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GEOLOGIC NOTE:

Curious Inclusions, Essentially of Sphalerite, in Stannite from Tekka, Perak

K.F.G. Hosking, University of Malaya.

Recently the writer had the priviledge of examining, in polished section, stannite-rich material collected from Tekka, Perak, by Mr. G.H. Teh. The lodes of this area, from which the specimen in question was collected, have been described earlier by Leow, Hosking and Teh (1969).

The stannite, which constitutes most of the section, appears to be the 'normal' variety and to consist of a mosaic of fairly large crystals. However, in the stannite are a number of interesting inclusions of varying size, shape and mineralogic composition and it is the characteristics of these, and their genesis, which warrant the writing of this note.

The majority of the inclusions consist of sphalerite, but a few small ones of variable shape are composed of chalcopyrite, or a brilliant white metallic mineral, which may be kobellite, but which, in any case, is identical to the species noted by Ramdohr (1969, p. 546) in stannite from Wheal Rock, Cornwall, etc., but which he was unable to identify. On occasion, also, small composite inclusions consisting of chalcopyrite and sphalerite, chalcopyrite and the white species, and all three species are to be seen.

Commonly, large inclusions of sphalerite, whose forms are, on occasion, reminiscent of Chinese characters, occur (fig. 1), and in the adjacent matrix small inclusions are common. Such "Chinese character"-type inclusions of sphalerite in stannite have never before been seen by the writer nor do they appear to have been described in the literature Elsewhere comparatively long trains of sphalerite inclusions are in evidence. These inclusions possess many different shapes but generally each body is somewhat elongated in a direction parallel to the long axis of the train of which it is a member (fig. 2).

Locally, small sphalerite bodies, of a variety of shapes, are orientated along the stannite grain boundaries (a fact which is most clearly revealed when the section is examined between partly crossed polars) (fig. 3).

If this were all the section had to offer it might be concluded that all the inclusions in the stannite were exsolution bodies. However, near the periphery of the section are several large masses of sphalerite which contain small inclusions: most of these are chalcopyrite but a few are stannite. (Brecciated massive cassiterite, which was deposited before the sphalerite, also occurs locally near the periphery of the section but will not be discussed further as it is not relevant to the problem under review.) Projecting from the largest of these sphalerite bodies is an elongate 'horn' whose width approximates to that of the trains of

Fig. 1—Chinese character-type Sphalerite inclusions in Stannite (st.)

