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GEOLOGIC NOTES

Bipyramidal {111} Cassiterite and cassiterite with a similar habit from West Malaysia

K.F.G. Hosking, Jabatan Geologi, Universiti Malaya

Recently, when the writer was examining a sample of detrital tin ore, which had been collected by Mr J. Bignell from a placer mine at Semiling, Kedah Peak area (Kedah), he found two small, but perfect crystals of bipyramidal {111} cassiterite (Fig. 1). Further examination revealed a few more broken crystals displaying the same habit.

On the following day, whilst examining heavy mineral concentrates, the product of Banka drilling in the Bakri area (Johore),the writer and Mr E.B. Yeap noted the presence of a number of small cassiterite crystals, each consisting of the first order {111} pyramidal slightly modified by the second order prism {100} (Fig. 2). Cassiterite crystals of these habits have not hitherto been described from West Malaysia.

The Kedah Peak and Bakri areas are unlike other mineralised areas in West Malaysia in that, in each, numerous granitic pegmatites occur, and placers there are notable for their unusual suites of minerals - unusual, that is, as far as Malaysia is concerned. Thus, Bradford (1961, p. 284) notes that in the placers of Kedah Peak one finds, in addition to cassiterite and tantalite, "tourmaline, zircon, garnet, gahnite, monazite, cheralite, magnetite, heamatite and traces of sillimanite". Bradford also records (1961) that in the Bakri area the placers contain - in addition to cassiterite - tourmaline, ilmenite, monazite, zircon, garnet, gahnite, tanteuxenite, arizonite, and traces of molybdenite. The placers of both these areas, unlike those elsewhere in Malaya, have yielded economically important concentrations of tantalite.

The cassiterite of the Kedah area under review has been examined in considerable detail by Singh and Bean (1967), although they did not record that it possessed, at least on occasion, a bipyramidal habit. Amongst other things, they demonstrated that this paramagnetic cassiterite contains a number of different types of tantalite and/or tapiolite exsolution bodies and that the cassiterite exercised crystallographic control over the blade - and rod-like forms.

Thin sections of this cassiterite, which have been examined by the writer recently, are remarkable in that all the grains display an intense blood-red to pale greenish-yellow pleochroism, which cannot be matched in intensity by those numerous other tantaliferous cassiterites from the hydrothermal deposits to the west of the Main

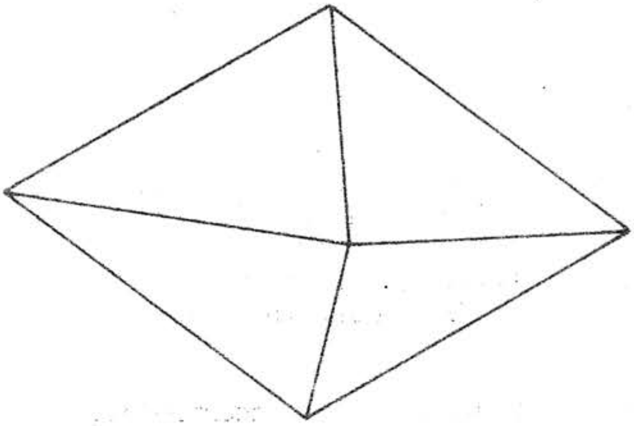

Fig. 1

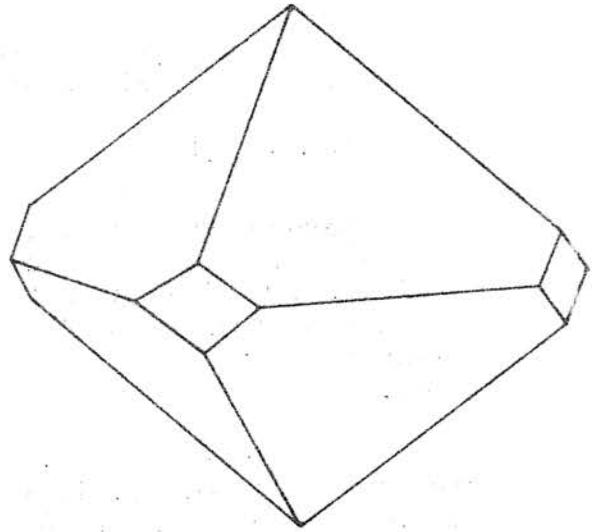

Fig. 2

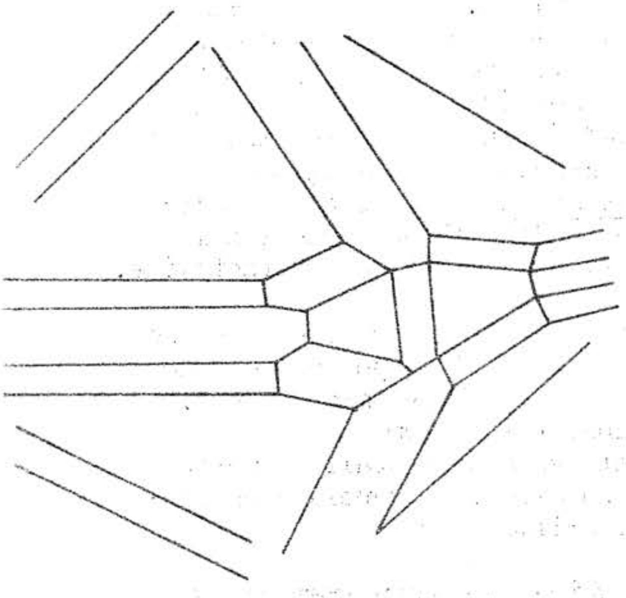

Fig. 3

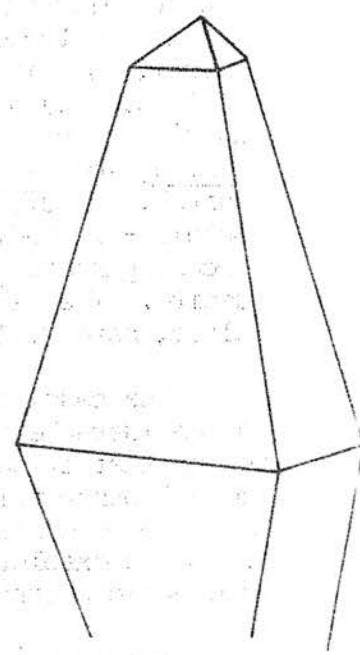

Fig. 4

Range that the writer has examined, except, perhaps, those from the Pantai Remis Mine, North Dindings. In addition, when the sections were examined in transmitted light by a X10 hand lens, one grain proved to contain most unusual pale-pink and pale-mauve patches. It might also be added that under the microscope many of these grains were seen to be strongly colour zoned, and some of them were fragments of geniculate twins. As yet the Johore cassiterite has not been examined in detail by the writer.

