council greatly appreciates the services of Mr Teh and wishes him success in his studies.

Mr N.H. Chong, a councillor, was coopted to be the new Treasurer. Mr Chong is a geologist with Associated Mines.

Second printing of the "Geology of the Malay Peninsula"

John Wiley & Sons Inc., the printers of the Society's publication "Geology of the Malay Peninsula" are planning to do another printing of the book. The book appears to be selling quite well.

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News Addresses

D.I. Holliss
Calle de Goya 38 39
Madrid I
Spain

R.P.B. Pitt
c/o UNOCAL Corp.
23 rd Floor, Shaw Centre
Scotts Road
Singapore 9

J.C. Pearson
c/o UNOCAL Corp.
23rd Floor, Shaw Centre
Scotts Road, Singapore 9

M. Veerappan
Laboratory Division
Conzinc Riotinto (M) Sdn. Bhd.
P.O. Box 202
Dengkil, Selangor

OTHER NEWS

Formation of Editeast

Editeast is a new association, formed at a meeting of scientific editors in Bandung on 5 November, 1975. Its purpose is, to quote its statutes:

> 'To promote improved communication in science by cooperation of editors of serial publications, including primary journals, monograph and memoir series, review series, abstracting and indexing services dealing with primary publications, serial micro-reproductions of such matter, and similar media specialized in the periodic dissemination of knowledge in science. The Association shall also help improve the training and education of scientific editors in the region and encourage cooperation in raising the standard of editing and publishing scientific publications among the countries of the region. The Association shall be organized and operated exclusively for scientific and educational purposes and not for profit'.

Geogrpahically, Editeast covers the countries bordering the western Pacific, broadened for the time being to include India (it is hoped that India will soon show enough interest to form an association of its own).

At the inaugural meeting, the first officers of Editeast were elected. They are:

President	:	K.A. Townley, Australia
Vice-President	:	D. Santokh Singh, Malaysia
Secretary	:	B. Abbas, Indonesia
Treasurer	:	A.M. Dalisay, Philippines

This skeleton Council has fixed subscriptions for 1976 at $A2.50 ($NZ2.50) or its equivalent in other currencies. At this low figure it is hoped that membership will be within reach of all who wish to join, whatever the relative financial state of their country. For the moment there is no question of proposal and election to membership: all editors, ex-editors, would-be editors, and managing editors who wish to join are welcome. You may send subscriptions either direct to Dr A.M. Dalisay, National Research Council, 149 Erwin Garcia, Cubau, Quegon City, Philippines; or Dr K.A. Townley, P.O. Box 63, O'Connor, A.C.T., Australia 2601.

Institutional membership, incidentally is $A5.00.

Publications of interest

1. Seapex Proceedings, Vol. II, 1975
2. Proceedings of the Conference on the Geology of Thailand held in December 1973 at Chiangmai, Thailand

Vol. I	50 baht
Vol. 2	25 baht
Vol. 1 & 2 together	70 baht

Prices indicated include inland postage only.

Money order or postal check should be made under the name of Mr Charn Tantisukrit payable at Chiangmai Post Office.

The publications gives comprehensive information on the geology and mineral resources of Thailand in summarized form according to Dr H. Sawata who told us about the publication.

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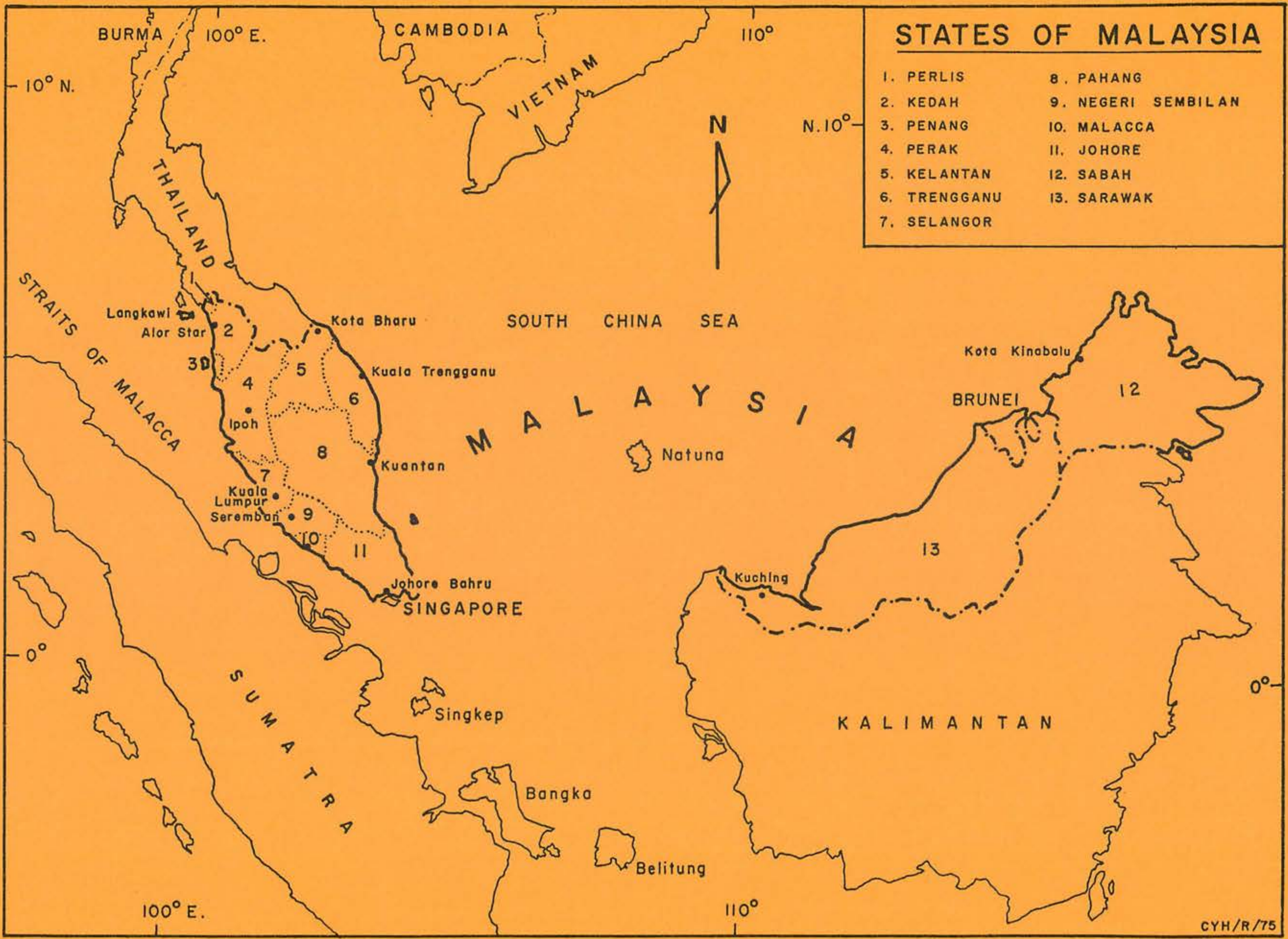

STATES OF MALAYSIA