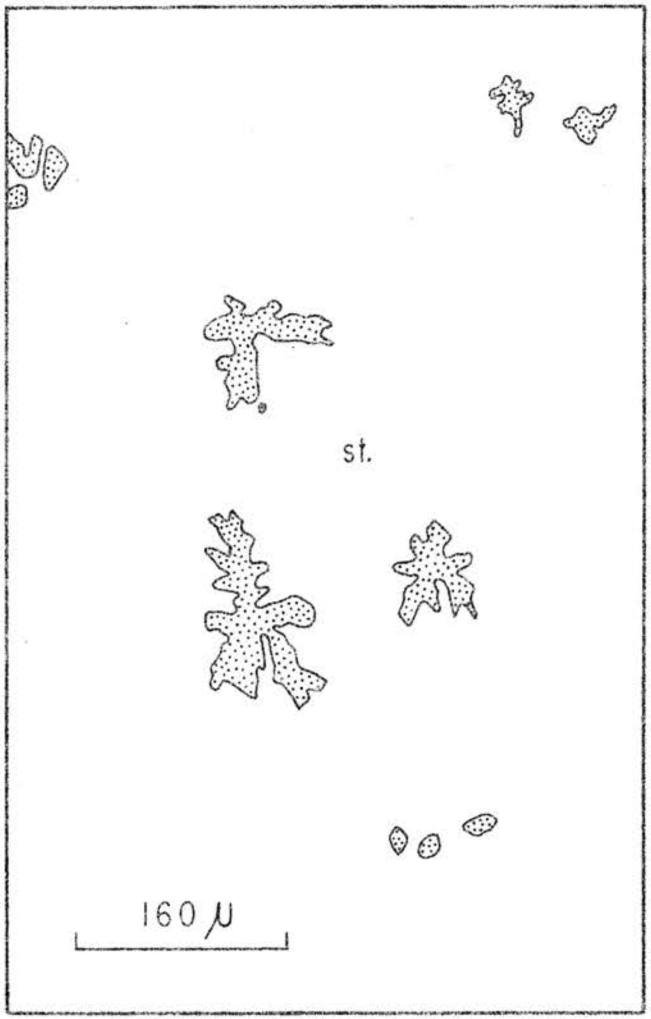


Fig. 2—Inclusions of Sphalerite in Stannite

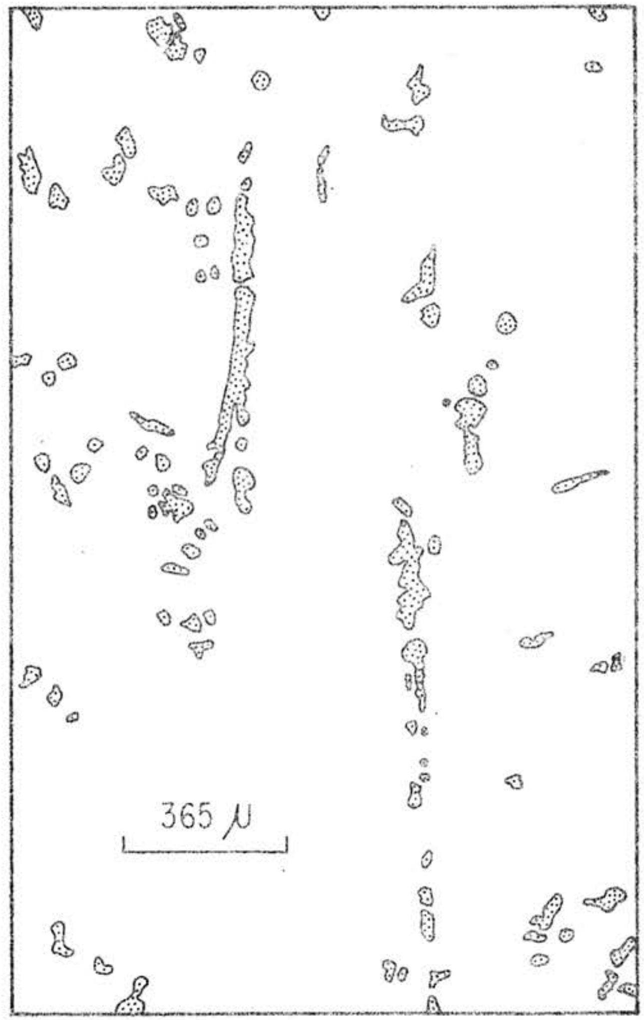


Fig. 3— Sphalerite inclusions orientated along Stannite grain boundaries

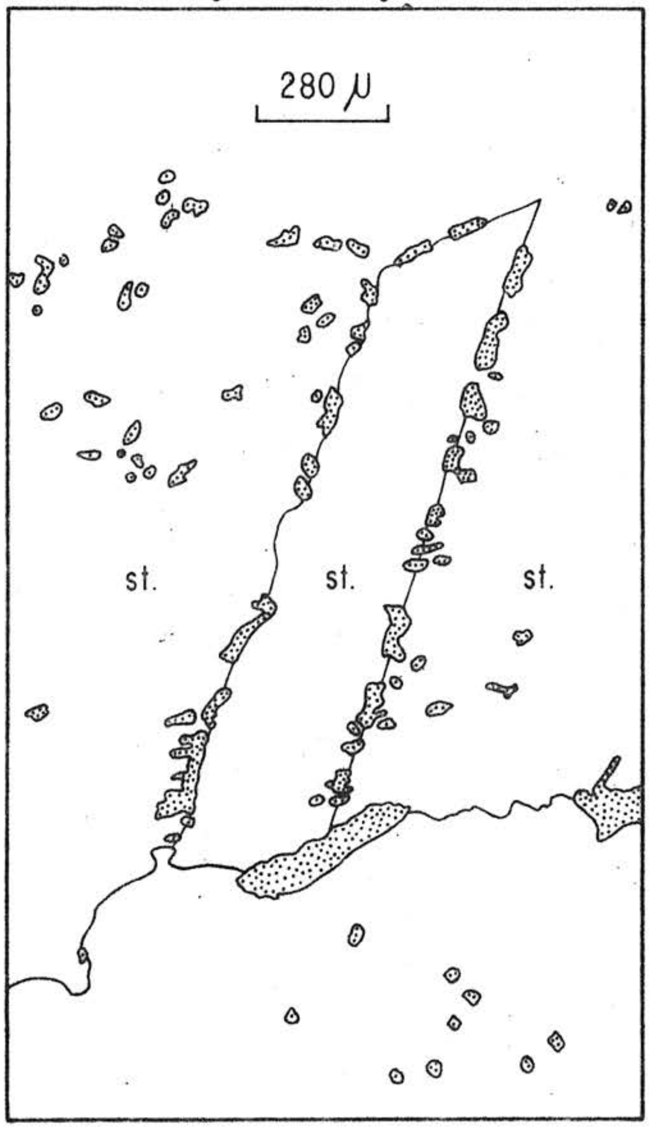
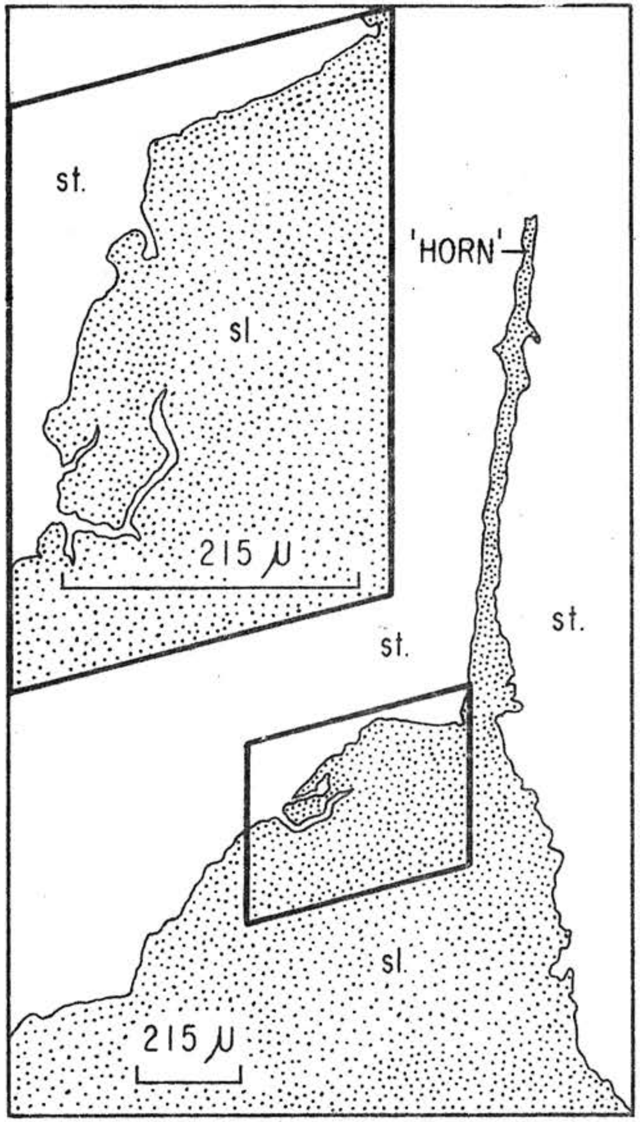