These discoveries of bipyramidal cassiterite in West Malaysia prompt the writer to make the following observations:

(i) Bipyramidal and slightly modified bipyramidal cassiterite is usually found in pegmatites, and in placers derived from them, in tantaliferous provinces. It occurs, for example, in the pegmatites of Wodgina (Australia); Bikita (Southern Rhodesia); Kamativi (Southern Rhodesia); the Congo; and Stoneham and Greenwood (Maine, U.S.A.).

(ii) In such pegmatites it may be associated with cassiterite of other habits. However, the associated cassiterites usually possess stumpy pyramids with squat bipyramidal terminations, as is the case, for example, at Kamativi (Fick, 1960).

(iii) Kostov (1968, p. 107) records that Varlamoff (1949) mentioned that in the Kaluna tin deposit of the Congo "bipyramidal crystals - are found in the deeper levels within a granitic intrusion, short prismatic crystals ---, as a rule more modified and often twinned, at intermediate levels, whereas at higher levels and away from the intrusion the crystals tend to be prismatic". Kostov continues, "the trend of crystallisation can be interpreted in terms of falling temperature and rising supersaturations. Finally, impurities (Fe, Nb, Ta) can also play a role in shortening the habit of the higher temperature types".

(iv) Bipyramidal {111} crystals, only slightly modified, occur in deposits other than pegmatites and in provinces other than tantaliferous ones. Thus, in one of a number of veins consisting of sericite and muscovite, with very minor quartz, that occurs in schists at Rutonde (Republic of Ruanda), a crystal of cassiterite, with {111} faces well developed and the {101} faces slightly developed, and weighing c. 50 kg, was discovered (Slatkine, 1965). It might be added that these veins are in a tantaliferous province.

Collins (1882) described cassiterite from the Peele Mine, Cornwall, in which the {111} faces overshadow all the others (fig. 3). This cassiterite occurs in a hydrothermal vein in non-calcareous hornfels, in a province that is certainly tantalum/niobium deficient, and in an area in which there are scores of other stanniferous veins, occurring in virtually the same geological environment, which lack cassiterite of a similar habit.

(v) Cassiterite, of acute bipyramidal habit, was also described by Collins (1882) from Cornish hydrothermal veins (fig. 4), and the writer has found such crystals, up to c. 25 mm in length, in a hydrothermal lode of the South Crofty Mine, Cornwall. There it was the latest of the cassiterites to have been deposited.

Cassiterite of this general habit has been observed by the writer and others in the scapolite-rich vein of Sungei Lah Mine, Perak, and by the writer in the ore of Klappa Kampit Mine, Billiton. (Unpublished studies).

<u>Conclusion.</u> To conclude, bipyramidal {111} and essentially bipyramidal cassiterite is most commonly found in pegmatites in tantaliferous provinces. However, it may occur in hydrothermal veins both in tantaliferous and tantalum-deficient provinces. Its occurrence in the latter environment cannot be explained. The suggestion made by Kostov, and noted above, that iron might play a role in the development of bipyramidal cassiterite, and cassiterite of closely allied habit, is surely not the reason for the Cornish example noted above, as there was an ample supply of iron during the deposition of most of the Cornish cassiterite, yet, with the exception noted above, the tin species apparently did not develop the habit in question. If iron could cause the development of such a habit it is surprising that some of the cassiterite, at least, in the feldspathic veins of Pelepah Kanan (Johore), which were part emplaced in magnetite, did not adopt it. Perhaps, after all, temperature is the most important controlling factor. Finally, it is quite unknown what caused some of the late-deposited Cornish cassiterite to adopt an acute bipyramidal habit.

