delocalisation of π electrons is possible. In this case, the small intensity of the peak at 2 960 cm^{-1} is also due to this effect, if it is attributable to C — H stretching vibrations.

Curve *b* on plate 5 shows the typical spectrum of the cell sheath. Dolomite is indicated by the lines at 1 100, 725 and 300 cm^{-1}. It can be concluded from the petrological studies that this dolomite is an alteration product derived from calcite. The calcite matter was apparently formed in a synsedimentary stage and became dolomitized subsequently, perhaps through diagenetic processes.

4. Conclusions

It must be regarded in the chemical interpretations that Ramsaysphaera (Plate 5) represent decomposed and fossilized remains of cell materials. Probably proteins, lipids, and carbohydrates were the main starting compounds involved in the post-mortem reactions. Recent studies show that upon death of cell, phenols, quinones, amino acids, and peptides are liberated which condense to form complex polymers of various molecular size (10). It is conceivable that mucopeptides are incorporated in the processes. Glucosamine also condenses with *p*-benzoquinone and may, therefore, act as the point of attachment of carbohydrates to the polymers. Phenols of the resorcinal type are characteristic substances that are formed by microbial fungi. Oscellinic acid is produced through their acetate metabolism. T.G. Felbeck (6) suggested that the central resistant core to which polymers and amino acids are bound is a polymer of four pyrene units linked together by methylene bridges at the 2,6-positions. Sulphur can be incorporated into the protobitumen by condensation reaction between thiols and quinones, aldehydes or sugars. The reaction products are relatively resistant against chemical and microbial attack and account for the high stability of the rock organic matter (G. Anderson, 1).

Probably the impregnating silica was additionnally involved in the chemical reactions. Estermann et al. (5) found protein-silica complexes to be much more resistant against decomposition than protein-clay complexes. Leo and Barghoorn (7) suggested that penetrating silicic acid may interact with the cell carbohydrates trough hydrogen bonding. The esters detected in the gas vacuole of *Isuasphaera* (Plate 4) are probably remains of metabolic products. The yeast cell contains large fat globules which commonly make up 30 to 40 % of the dry weight of the organism and reach 50 to 60 % in some genera. Additionally; copious amounts of lipids are stored in the extracellular cell sheath. Among the saponifiable lipids are fatty acids, the triglycerides, and other fatty acid esters, phospholipids and glycolipids. The unsaponifiable lipid materials are long-chained hydrocarbons and alcohols, phloroglucinal derivatives polynuclear quinones, terpenoids, and sterols (3). Many of the alcohols and sterols are bound with fatty acids to form esters. Compounds of the lipid fraction are relatively resistant to decomposition and can, under proper conditions, apparently last for long periods at time. Lipids are believed to be a main source material for the petroleum hydrocarbons.

It must be taken into account with the interpretation of the Raman spectra that the analysed rocks have suffered metamorphism, the Isua quartzite more, the Swartkoppie chert less. Consequently, the organic substances present in the rocks must have been subjected to intense alterations.

Our results obtained from the Mole analysis generally coincide with these findings. The compounds detected in the *Ramsaysphaera* cells (curve *a*, Plate 5) can be interpreted as products of an advanced bituminization resulting in condenses aromate clusters. Apparently, the Isuasphaera material is partly in a chared condition, partly close to a final stage of graphitization (Plate 3).

However there are samples in our collections the metamorphic rank of which is considerably below average. Apparently, the geologic heat flows have note reached all regions of the rock formations with the same intensity.

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Analyse d'inclusions fluides à la microsonde Mole à effet Raman

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Analysis of fluid inclusions with the Raman microprobe Mole

Nine fluid inclusions have been analyzed non-destructively by spectroscopy with the Mole microprobe and simultaneously by microthermometry.

The effort was principally directed on the gaseous phase in four inclusions rich in hydrocarbons (Remuzat, Drome; Lastourville, Gabon; Vermutfluh, Berne and Val d'Illiez, Valais) and in two

inclusions rich in CO_2 (Bournac, Massif Central and Camperio, Tessin). Quantitive analyses for CH_4, C_2H_6, C_3H_8, CO_2, N_2 and H_2S were obtained. An isotopic analysis (^{13}C) of CO_2 from Camperio has been attempted.

The solid phases of small size contained in three fluid inclusions were determined : calcite in Bitsch quartz (Valais), nahcolite in Bancroft quartz (Ontario), and hematite in a dolomite from Rabitte Lake (Saskatchewan). The sensitivity of the instrument and its limits for mineralogical purposes are discussed.