Fig. 4— 'Early' Sphalerite (sl) showing features which suggest it is being replaced by Stannite (st)



(All figures are tracings from microphotographs) sphalerite bodies noted earlier. In addition, these large peripheral sphalerite masses, some of which are completely surrounded by stannite, are locally clearly embayed and veined by the tin-bearing sulphide (fig. 4).

From these observations it may be concluded that the trains of sphalerite bodies may well be relicts formed by the segmentation of horns of the type noted above during their progressive replacement by stannite. The large Chinese character-type inclusions may be true exsolution bodies with a comparatively long history of growth similar to that of sphalerite stars in chalcopyrite (Ramdohr, 1969, pp. 527-529), but, on the other hand, they may be relict features. That true exsolution bodies occur in the stannite is supported by the virtual lack of 'white mineral' in the sphalerite but much more particularly by the local accumulation of sphalerite blebs along the grain boundaries.

From these observations what can be concluded concerning the genesis of this ore? It seems certain that iron-rich sphalerite, with a sufficiency of copper and iron to permit the generation of exsolution bodies as the temperature waned was deposited some time after cassiterite. This was followed either by the incursion of components capable of depositing the stannite and its exsolution bodies without local additions, or by components that could lead to the development of the stannite and its exsolution bodies if sphalerite were assimilated. Such assimilation, even on a modest scale, would doubtless provide all the ingredients for the sphalerite and chalcopyrite exsolution bodies and might well contribute further iron, zinc and copper which might be incorporated into the lattice of the stannite. The writer believes that the latter hypothesis is the more probable as it goes far towards explaining what happens to the sphalerite components which, judging by the distribution of what he believes to be trains of relict sphalerite, must have been liberated in considerable quantity. Further support for this hypothesis lies in the fact that in the writer's experience stannite never contains exsolution bodies of sphalerite unless earlier sphalerite is also present in the ore.

Apart then from the curious shapes of some of some of the sphalerite inclusions, the section under review merits a note because it clearly demonstrates, as Ramdohr (1969, pp. 170-200) has pointed out, that on occasion it may be extremely difficult to determine whether observed inclusions (particularly if they are of isometric species) are relict or exsolution bodies. It possesses a further distinction in that it, unlike so many polished sections of ores, gives a real clue as to the possible fate of ions liberated during the replacement of one mineral species by another.

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Ramdohr, P. 1969. The ore minerals and their intergrowths. Pergamon Press, Oxford.

REPORT ON KUCHING DISCUSSION MEETING, JULY 27-31

The Society's week-long Discussion Meeting, held in Kuching, Sarawak, from 27 to 31 July 1970, was a considerable success. Attendance far exceeded original expectations, with 68 registered participants, and members seemed to enjoy the discussions and field trips. The large attendance was due mainly to the unexpectedly strong interest from the petroleum industry, with oil company geologists coming from as far as Sydney and USA for the meeting. The meeting was useful in providing an opportunity for informal discussions among geologists concerned with petroleum exploration in this region. For many it was their first chance to meet one another and exchange views.

The indoor sessions on "The geology of the Sunda Shelf and its environs" covered the 27th and 28th of July. The meeting was formally opened on the morning of the 27th by the Hon. Mr Stephen Yong, Deputy Chief Minister of Sarawak. In his remarks, Mr Yong emphasized the State's great interest in the economic potential of the offshore shelf seas adjoining Sarawak. Following the opening ceremonies, a paper by N.S. Haile of the University of Malaya on "The geology of the Sunda Shelf between Borneo and the Malayan Peninsula" was read for Prof. Haile by P.H. Stauffer. This interesting paper presented new data on the geology of the shelf and the islands in the South China Sea, and offered observations on the structural relationships of the islands and Borneo.

The other papers presented on the 27th dealt with specific aspects of the geology of the Sunda Region. C.H. Kho, Principal Geologist of the Geological Survey in Sarawak in his "Introduction to the geology of West Sarawak" gave an outline of the complex and far from fully resolved stratigraphy and structure of the area. This talk provided a good preview and introduction to the field trips held later. K.M. Leong, of the Geological Survey in Kota Kinabalu, spoke on the "The pre-geosynclinal rocks of West Sabah". He described small inliers of schist and gneiss, similar to the 'basement' rocks of East Sabah, which occur near Mt. Kinabalu, and suggested that a crystalline basement of such rocks may extend under the thick cover of the Rajang Group in the Northwest Borneo Geosyncline. P.H. Stauffer of the University of Malaya presented a paper on "Depositional directions in the Plateau Sandstone Formation of West Sarawak". The orientation of cross bedding in areas north, west, and south of Kuching indicate that the source area for the Plateau Sandstone was to the southwest and also suggest a paleogrographic trend extending northwestward into the South China Sea toward the Natuna Islands. A paper by D.S. Dhillon of The Analytical Laboratories on "Deposits of foraminiferal tests off the Pahang River estuary, east coast of West Malaysia, South China Sea" was read by Margaret Long. A traverse normal to the coast shows marked changes in bottom sediment and abundance and type of Foraminifera, with salinity and sediment type appearing to be the main controls on the distribution of the Foraminifera.