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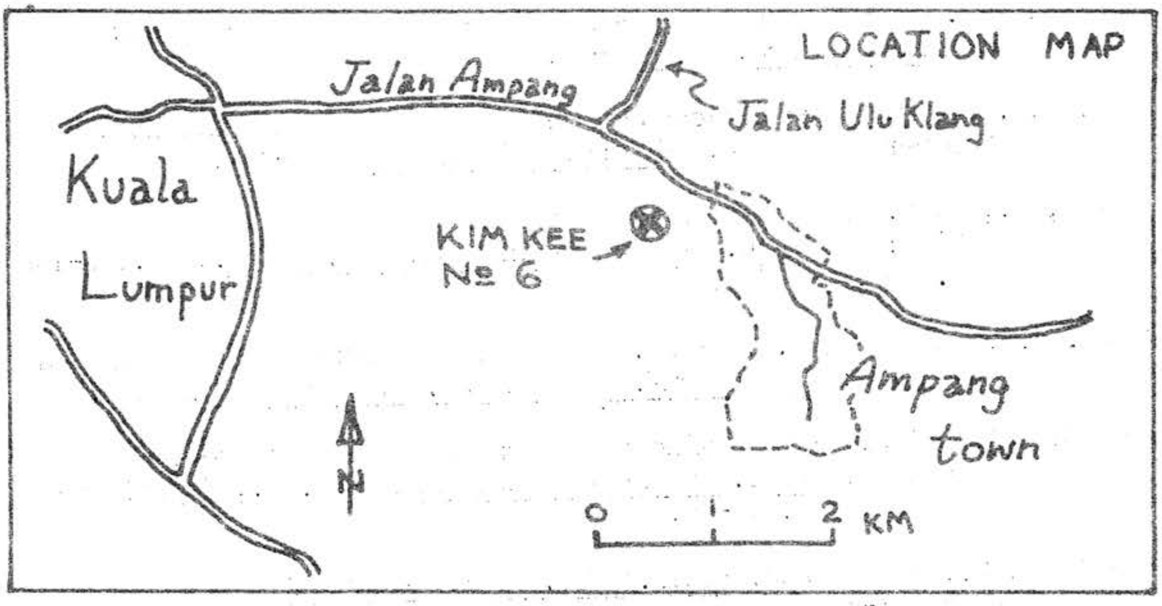
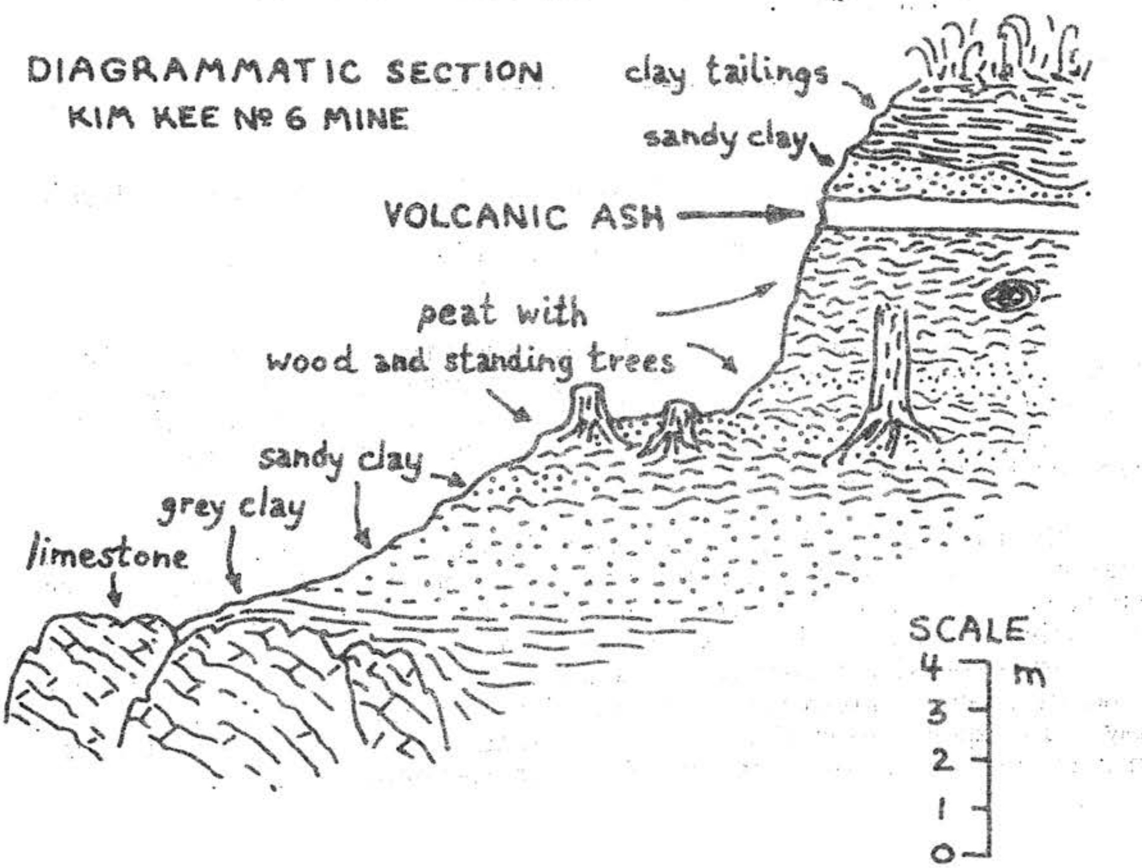
Quaternary Volcanic Ash at Ampang, Kuala Lumpur, West Malaysia

P.H. Stauffer, Jabatan Geologi, Universiti Malaya

Quaternary volcanic ash in Malaya was first reported by Scrivenor (1930) and has been recorded from several sites in Perak and western Pahang (see Stauffer, 1970, and in press). The purpose of this note is to report the finding of similar ash in stratigraphic context in a tin mine at Kuala Lumpur, Selangor.

The mine in which the ash occurs is the Kim Kee No. 6, about 1 lm west of Ampang town (grid reference 567813 on the 1970 edition of the 1:63,360 topographic map of the Kuala Lumpur area - sheet 94). The approximate location is shown on the sketch map. This is an area which has been extensively mined, and hence it is something of a surprise to find an almost completely intact section of virgin deposits. The ash layer is exposed near the top of this sequence, not far below the present ground surface outside the mine (see diagrammatic section).


LOCATION MAP
Jalan Ampang
Jalan Ulu Klang
Kuala Lumpur
KIM KEE
No 6
Ampang town
N
0
1
2 KM


DIAGRAMMATIC SECTION
KIM KEE No 6 MINE
clay tailings
sandy clay
VOLCANIC ASH
peat with
wood and standing trees
sandy clay
grey clay
limestone
SCALE
4
m
3
2
1
0

The ash occurs as a distinct and visible layer about 4.5 m thick, with a sharp and regular base and a more irregular top surface. Its exposures extend through a lateral distance of about 120 m with essentially no change in its thickness and only about 1 m variation in elevation, as determined by Abney level. More careful levelling to a benchmark on Ampang gives the elevation of the base of the ash at about 41 m (135 feet) above sea level.

The ash appears to be a pure pyroclastic deposit, consisting of small pumice fragments and glass shards, with some crystal fragments including quartz and feldspar. The material is mostly in the fine sand to silt size-range. Although the ash directly overlies very dark peat, it is itself very light in colour and mostly free of organic material. However, in some places, especially in the upper part, there is local mixing with peaty clay, possibly by burrowing organisms or growth of plant roots. No internal lamination or structures suggestive of water transport were seen.