Neuf inclusions fluides ont été analysées de manière non destructive à la fois par microthermométrie et par spectroscopie Raman à l'aide de la microsonde Mole.

L'effort a porté principalement sur la phase gazeuse dans quatre inclusions riches en hydrocarbures (Remuzat, Drôme ; Lastourville, Gabon ; Vermutfluh, Berne et Val d'Illiez, Valais) et dans deux inclusions riches en CO_2 (Bournac, Massif Central et Camperio, Tessin). Des analyses quantitatives pour CH_4, C_2H_6, C_3H_8, CO_2, N_2 et H_2S sont données. L'analyse isotopique (^{13}C) du CO_2 de Camperio a été tentée.

Les phases solides de petite taille contenues dans trois inclusions fluides ont été déterminées : calcite dans un quartz de Bitsch (Valais), nahcolite dans un quartz de Bancroft (Ontario) et hématite dans une dolomite de Rabbit Lake (Saskatchewan). La sensibilité de l'appareil et les limites de son utilisation en minéralogie sont discutées.

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Applications de la microsonde moléculaire à laser Mole en micropaléontologie : étude du test des foraminifères

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Applications of the microprobe Mole in the study of foraminifera

Foraminifera are unicellular animals whose protoplasm is protected by a shell usually mineral in nature. The size of individual specimens varies from a few hundred microns to a few millimeters, and the thickness of the shell rarely exceeds several tens of microns. Those dimensions make it difficult to study these organisms, requiring the use of advanced technology. Because of its performance, the laser molecular microprobe, Mole has found an application in micropaleontology. Its powers of resolution and the possibility of quick, in situ, *analysis have enabled the mineralogical characterization of the different layers contained in the shells of two species, one « calcitic » the other « aragonitic », thereby raising some doubt concerning the mineralogical nature of these two species. The use of the Mole has also allowed the solution of a problem concerning the classification of Foraminifera by revealing the calcitic nature of one species attributed to an aragonitic family ; for this type of study the method has proved invaluable because it does not destroy the sample, which is very important, if not indispensible, when rare or reference specimens are being examined. The examination of the sample requires neither the use of a vacuum nor special preparation of the specimen thereby avoiding a tedious, detailed job when such small and fragile organisms are to be handled. Knowing that the present number of species of Foraminifera both living and fossilised is over 21,000, that have been in existence since the Primary era and that the shell is susceptible to modification during diagenisis through geological periods, one can easily imagine the interest generated in the use of the Mole in micropaleontology.*

En raison de ses performances la microsonde moléculaire à laser Mole s'est révélée un outil précieux adapté à l'étude du test des Foraminifères. Avant de donner les principaux résultats obtenus, il me semble judicieux de présenter ce groupe zoologique et de donner quelques renseignements qui aideront à la compréhension de l'exposé.

Les Foraminifères sont des organismes unicellulaires dont le protoplasme est protégé par une coquille appelée test. Ce test est composé de une ou plusieurs loges dont l'arrangement varie selon les espèces. Ces loges communiquent entre elles par une ouverture ou foramen. La composition du test est également fonction des espèces : les plus primitifs sont constitués d'une membrane flexible et transparente, mais le plus souvent le test s'enrichit en matières minérales qui peuvent être, soit empruntées au milieu (micas, magnétite, spicules d'éponges, etc...) et soudées par un ciment élaboré par l'animal, soit sécrétées par le protoplasme (dans ce cas il est le plus généralement calcaire, quelquefois siliceux). La croissance s'effectue suivant plusieurs modalités :

a) chez les espèces uniloculaires, elle est continue ou réalisée d'emblée ;

b) chez les espèces pluriloculaires elle peut être :

- non-lamellaire et se fait par juxtaposition de loges successives ;
- lamellaire : lors de l'adjonction d'une nouvelle loge, du carbonate de calcium est sécrété sur les loges préexistantes ; il en résulte un épaississement progressif de la paroi de la dernière loge vers la première loge, et l'aspect lamellaire du test (Pl. 1, Figure 1).

Les individus entiers mesurent de quelques dizaines de microns à quelques centimètres et l'épaisseur de la paroi des loges varie de quelques microns à quelques centaines de microns. Ces dimensions en font un matériel difficile à étudier. La microsonde moléculaire à laser Mole a permis de résoudre quelques problèmes concernant le test de ces organismes. Les résultats obtenus apportent des éléments nouveaux dans trois des grands axes de recherche sur l'étude de ces Protistes : la systématique, la biominéralisation et l'écologie.

1. Application de la microsonde Mole en systématique

Comme tous les groupes animaux et végétaux, les Foraminifères sont répartis suivant des critères bien définis, dans une classification dont