In Tuesday's session, July 28th, P.H. Stauffer presented a second paper, this time on "Some speculations on pre-Tertiary paleogeography in the South China Sea region". This paper pointed out that the geology of land areas adjoining the South China Sea requires the now submerged shelf areas to have been the site, at various times in the past, of uplifted land masses and deep marine areas. Subsurface information acquired by petroleum exploration companies should help unravel the geologic history of the region, which is probably quite complex. Following the paper, two papers on the use of seismic methods in oil exploration were presented. H.L. Guerts of Brunei Shell Petroleum Corp. spoke on "The seismic method as an exploration tool", and W.R. Cotton of Geophysical Service International traced the route "From seismic data processing to geological interpretation". These two papers gave a full account of modern sophisticated seismic techniques, which now involve extensive use of computer systems. Guerts' paper was an outstandingly lucid presentation and one of the high points of the symposium.

On the evening of the 28th of July, all participants were entertained to a dinner at the Aurora Hotel in Kuching. Host for the dinner was the Shell group of companies, with the Manager of Shell Sarawak Berhad in Miri, Mr Boersma, presiding. Shell's generosity made the evening a thoroughly enjoyable occasion.

The 29th, 30th and 31st of July were taken up by three one-day field trips to areas near Kuching. The trip on the 29th examined the Bau area in the morning and outcrops along the Bau-Lundu road in the afternoon. In the Bau area, visits were made to the Bukit Young Gold Mine and two small antimony mines, in one of which deposits of native arsenic are found along with stibnite. Fossiliferous outcrops of the Bau Limestone Formation were also examined. The outsrops on the Bau-Lundu Road were in the Pedawan Formation and the overlying Plateau Sandstone Formation. These showed the transition from the marine slope deposits of the Pedawan Formation to the fluvial, deltaic, and littoral marine deposits of the Plateau Sandstone Formation, but provided no evidence on whether the contact was a conformable one or not.

The field trip on July 30th covered areas near Kuching town and along the Penrissen and Bau Roads. In the morning participants examined outcrops of pre-Triassic carbonaceous phyllite, a microtonalite of probable Miocene age and excellent exposures of fossiliferous Bau Limestone Formation at the Poh Kwong Quarry, where some shales of the Pedawan Formation also occur, probably in fault contact with the limestone. Just before lunch, a visit was made to a Land Dayak longhouse at Kampong Benuk, which allowed participants to see this characteristic Borneo style of native architecture and social organization. In the afternoon, two exposures of the Pedawan Formation were examined. One showed pebbly mudstones and slump breccias interbedded with normal shales and mudstones. The other, a large double roadcut on the new Serian Road by the new roundabout at Mile 7, contains shales and sandstones of the Pedawan Formation, intruded by porphyry dykes and sills, and unconformably overlain by

Pleistocene gravelly alluvium, which also fills several beautifully displayed channels. The Pedawan sedimentary rocks there show a variety of sedimentary features, including sole markings, shale-chert breccias, plant fragments, shell debris in some sandstones, and a number of armored mud-balls. It is an extremely interesting exposure and members of the trip were fortunate to see it now, as cuttings in soft rocks do not last long in this climate.

On the 31st of July a boat trip was made by government launch down the Sarawak River from Kuching to the Bako Peninsula on the coast. During a rather brief stay at the National Park Headquarters at Telok Asam, participants were able to examine the excellent sea-cliff exposures of Plateau Sandstone Formation, there rather uniformly coarse-grained and cross bedded. One energetic soul even took time off to run up to a high point of the peninsula.

These three field trips were well-attended, 30 to 40 members participating in each, and they provided some introduction to the rocks of West Sarawak in the field. Numerous arguments over the interpretation of features seen were interesting and left many questions unresolved.

On the last evening, July 31st, the Society held a dinner for participants at the Loke Restaurant in Kuching. This pleasant occasion rounded off the week's activities.

All in all, it was a very successful meeting. The formal program of papers was brief and a bit thin, but the informal discussions and get-togethers, as well as the field trips, made it a worthwhile and enjoyable week. The Society is extremely grateful to all who helped make the meeting the success it was. First and foremost, our gratitude must be expressed to the companies - AGIP, ESSO, Gulf (Thailand), Gulf (S.E. Asia) and G.S.I. - who gave generous financial support, enabling the Society to subsidise transport between Singapore and Kuching, and allowing more than a dozen undergraduate students from the University of Malaya to attend. Without this support, it is safe to say, the meeting would not have been possible. Thanks are also due to the Shell companies, for their splendid hospitality on the Tuesday evening. Various offices of the Sarawak Government gave assistance: The Deputy Chief Minister, Mr. Stephen Yong, kindly consented to open the meeting; Radio Malaysia, Sarawak, made the facilities of their Studio A available at no charge for the indoor sessions; the Information Office lent the Society visual aid equipment; and the Principal Geologist of the Geological Survey, Sarawak, Mr C.H. Kho, not only made available the Survey's offices for the Registration on Monday, but also helped in the planning and preparation of the meeting in a thousand ways. The British Council lent an overhead projector.

As a result of the Kuching meeting, the Society now has a better idea of what is possible. It is hoped to repeat this type of Discussion Meeting, perhaps on an annual basis, and with locations in various major towns of both East and West Malaysia.