The peat below the ash is 4-6 m thick and includes numerous trunks of trees in vertical growth position. The sharp base of the ash against this peat suggests, as noted by N.S. Haile (personal communication), that deposition was in a quiet water lake rather than a vegetated swamp. Below the peat and also interstratified with it are deposits of grey to brown clay and sandy clay of the sorts characteristic of the Old Alluvium (Sivam, 1969). In the bottom of the mine pit are weathered pinnacles of bedrock limestone. Above the ash in most places is a layer, less than 1 m thick, of brownish, slightly peaty sandy clay, also probably ascribable to the Old Alluvium. Above this along an irregular erosional contact, lie thin deposits of clay tailings from earlier mining activities.

It seems highly probable that this ash is the same deposit as that reported from elsewhere in Malaya. Its discovery as a layer in an alluvial section offers hope of determining its age by C-14 analyses of wood from above and below, and also suggests that it might make a useful stratigraphic marker and should be looked for elsewhere in mines in Selangor and west coast areas. The thickness of what appears to be an air-fall deposit (0.45 m) reinforces the belief that the event producing this ash in Malaya must have been a truly spectacular and catastrophic eruption in Sumatra.

This preliminary study, including the levelling work, was done with the able assistance of M. Tharmarajan, S.P. Sivam, T.E. Yancey, and F.O. Shoup. N.H. Bostick is thanked for inducing me to visit the mine. Studies of the ash are continuing.

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A Fossil "Portuguese Man-of-War" (Velellidae) from the Paleozoic of the Raub area, Pahang, West Malaysia

B.K. Tan & S.P. Sivam, Department of Geology, University of Malaya

The primary purpose of this paper is to report on a new fossil locality near Raub, Pahang. These fossils, on comparison with known similar fossils, appear to be specimens of Plectodiscus, a kind of jellyfish. This locality (see fig. 1, location A), was discovered by the authors in March 1971 during a student field excursion organised by the Geology Department, University of Malaya. The fossils found appear to be of a type which has not been described before in Malaysia, and may possibly be a new species of Plectodiscus.

Plectodiscus is a genus of fossil siphonophores referred to the family Velellidae. The siphonophorids are relatively fragile, polymorphic hydrozoan colonies which are adapted for existence at or near the surface of the seas. A modern day example is provided by the Portuguese man-of-war, also popularly known as "by-the-wind-sailor" or "blue bottle".