Abstracts of the papers presented at Kuching, with the exception of the two papers on the seismic method, are appended with this Newsletter.

-PHS -

OTHER RECENT MEETINGS

MEETING OF 22 JULY: R.E. STANTON

A meeting of the Society was held at 8.00 p.m. on the 22nd of July in the Geology Department, University of Malaya. Mr R.E. Stanton, formerly Reader in Geochemistry at Imperial College of Science and Technology, London, addressed the meeting on the topic "The colorimetric determination of molybdenum and tungsten".

The President, K.F.G. Hosking, introduced the speaker, who is well known in geochemistry for his development of the rapid methods of analysis such as those he described in his talk. Mr Stanton outlined the methods used for molybdenum and tungsten in some detail with attention to the practical difficulties sometimes encountered and how to overcome them. He pointed out that the colorimetric methods are still much used for these two elements because the newer atomic absorption methods do not work well with them.

About 45 members and guests attended the meeting, and there was considerable discussion, mainly on the practical problems experienced in applying the methods to materials of different composition.

- PHS -

MEETING OF 11 SEPTEMBER 1970: PROFESSOR E. SEIBOLD

A meeting of the Society was held at 8.00 p.m. on the evening of the 11th of September, in the Geology Department, University of Malaya, Kuala Lumpur. The President, Professor K.F.G.Hosking, introduced the speaker for the evening, Professor E. Seibold, Director of the Geological-Paleontological Institute at the University of Kiel, West Germany, who spoke on the topic "The geology of adjacent seas in arid and humid climates". Professor Seibold was on a week's visit to Kuala Lumpur sponsored by the Goethe Institute. A synopsis of Dr Seibold's talk follows:

At the Geol. Paleont. Institute at Kiel the attempt is being made to find models in the present oceans for the sediments we find in the geologic column. Many sediments were deposited in adjacent seas bordering land masses. Some of the present-day adjacent seas occur in the two arid climatic belts flanking the equatorial zone. Others occur in humid climates, both warm (equatorial) and cold (temperate and polar).

What is the principal difference between these two environments? In arid adjacent seas, evaporation from the sea surface is greater than the influx of fresh water from rain and rivers. Hence the water becomes super-saline, hence denser, and consequently sinks down and flows out toward the deeper ocean, while a compensating landward flow of normal sea water occurs at the surface. Examples of such seas today include the Mediterranean, the Red Sea, and the Persian Gulf.

In humid adjacent seas, by contrast, influx of fresh water exceeds evaporation. Hence there is an outward surface flow of less saline (hence less dense) water, and a landward bottom flow of normal sea water.

For a humid example we will take the Baltic sea; for an arid one the Persian Gulf.

The first point to make is that these seas are not flat on the bottom. In adjacent seas there is always a sill and one or more basins. In the Baltic the first and most important sill is between the island of Zealand and the Danish mainland. In the Persian Gulf it is the same story: there is a sill just inside the Strait of Hormuz and two basins, the central and western basins, in side this sill.

A second point is that there is always a key area near the entrance and sill. The character of the entrance is very important for hydrology, for sedimentation, for the biology of the adjacent sea. Examples are the Straits of Gibraltar and the Strait of Hormuz. These are tectonically sensitive areas; slight movement here will influence the whole area of the sea within. We must remember this in examining fossil sediments of adjacent seas.

Hydrology of adjacent seas: Isolines of salt content dip toward the basin from the sill in humid adjacent seas, the opposite way in arid adjacent seas. The same applied for any other measures of water character: density, phosphate content, etc. In humid adjacent seas the bottom water in closed basins is generally very stable, because there is no heavier water descending from above to disturb it. A stable and stagnant density profile is formed below the sill depth. In the Baltic, for example, a sharp and horizontal hydrographic boundary at a depth of about 70 meters separates brackish water above from saline water below. In the arid Persian Gulf, on the other hand, supersaline and therefore dense water sinks from the surface and seeks the bottom. This flushes out the bottom water and prevents the formation of good stratification within the water column.

What are the implication of these differences for the geologists?

In the humid model there is abundant oxygen above the picnocline, but below there is stagnant water in which oxygen is depleted by organic matter. Hence the bottom water is very oxygen-poor (commonly less than 5% saturation) and often H_2S is present. This environment is toxic and there is little or no benthos. The sediments deposited here will therefore show no bioturbation. In cold humid areas there are some exceptions and complications produced by the sinking of water made dense by cooling, but this does not occur in tropical humid areas.

By contrast, in arid adjacent seas, the overturn of the water column brings oxygen from the surface, hence there is life at the bottom and the sediments show a great deal of bioturbation.

These differences in benthos are visible in cores obtained (undisturbed lamination in humid areas; disturbed in arid areas) and in bottom photographs (organisms, their tracks and burrows show in arid areas).

Another result of this difference in bottom conditions is the fate of organic matter on the bottom, which may be the raw material of petroleum. In the central part of the Baltic, in the Gotland Basin, you have very high organic content - up to 10% organic carbon. Now the amount of organic matter in the sediments will depend on four factors:

1. Rate of production
2. Dilution by river sediments
3. Close association with fine-grained sediments (i.e. absence of strong currents)
4. Rate of destruction: high in arid model, with oxygen at the bottom (and scavengers); low in humid model, with oxygen-poor bottom water and little or no life.