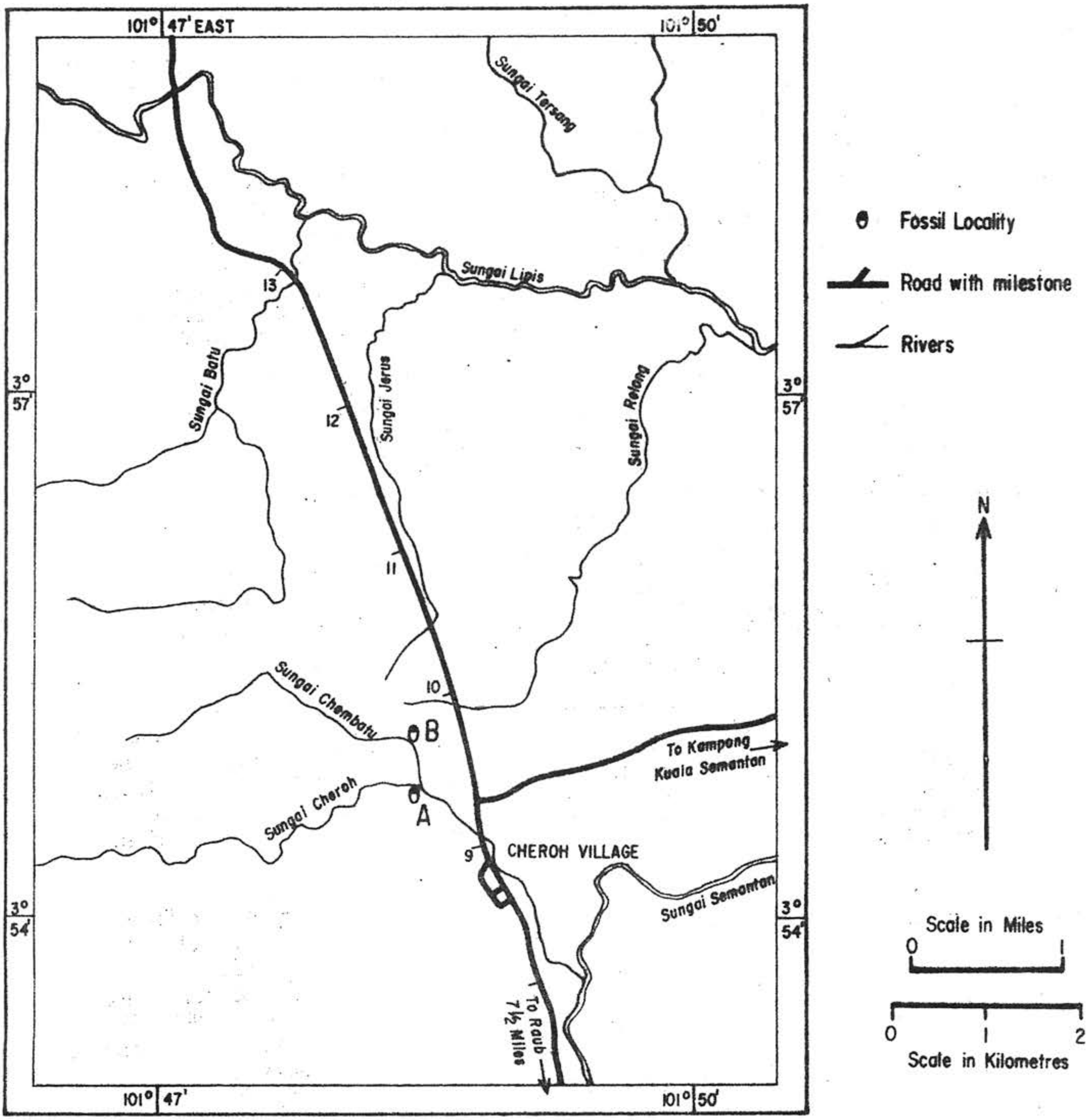

Fig I. Map Showing Fossil Localities

These new fossils are found in metasediments along Sungai Cheroh (Cheroh River) which have been mapped by Richardson (1939, 1947) and Alexander (1968) as being part of the "Raub Group", believed to be of either Permian or Late Carboniferous age. This locality is approximately 500 metres south of another known fossil locality along Sungai Chembatu (see Fig. 1, location B), where brachicpods (spiriferids and productids) and bivalves (Pernopecten?) occur in carbonaceous metasediments. These brachiopods and bivalves were found in 1965 by the Year III geology class of the University of Malaya but have yet to be described. Preliminary examination of these specimens suggests a probability of a Carboniferous age (T.E. Yancey personal communication). Field evidence favour the same age for both fossil assemblages, as the rocks in which they occur appear to be part of a conformable sequence.

The new specimens found in the "Raub Group" occur as moulds and casts which are characterized by their concentrically corrugated appearance due to shallow concentric grooves spaced approximately 1 mm apart. The outer grooves of the largest specimen found have a diameter of approximately 30 mm. On closer examination, the grooves are seen to have a bilateral symmetry about a slight depression running throughout the length of the fossil. A central conical depression approximately one quarter of the entire disc size may also be observed in some of the better preserved specimens. A drawing from a photograph of one of the specimens is shown in figure 2. Figure 3 shows the reconstruction by Chamberlain (1971) of Plectodiscus circus n. sp. a species believed to have many similarities with the new fossils found. The sail is not preserved in any of the specimens found. The non-preservation of the "sail" appears to be common in most specimens of velellids known (e.g. Chamberlain, 1971). If the sail is preserved at all, it should be encased in the overlying rocks above the imprint or flattened against the disc.

The Paleozoic existence of the "Portuguese-men-of-war" or "by-the-wind sailor" (Velillidae) was first established by Caster (1942) from the Devonian of New York and Ordovician of Ohio. Fossils of these soft bodied siphonosphores are rather rare. Fossil siphonosphores are found only as imprints, as might be expected from the general absence of any hard parts. The fossils found in the Raub area are in unweathered, metamorphosed sedimentary rocks, and appear better preserved than previously described specimens of siphonosphores, judging from the published photographs.

Further research by the authors and Dr T.E. Yancey is in progress. It is hoped to establish the geochronology of the rocks containing the

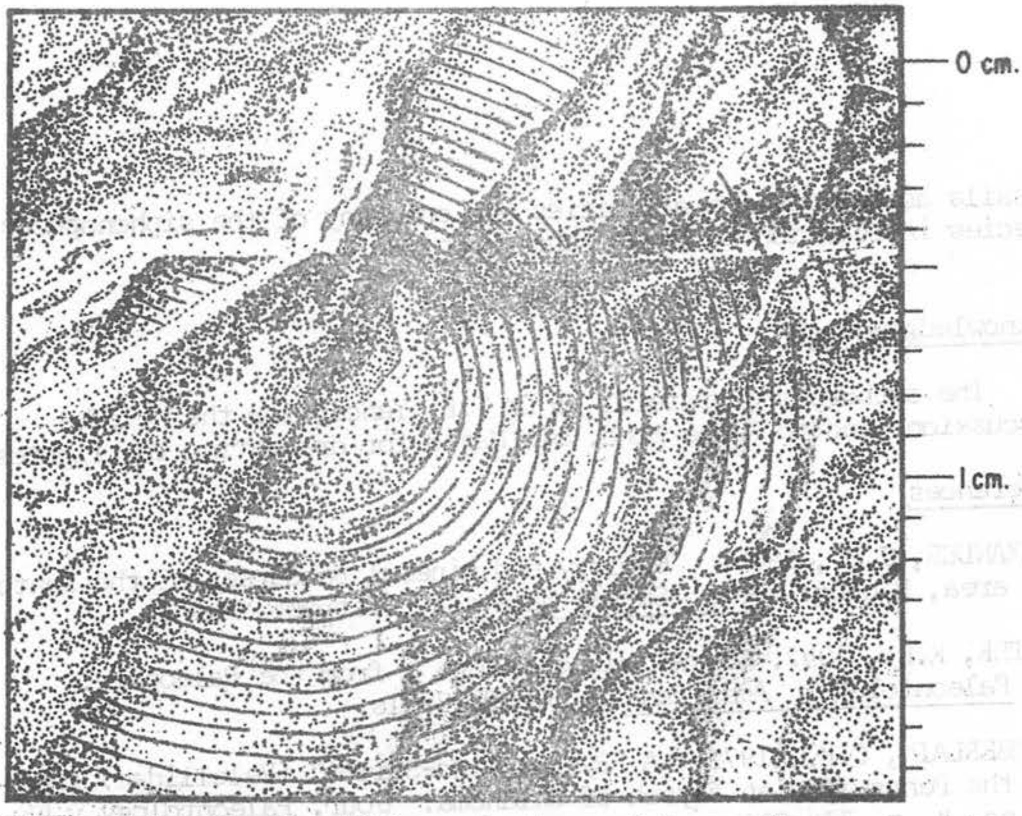

Fig. 2 Drawing from photograph of one of the specimens of *Plectodiscus* from Sungai Cheroh