In the Persian Gulf, the bottom sediments never contain more than 2% organic carbon. As the surface water flows into the Gulf, it is progressively impovrished in nutrients, hence the productivity in the surface waters of the Gulf is low. Also, as the bottom water flows toward the sill, it becomes depleted in oxygen. For these reasons, the highest organic contents in the Persian Gulf are found in the lower end, near the sill. At first it was thought this might be simply because the sediment si finer there, but comparison of sediments of the same grain size from various parts of the Gulf shows it to be an independent effect.

In the Far East, the Gulf of Thailand has a sill at a depth of about 60 meters. Organic content of sediments within the Gulf is kept low by dilution, however. In Kau Bay on Halmahera Island in Indonesia, the sediments have over 2% organic carbon, despite dilution by sediment from active rivers.

The humid model Japan Sea is different because in the northern part water at the surface is cool in winter till it sinks, thus "flushing out" the system and bringing oxygen to the bottom. Oxygen saturation is present sometimes down to 3000 meters. The bottom sediments in the central and deepest parts of the Japan Sea are poor in organic carbon.

Calcium carbonate content of the sediments also shows marked differences between humid and arid areas. In the Baltic the content of $CaCO_3$ is extremely low. In the Persian Gulf the content of $CaCO_3$ is about 20% on the Iranian side. This material is entirely from the tests of organisms and the amount is kept low by dilution with silicate sediments from rivers. Toward the center of the Gulf, the content is greater than 40%. In the humid model seas you may have solution of carbonate at the bottom.

The hydrographic differences between humid and arid seas effect the biofacies of benthonic organisms. In the Baltic one seas facies marked by index organisms controlled by salinity of the water. But because of the good stratification in the water column, the biofacies boundaries follow depths as well. There is one very sharp boundary at a depth of 12 meters. Although studies of biofacies in the Persian Gulf are still in an early stage, there is evidence that the boundaries there are less sharp and that, rather than being horizontal, they dip with the isolines toward the sill, proving that they are not directly controlled by depth.

Currents on the bottom: In the Baltic heavy salty bottom water incurs easily to the first sill among the Danish islands, but only makes it into the basins of the Baltic every few years under special conditions of sustained strong westerly winds. Detailed studies show the effects of bottom currents in the strait north of Fehmarn Island near Kiel. Erosion has in many places exposed Pleistocene boulder clays at the surface. Echo sounding records show trains of regular sand waves or giant ripples. These are asymmetric, showing currents from west to east as the dominant influence forming them.

A useful index of where you are in an adjacent sea is the ratio of planktonic to benthonic foraminifers. This ratio is high in the open sea, lower near shore. Globigerina cannot live in depths less than about 20 meters. In the Persian Gulf there is a gradual drop-off in this ration coming in from the open ocean, as planktonics are carried in by the inflowing surface waters. The current pattern gives the distribution a lobate character, and Coriolis force presses the main currents toward the Iranian side of the Gulf. This is shown in the distribution of salinity and other factors as well as by the foraminifers. A hydrographic station outside the sill, in the Arabian Sea, shows a water column marked by a sharply defined mass of super-saline water at a depth of 200 to 300 meters. This is the outflowing bottom water from the Persian Gulf, which sinks till it finds its density level and then spreads out horizontally. This water is more saline but also warmer than the water above and below it - the two effects on the density cancel out. The mass spreads out widely at this depth and can be detected even on the other side of the Indian Ocean, off India.

At the Straits of Gibraltar, Mediterranean bottom water similarly flows out and down till it finds its density level in the Atlantic water column at about 1000 meters, and then spreads out horizontally. Presumeably Coriolis force pushes the outflowing current initially against the north side of the strait, along the coast of southwest Spain. Indeed at the base of the continental slope here one finds a trough-like channel, flanked on its outer (southwest) side by a gentle rounded ridge composed of layers of sediment conformable to the surface shape. While this structures may be the result of large-scale slumping, it may also be that it represents the channel and the natural levee of the Mediterranean outflow current.

Hence we see that study of these modern models of humid and arid adjacent seas can help explain many feature in ancient sedimentary rocks.

Discussion:

Nik Mohd: Since they are both humid seas, why should the surface water in the Malacca Straits be more saline than in the Baltic?

ES : The Baltic is much more enclosed and cut off from the ocean. And also, the salt water coming into the Baltic along the bottom is from the North Sea, which is already a little less saline than the open ocean.

N.S. Haile: Would you care to speculate on the effects of the sea level changes in the Pleistocene on the South China Sea?

ES : This is a very complex matter. In other seas with which I am familiar, there is evidence of major changes in circulation. There is a suggestion that in the Ice Age the Mediterranean circulation was the other way - i.e. that it was a humid model sea, with surface outflow. This would explain the Pleistocene incursion of Atlantic benthos. During the lowest stages of Pleistocene sea level, the Red Sea was probably completely closed off; in the sediments there are no Globigerina at all.

K.F.G. Hosking : Would you care to comment on the origin of the Kupferschiefer?

ES : This is a peculiar deposit difficult to explain. The associated rocks - e.g. the Zechstein - imply arid conditions. But the features of the Kupferschiefer itself - high organic matter, no bioturbation, high metal content (which I didn't discuss) - these indicate a humid model. Brongersma-Sanders has suggested that it was an arid climate but with such strong and persistent off-shore winds that a circulation of water as in the humid model was produced. But this would require strong winds during the whole year.

K.F.G. Hosking: Possibly if the metals were indigenous, coming from below, they could poison the bottom water and so allow the preservation of organic matter.

ES : Possibly.

A guest : How could you have prevailing winds from the southeast?