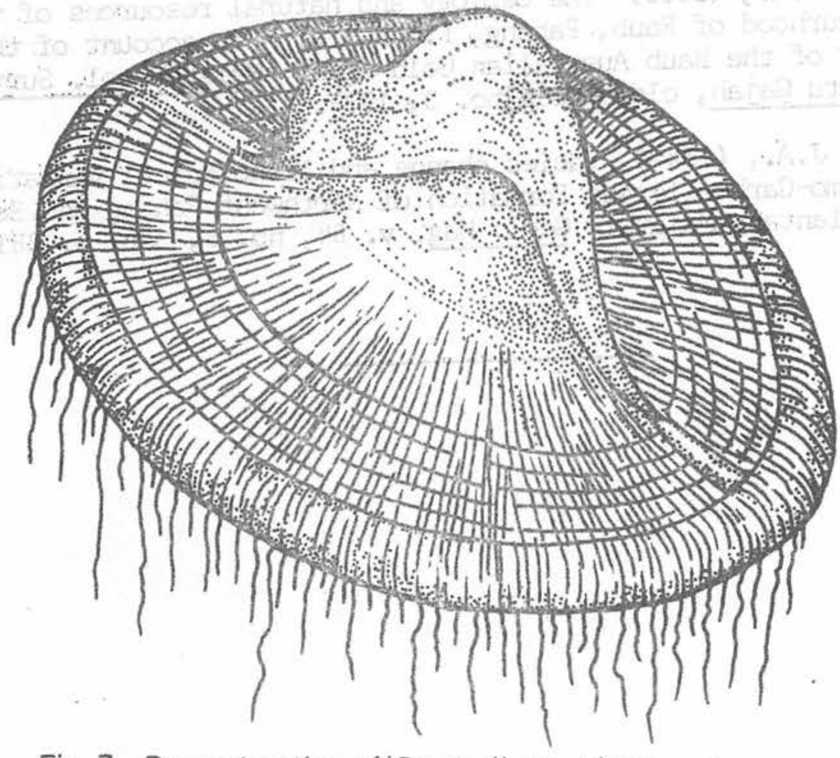

Fig 3 Reconstruction of *Plectodiscus circus n.sp*
(after Chamberlain 1971)

fossils as well as the affinities and ontogeny of the siphonophore species in relation to modern chondrophores.

Acknowledgements

The authors are grateful to Dr T.E. Yancey for the helpful discussions and to Enche Mohd. bin Majid for draughting the figures.

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NEWS FROM THE UNIVERSITIES

University of Malaya

The Department of Geology has increased its academic staff considerably during the year, being successful in recruiting new staff to fill long-standing vacancies. Those recruited during the year include:

Enche Nik Mohamed B Sc (Hons) New England, appointed Temporary Assistant Lecturer from May 1971. After graduating from the University of New England, Armidale, Australia, where he did research on applied gravimetry, he has been working as tutor in the Department of Geology. His field of research is a geophysical study of Quaternary sediments of the Continental Shelf off Malaysia. He is working on the Geology Subcommittee of the Faculty Committee on scientific terminology in Bahasa Malaysia.

Enche Yeap Ee Beng B Sc (Hons. First Class) (Malaya), appointed Temporary Assistant Lecturer from May 1971. After graduating from the University of Malaya with first-class honours, he joined the Geophysical Services International, Singapore, as a Geophysical engineer. He returned to the University of Malaya and joined the Geology Department as a tutor in May 1970. At present he is doing research on the Primary Mineralisation of the Kuala Lumpur Tin Field.

Dr K.R. Chakraborty, MSc, PhD, appointed Lecturer in June 1971. After completing his doctorate in 1966, he taught for a year in I.I.T. Kharagpur, India. He then went to Canada on a Postdoctoral fellowship and subsequently joined the Geology Department of Lakeheat University, Ontario, Canada, as an Assistant Professor. His primary research interests are thermodynamics of metamorphic processes and phase equilibria.

Dr S.S. Sarkar, MSc (Calcutta, 1946), State Doctorate of France (Dr es - Science, 1954) in Geology, has joined from the Geological Survey of India, where he had been a Senior Geologist. Dr Sarkar has served Geological Survey of India for 18 years as a geologist and the University Rangoon, Burma, as a Senior Lecturer in Geology from 1947 to 1951. His main research interest has been in uncoiled forms of fossil mollusca especially Cretaceous Ammonites. He has also done work on paleobotany and micropaleontology.

Dr T.E. Yancey, M A, PhD, was appointed Lecturer in November 1971. His training was at the Universities of Syracuse, New York, and at Berkeley, California, where he was awarded B.A. to M.A. degrees in geology, and a Ph.D. degree in Paleontology. His research interests include modern marine sediments and paleoenvironment studies, particularly of Permian sedimentary rocks.

Dr E.V. Gangadharam, BSc, MSc, joined as a Lecturer on 30 October 1971. After graduating with B.Sc. (Honours) in Geology and M.Sc. in Nuclear Geology from Andhra University, Waltair, India, he worked on several research projects covering heavy minerals in river and beach sands, geochemistry of weathering, and neutron activation and analysis of minor and trace elements in ultramafic rocks and kimberlites. The institutions he attended include Centre of Advanced Study in Geology at Saugar and Bhabha Atomic Research Centre at Bombay. The last two years he was a Research Associate at Cornell University, Ithaca, N.Y. where, as a Co-Investigator on NASA Lunar Samples Analysis Program, he studied a wide range of elements in Apollo 11 and Apollo 12 lunar samples and comparable meteorites.

His fields of interest include geochemistry of terrestrial materials and meteorites applying neutron activation and other techniques.

Fossil exchange requested. The Department is interested in exchange of fossil specimens with other institutions or individuals. Those interested please contact Dr S.S. Sarkar or Dr T.E. Yancey.

Universiti Kebangsaan Malaysia

The Department of Geology, Universiti Kebangsaan Malaysia, hopes to enter its third year of existence with a full complement of eight staff members. Advertisements have been published inviting applications in the following subjects: Igneous and metamorphic petrology, geophysics, geochemistry, sedimentology and geomorphology (assistant to senior lecturers). At present the department has one post-graduate student (working under Dr Kardinal Kusnaeny) and seventy-five first and second year students. In the past year the department has received various kinds of invaluable assistance from the Geological Survey of Malaysia at Ipoh as well as in East Malaysia.

Jabatan Kajibumi, Universiti Kebangsaan Malaysia, telah mempelawa permohonan menjadi penolong pensharah hingga pensharah kanan untuk mengisi lima jawatan kosong, iaitu: petrologi batuan ignias dan jelmaan, fisikabumi, kimiabumi, sedimentologi dan geomorfologi. Kini ada seorang penuntut kursus lanjutan (bekerja dibawah penyeliaan Dr Kardinal Kusnaeny) dan tujuh puluh lima penuntut tahun kedua dan pertama. Pada tahun lepas jabatan ini telah menerima berbagai jenis bantuan berharga dari Jabatan Penyiasatan Kajibumi Malaysia, baik di Ipoh maupun di Malaysia Timur.

NEWS OF THE SOCIETY

Regional Conference

Planning for the Regional Conference on the Geology of South-east Asia (20-25 March 1972) continues. So far about 50 participants have actually registered - and paid fees (!), and an attendance of 100-200 is expected. Forty four titles have been accepted. The Right Hon'ble, the Prime Minister of Malaysia, Tun Abdul Razak, has kindly agreed that he or his deputy will open the Conference.

Anyone who has not yet registered, who wishes to attend should contact the Conference Secretary, Dr B.K. Tan, c/o Department of Geology, University of Malaya.

Meeting of 1 October: K.J. Müller

Conodonts

Professor Klaus J. Müller, Director of the Institute for Paleontology, University of Bonn, Federal Republic of Germany, addressed a meeting of 26 members, with the President, Dr D. Taylor, in the chair, on 1 October 1971, in the Department of Geology, University of Malaya.

Professor Müller began by stating that conodonts are important in stratigraphy as they are the best index fossils in the Paleozoic. No other group has yielded so many and so widespread index fossils, from nearly all units. The conodonts appear in the higher Lower Cambrian and continue until near the top of the Trias. Papers on conodonts have been increasing from one, in 1856, to about 370 published last year.

In spite of the enormous amount of research which has been done on conodonts, it is still not known what type of organism they represent. It is generally agreed that they are isolated elements of an unknown animal group, although it has even been suggested that they are parts of Algae (a suggestion which in Professor Müller's opinion does not merit serious consideration).

Conodonts, which are small (1-2 mm), phosphatic, variously shaped bodies, occur as several types - "bladed", "platform", and "bar". They show strong bilateral symmetry, i.e. occur in forms which can be paired, as mirror images. Some occur as joined forms with bilateral symmetry, which (in rich samples) can be shown to be about half as abundant as paired forms. Conodonts have, in a few rare and scattered areas, been found as a group on bedding planes of shales formed in still water, suggesting that each organism had a number of joined "bar" types, and a pair each of "bladed" and "platform" types.

They can be obtained from the containing rock by washing out of shales, or, more commonly, from limestone by dissolving the carbonate in dilute acetic or formic acid. They are rarely so common as to be visible in the rock or in thin section. From 1 kg of limestone a yield of 15-20 conodonts is considered fairly good. The most favourable limestones are those containing cephalopods; reef limestone and fusulinid limestones are not so favourable. Conodonts can survive a degree of low-grade metamorphism that will destroy all calcareous and siliceous fossils.

For applied purposes (i.e. biostratigraphic zoning) it is not necessary to solve the mystery of the nature of the parent animal. "Platform" type conodonts changed rather rapidly throughout geological time, and so are the most useful. All have been named as genera and species, although they are not complete animals. From cutting thin sections of conodonts (a difficult and delicate task) the internal structure can be studied, and shows that conodonts must have grown embedded in tissue. Thus they cannot be teeth, but probably functioned as supports, as a form of endoskeleton. Discontinuities due to resorption suggest the possibility that they were also used as a method of storing energy.

The bilateral symmetry of the conodont animal indicates that it was an active, free swimming animal, a view supported by its occurrence in various marine facies - limestone, chert, shale, and sandstone. Some species had a world-wide distribution.

Conodonts were well-established in the Cambrian and achieved their first acme in the Ordovician - when they were very abundant and diverse, enabling precise biostratigraphic zones to be defined, especially in the Lower Ordovician. Even the simple conical forms have complex grooves and fluting. In the Upper Ordovician and Lower Silurian rather fewer forms are found, whereas in the Devonian conodonts are again widespread and common. As many as 22 biozones in the Upper Devonian have been defined by conodonts. Although most forms have a wide distribution in space, a few have only been found locally, and some sidelines were facies-bound, such as forms which appear to have been confined to a "near-reef" environment. Conodonts achieved another acme in the Early Carboniferous, but throughout the Late Carboniferous and Permian the conodonts declined, and are not found in post-Triassic strata.

Professor Müller described and illustrated some forms which he obtained from limestone at Gunong Katang, Kinta Valley, where a section a few tens of metres thick yielded a series of conodont faunas ranging from Upper Silurian to Lower Devonian. He considered that conodonts offer good prospects for working out the stratigraphy of the Paleozoic of Malaysia.

Professor Müller referred to a Memoir of the Geological Society of America, published in September 1971, which summarizes current knowledge on conodonts. Professor Müller's talk aroused considerable interest in the audience and it, is to be hoped, may stimulate a further search for conodonts in Malaysian limestones.

Meeting of 17 November 1971: R. Rice

Mineralization in Ireland

The paper by Mr R. Rice, Chief Geologist of Conzinc Riotinto (Riofinez), on "Mineralization in Ireland" was presented by the President, Dr. D. Taylor, at a meeting of 19 members, on 17 November 1971 in the Department of Geology, University of Malaya, Mr Rice being unable to be present.