ES : We don't of course know just where and at what angle the equator was at the time. But even so, prevailing winds from the southeast do not seem impossible.

Professor N.S. Haile proposed a vote of thanks to the speaker for his fascinating and very stimulating talk, and the meeting adjourned. About 40 members and guests attended.

-PHS -

MEETING OF 18 SEPTEMBER: PROFESSOR Th. G. SAHAMA

There was a meeting of the Society at 5.15 p.m. on 18th September in the Geology Department, University of Malaya. The President, K.F.G. Hosking introduced the speaker, Professor Th. G. Sahama of Helsinki University. Professor Sahama, co-author of the standard work Geochemistry, had recently attended the IMA meeting in Tokyo and was making his first visit to Malaysia. He spoke on the topic "Some secondary tungsten minerals from Africa". A synopsis of Prof. Sahama's talk follows:

Malaysia is famous for its tin and its tungsten deposits. I am sorry I have never been able to visit here before, and I know only little about Malaysian mineral occurrences. But I have been concerned for some years with African tungsten minerals, and this may be of some relevance to Malaysian deposits.

In central Africa there are a large number of tungsten deposits forming what one may call a tungsten "belt". These deposits are of pre-Cambrian age. They occur in parts of three countries: In Southwestern Uganda (the Kigezi district); in Northwestern Rwanda; and in eastern Congo (Kivu Province).

The main minerals in these deposits are ferberite and wolframite. The ferberite is predominant, while wolframite forms the main mineral of only a few deposits. Scheelite is really quite rare, and in only one deposit I know of does it form the principal tungsten mineral.

It is remarkable to find both wolframite and ferberite occurring together in the same deposit, because they are really parts of one continuous series, with ferberite representing the iron end-member, while wolframite contains more manganese. Wolframite forms nice black crystals showing shiny cleavage reflections and no alteration - they are quite fresh. Ferberite, on the other hand, occurs in dull black masses in which no cleavage reflections are visible.

My studies have been limited to the ferberite. Within the masses of ferberite are numerous cavities filled with a white powdery material. This material consists of secondary minerals, four of which have been defined:

1. Anthoinite — triclinic

   $Al_2O_3 \cdot 2WO_3 \cdot 3H_2O$ — $Z = 5$

   Anthoinite has been known for twenty years, is apparently a sheet structure and forms a white powder.

2. (unnamed and unpublished) — monoclinic

   $(Al,Fe)_2CO_3 \cdot 2WO_3 \cdot 6H_2O$ — $Z = 5$

   This mineral is rare.

3. Cerotungstite — monoclinic

   $(RE)W_2O_6(OH)_3$ — $Z = 2$

4. (unnamed and unpublished) — cubic

   Al-analogue of ferrotungstite

   $(Ca,RE)_x(W,Al,Fe)_2(O,OH)_2$ — $Z = 8$

Masses of ferberite and masses of anthoinite sometimes show nice crystal forms which are clearly pseudomorphous after scheelite. Cerotungstite occurs as radiating groups of tabular small crystals elongate along the b-axis and flattened along the c-axis. The Al-tungstite forms octahedral crystals associated with cerotungstite. The octahedral are sometimes in rosettes and show twins according to the spinel law.

What is the genesis and order of formation of these minerals? The crystal forms of masses of ferberite resembles scheelite and never that of monoclinic wolframite. If we look under the microscope at ferberite, we find the crystals are not homogeneous, but are composed of small sub-grains. Hence we infer than scheelite goes to ferberite pseudomorphs. Along the borders of the cavities filled by secondary minerals, the sub-grains are aligned normal to the cavity wall. Within the cavities themselves, there is commonly a marginal layer of octahedra of the Al-tungstite projecting into the interior, and radiating hemispherical aggregates of cerotungstite also facing inward. The remaining space is occupied by massive anthoinite.

One may therefore suggest that anthoinite in the cavities is being replaced by ferberite, with a reaction rim of cerotungstite and the Al-tungstite. These "cavities" therefore would represent relict cores of unattacked anthoinite, and the complete sequence would be: scheelite goes to anthoinite goes to ferberite. That is, tungston minerals with calcium as dominant cation go to ones with aluminum and finally to ones with iron as the main cation. At the end any rare earths which were able to exist as minor impurities in the lattice of the calcium-bearing minerals must come out to form their own tungsten minerals, as the iron-bearing species do not allow the rare earths in the lattice.

If this sequence of successive replacements is correct, it suggests that scheelite is not a stable species in metamorphic environments, but rather the calcium is fairly easily leached out and replaced by aluminum and iron.

Tungsten minerals are still worthy of much study and attention by mineralogists.

Discussion:

Loganathan	:	Do any of the secondary tungsten minerals fluoresce under ultraviolet light?
Th. G. S.	:	No. At least not with the instrument I have used. Perhaps with very short wave ultraviolet they might.
E.B. Yeap	:	How does the wolframite in these African deposits relate to the minerals you have discussed?
Th. G. S.	:	I haven't studied the wolframite and so I don't know how it fits in. It is possible it represents a separate generation of tungsten minerals, but I don't know. The crystals are quite fresh.

K.F.G. Hosking : It is of interest to note that in the south-west of England I have seen rare pseudomorphs of chalcedony after scheelite. It's curious that the ferberite pseudomorphs are so rare outside of Africa: Examples, however, have been recorded from Cornwall.

Th. G. S. : Some ferberite pseudomorphs after scheelite have also been found in Portugal and in Japan, but they are certainly rare except in Africa, where they are quite common.