Prospecting for base metals in Ireland has been intensified since the discovery in 1961 of the Tynagh zinc-copper, lead-silver mine, which is now one of the biggest such mine in Europe, A number of deposits are now known in Ireland. They include:

Tynagh (Pb, Zn, Cu, Ag)
Silvermines (Zn, Pb)
Ballynoe (Barite)
Gortdrum (Cu, Ag, Hg)
Navan (Zn, Pb, being drilled)
Keel (Zn, Cd, Pb, potentially productive)
Ballinalack (Zn, Pb, potentially productive)
Adherlow (Cu, Ag, potentially productive)

The majority of these deposits occur in the lower part of the Lower Carboniferous limestones and clastic rocks, but Ordovician sedimentary rocks and volcanic belts, Caledonian granites, and parts of the Old Red Sandstone, and Dalradian rocks, are being prospected. Geochemical methods have been successful and have led to most of the discoveries. Boulder hunting and outcrop investigation have proved effective in detailed follow-up of geochemically anomalous areas.

Airborne geophysical surveys have not been very successful so far. Induced polarization surveys have contributed to several discoveries. Electromagnetic surveys have been more restricted but effective in a few cases including Tynagh. Resistivity and self-potential methods have been little applied. Magnetic surveys are not directly applicable for these ore deposits, but have been helpful in outlining geological structures. Gravity methods have been used successfully over the Pb-Zn deposits at Navan and the sulphide deposits at Tynagh that cannot be detected with geo-electrical methods.

The economically important deposits found so far are in the Lower Carboniferous (Dinantian). Cross-cutting, stratabound, and stratiform bodies occur in the mine deposit. All the deposits that have been investigated in detail are associated with normal faults of Caledonian trend (060°). Mineralogically the deposits are relatively simple, sphalerite and galena being the main ore minerals with varying amounts of pyrite. Tynagh, Gortdrum and Aherlow contain appreciable quantities of copper minerals. Barite is associated with the lead-zinc deposits and is extracted commercially at Silvermines (Magcobar) and Tynagh.

A regional zonation varying from copper-silver-mercury in the south (Gortdrum-Kilteely-Aherlow) through copper-lead-zinc (Tynagh) to lead-zinc in the north (Ballinalack, Keel and Navan) is present. In lead-zinc deposits, zinc is usually dominant, the zinc/lead ratio increasing to the north.

Meeting of 26 November: Dr Paul Liechti

Synsedimentary tectonics

On 26 November 1971, Dr Paul Liechti addressed a meeting of 21 members in the Lecture Hall, Department of Geology, University of Malaya on the subject of "Synsedimentary Tectonics" with the President, Dr D. Taylor in the chair.

Dr Liechti began by outlining the two long recognized types of tectonic movements classified as epeirogenic and orogenic. A third type of movement resulting in folding of sediments is termed synsedimentary tectonics, by which is meant all those dynamic processes that occur as a direct result of the sedimentation and in close connection with it, the main agent being gravity.

Such synsedimentary tectonics have probably been much more widespread, especially in geosynclines and on geosynclinal slope areas, than has hitherto been recognized. Closely related to them is the wildflysch, which represents a particular type of geosynclinal slope sedimentation, that is, a eugeosynclinal scree.

The difference between synsedimentary tectonics and orogenic-compressive folding can be summarized as follows:

	Synsedimentary Tectonics	Orogenic-Compressive Tectonics
Duration:	(Pre-orogenetic) Movements during long geological periods, e.g., from the Mesozoic into the Neogene.	Definite orogenic phases of short duration; long intermediate periods of rest.
Causative force:	Gravity; tensional vertical, <u>passive</u>	Compressive forces; mainly horizontal, <u>active</u>
Magmatism:	Ultrabasic to intermediate (ophiolites). Submarine basalts-spilite. Gabbro and peridotite-<u>simatic</u>.	Syn- and late orogenic granite batholiths. Post-orogenic, basic lava effusions.
Metamorphism:	Regional metamorphism, if any	Mainly dynamo-metamorphism if any.
Correlation with adjacent areas:	Impossible or problematic, as movements in space and time are often poorly defined and incoherent	Correlation mostly conclusive; orogenic structure being better defined and geographically more persistent.
Tectonic style:	Normal faults and flextures; rare overthrusts; folding intensity and direction very variable and accidental. Stratigraphic repetition due to sliding of sheet parcels.	Reversed faults, overthrusts, nappes - folding intensity and direction relatively constant.

Dr Liechti then outlined the modern concepts of orthogeosyncline, and referred to examples in the Northwest Borneo Geosyncline. There the Late Eocene (Tb) folding affected much of Sarawak but dies out to the northeast, whereas a Miocene (Te_5) folding in Sabah dies out to the southwest, and in Sarawak can only be recognized in the extreme northeast.

The local character of the folding phases, the absence of a morphogenic phase, and the fact that folding intensity decreases stratigraphically upward, and rarely resulted in a clear-cut unconformity, moreover, the fact that the folding did not bring about a change of the environment and that eugeosynclinal conditions of sedimentation persisted, indicate that the folding was essentially of a synsedimentary nature. The younger age of the folding in Sabah is to be explained by the fact that sedimentation began later there. The character of the tectonics was illustrated by Dr Liechti with special reference to the Rajang and Arip-Pelagau area of central Sarawak, and the "isolated basins" of the Mio-Pliocene in north Sarawak. The Kelawit fault and various others large faults in Sarawak and Sabah are probably synsedimentary.

In the Philippines, synsedimentary tectonic movements are well established in the Cagayan Valley of Luzon (Christian, 1964), the islands of Cebu, Negros, Leyte and others and also in Mindanao. On the other hand, a Pliocene orogenic folding is known and safely established in both countries, Borneo and Philippines; it still appears to be in progress, particularly on the Philippines.

Dr Liechti then discussed the question of 'embryonic tectonics' and the wildflysch problem in the Alpine geosyncline, stating that some of the classical conceptions on these questions are now obsolete. Interpretations in terms of orogenic compressive processes have been advanced for both, whereas the conception of synsedimentary tectonics now permits an easier and more natural interpretation. Embryonic tectonics are certainly synsedimentary and tensional, closely related to the subsidence of the geosyncline. The wildflysch is a geosynclinal slope submarine slump deposit, and is strictly limited to the pre-orogenic phase.

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