L.S. Leong : I have scheelite in pyrometasomatic deposits; is it likely to be leached out?

Th. G.S. : The African occurrences are in a sedimentary setting, yours are probably in a magmatic setting. Here it's less likely to be leached out. You have only scheelite or other tungsten minerals?

L.S. Leong : Only scheelite.

K.F.G. Hosking : I have seen some ferberite "micro"- nodules in grey, tungsten-rich schist from East Africa: might these also have been scheelite originally?

Th.G.S. : I think that they may well have been scheelite originally: others also think so.

Y.L. Tong : Is it possible to have a tantalum and niobium-bearing wolframite? I have been analyzing some material sent me, which seems to be wolframite but contain up to 10% tantalum and niobium. I wonder if this can be a true wolframite?

Th.G. S. : It is possible that under rather extreme conditions you could get a mineral which was halfway between a clumbite and a wolframite. I think the wolframite structure could, under certain conditions, take up some tantalum and niobium.

K.F.G. Hosking : May I suggest that you should look for inclusions; can you be sure you don't have inclusions of columbite?

Y.L. Tong : There isn't enough material - I was only sent a few grains for a complete analysis.

Mr. D. Santokh Singh proposed a vote of thanks to the speaker for his interesting and instructive talk, and the meeting adjourned. About 45 members and guests attended.

- PHS -

OBITUARY: W.R. JONES

The following is largely taken from a notice in the Commonwealth Geological Liaison Office Newsletter for July 1970.

Emeritus Professor W.R. Jones died suddenly on 9 June, 1970 at the age of 90. He completed his geological training at Imperial College in 1910 and was later awarded the degree of D.Sc. of the University of London for his work with the Geological Survey of the Federated Malay States on the origin of the Malayan alluvial tin deposits. His work in the Kinta Valley yielded the first coherent picture of the unconsolidated sediments, and was mainly responsible for discrediting the early hypothesis of a glacial origin for some of the deposits.

He became Professor of Mining Geology in Imperial College in 1941 retiring from there in 1947. In 1948 he was awarded the C.B.E. for his effective chairmanship of a working party set up by the Government to promote the rehabilitation of the china clay industry in Cornwall and Devon. Professor Jones was awarded the Gold Medal of the Institution of Mining and Metallurgy in 1955 'in recognition of his services to the science of economic geology and to the Institution'.

- SPS -

DATES FIXED FOR IPOH DISCUSSION MEETING IN DECEMBER

The Society's planned Discussion Meeting in Ipoh has now been fixed for Friday and Saturday the 18th and 19th of December. This is reported by the chairman of the organizing committee, Dr. D. Taylor, who is also Vice-President of the Society.

Tentative plans are to have indoor sessions all day on Friday and probably Saturday morning, with possible field trips on Saturday afternoon and Sunday. Further details will be circulated later.

Dr. Taylor also wishes to remind members desiring to contribute papers to the meeting that they should inform him as soon as possible. The topics for the two sessions are (1) plutonic and volcanic rocks of Malaysia, and (2) economic mineral deposits associated with the plutonic and volcanic rocks.

Dr. Taylor may be contacted at:

Conzinc-Riotinto
Bangunan Getah Asli
150 Jalan Ampang
Kuala Lumpur.

NEW MEMBERS

The following persons were elected to membership in the Society by Council at its meeting on September 25th, 1970, and their class of membership approved as given below (A = Associate member; S = student member; others Full members):

Mr Ang Thien Sze (S)
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University of Malaya
Kuala Lumpur

Mr James Keith Blake
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Mr Ian Langham Burnet
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Mr Cheang Kok Keong (S)
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University of Malaya
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Mr Chuw Yu Tot (S)
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Dr William Rodney Cotton
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Mr Jere Graham
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Djkarta, Indonesia

Mr Andrel Grepin
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Mr Richard Coleman Harp
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Mr Victor Hon
Geological Survey, Kuching
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Mr Lynn Bogue Hung
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Mr Michael W. Kontz
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Mr Kong Shau Cheng (S)
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Mr Lau Kok Loon
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Mr Mah Weng Hong (S)
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Miss Tan Kwi Lin (S)
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Mr Thiruchelvam Yoganathan (S)
5th Residential College
University of Malaya
Kuala Lumpur

Mr Voon Choon Chan (S)
138, 17/3 Happy Garden
Petaling Jaya

Dr Thomas F. Weaver (A)
Faculty of Agriculture
University of Malaya
Kuala Lumpur

Mr Wong Lee Ching (S)
37 Kampong Dollah
Kuala Lumpur

Mr Lee Meng Chong (A)
c/o Department of Geology
University of Malaya
Kuala Lumpur

CHANGE OF ADDRESS

The following members have informed the Society of their change of address as noted:

Enche Ahmad bin Jantan to:

c/o Jabatan Kajibumi
Universiti Kebangsaan
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Mr M.C. Cater to:

Robertson Research Int. Ltd.
23 Nassim Road
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Dr S.H. Chan to:

Department of Geology
University of Malaya
Kuala Lumpur

Mr W.N. Cho to:

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P.O. Box 119
Ipoh
Perak

Mr Choy Kam Wai to:

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Dr Ja'afar bin Ahmad to:
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Mr Joginder Singh to:

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Selangor

Mr Kannapiran Sabapathy to:

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Mr Teoh Kan Tin to:

c/o Gopeng Consolidated Ltd.
Gopeng, Perak

Dr H.D. Tjia to:

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Universiti Kebangsaan Malaysia
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