cycle. Jasper and Andrews (*3*) report a variation of only 1–2 per cent between measurements made on six normal individuals over a period of 6–18 months. Rubin (*5*), whose method of calculating mean alpha frequency corresponds closely to ours, found a variation of less than 1 cycle/second in the mean alpha frequency of a number of normal subjects and schizophrenics observed over periods up to four months. Thus, our results confirm and extend earlier observations.

The failure to find any correlation between the mean frequency and blood sugar level is of some interest, since we had previously reported variations in mean frequency with changes in blood sugar (*2*). However, in those studies the change was produced by the intravenous injection of sugar or insulin and was rapid. Evidently, at any given frequency level rapid changes in blood sugar will produce shifts in frequency, but the day-to-day variations in mean frequency must be accounted for on some other, as yet unknown, basis. This does not appear to be body temperature.

These results also give some indication of the reliability of this method of frequency analysis of the electroencephalogram. For clinical purposes, changes in mean frequency of greater than 1 cycle/second may be considered significant.

References

1. Davis, H., and Davis, P. *Res. Publ. Ass. nerv. ment. Dis.*, 1939, **19**, **50.**
2. Engel, G. L., Romano, J., Ferris, E. B., Webb, J. P., and Stevens, C. D. *Arch. Neurol. Psychiat.*, 1944, **51**, 134; Engel, G. L., Webb, J. P., and Ferris, E. B. *J. clin. Invest.*, 1945, **24**, 691.
3. Jasper, H. H , and Andrews, H. L. *Arch. Neurol. Psychiat.*, 1938, **39**, **96.**
4. Loomis, A. L., Harvey, E. N., and Hobart, G. *J. exp. Psychol.*, 1936, **19**, **249.**
5. Rubin, M. A. *J. Psychol.*, 1938, **6**, 325.

Ordovician Chazyan Classification in Vermont

Marshall Kay and Wallace M. Cady

Department of Geology, Columbia University, and *U. S. Geological Survey, Washington, D.C.*

Middle Ordovician limestones of west-central Vermont have been described and mapped by Cady (*1*), who included the Crown Point, Beldens, and Middlebury formations in the Chazy "group." Inasmuch as the first-named formation is structurally separated from the Crown Point limestone of the type locality and other outcrops in New York and is succeeded by the Beldens formation rather than by the Valcour limestone, it is proposed that the "Crown Point" formation east of the Champlain thrust in west-central Vermont be designated the Burchards limestone, named from a stream that enters the Lemon Fair River three miles west of the type locality in the belt of outcrop between Cornwall village and The Ledges, Addison County; the formation consists of about 150 feet of somewhat magnesian limestone that has a species of *Maclurites.* The Burchards and succeeding Beldens limestones and dolomites comprise a lithologic sequence that contrasts with the succeeding thinner-bedded Middlebury limestone. This sequence of Burchards and Beldens is designated the Chipman group from Chipman Hill, which lies in the belt of outcrop north of Middlebury village.

The "Chazy" rocks of northern Lake Champlain have been studied by Kay, who has described the Carman quartzite and Youngman formation of northwestern Vermont and southeastern Quebec as succeeding the Beldens in the Highgate Springs slice (*3*). The type Carman consists of about 120 feet of quartz sandstone. The Youngman, more than 300 feet of argillaceous, thin-bedded limestone grading up into dark slate having dense limestone lenses, has *Lonchodomas halli* (Billings) persisting, *Christiania* sp. common in basal beds, *Maclurites* sp. present higher, and *Rostricellula* sp. near the top; the section is somewhat incomplete in the type exposure because of a thrust fault. Kay believes it probable that the Carman quartzite is essentially equivalent to the quartzite in the lower Day Point formation that, with the succeeding Crown Point and Valcour, is the Chazy sequence in New York. It is proposed that the Carman and Youngman formations comprise the Maquam group, named from Maquam Bay, six miles south of the type sections at Highgate Springs, Vermont.

Inasmuch as all these sequences have been called Chazy for nearly a century or longer, it is recommended that the Chazyan series consist of the Chipman and Maquam groups, as well as the Chazy limestones of eastern New York. This use of Chazy is considered to have priority over the Chazyan of Grabau, which added the Black River group (*2*), and of Ulrich, which was for a composite of widely scattered stratigraphic units (*4*).

References

1. Cady, W. M. *Bull. geol. Soc. Amer.*, 1945, **56**, 548.
2. Grabau, A. W. *J. Geol.*, 1909, **17**, 223.
3. Kay, M. *Bull. geol. Soc. Amer.*, 1945, **56.**
4. Ulrich, E. O. *Bull. geol. Soc. Amer.*, 1911, **22**, 391.

A Study of the Inner Bark and Cambial Zone of Black Spruce (*Picea mariana* B.S.P.)[1]

Ernest Anderson and W. W. Pigman

The University of Arizona, Tucson, and *The Institute of Paper Chemistry, Appleton, Wisconsin*

The inner bark and cambial zone of a tree contain living cells that are active in its life processes and growth. These cells take part in the conversion of sugars and other compounds, synthesized elsewhere, into wood and bark. A study of the composition of the living areas of the tree should help greatly in understanding the genesis of materials present in mature woods. Hitherto, relatively few investigations of this type have been undertaken, and, to the best of our knowledge, these have been limited to European woods (*1*). With this in mind, a study of the inner bark and cambial zones of freshly cut trees was begun during the summer of 1946.

Six layers were separated from a black spruce log, approximately 65 years old, which was cut on June 3, 1946. These layers were: (1) the outer bark, (2) the inner bark, (3) the cambial zone, (4) the young sapwood, (5) the sapwood, and

[1] This investigation was suggested by Harry F. Lewis, of The Institute of Paper Chemistry. Acknowledgment is also made to the following staff members of the Institute: I. H. Isenberg, M. A. Buchanan, L. E. Wise, and P. F. Cundy. The authors express their appreciation to Robert Buxton and Mrs. Evelyn K. Ratliff, who made many chemical analyses of products isolated during the investigation.

(6) the heartwood. The cambial zone occurs as a slightly viscous layer on the inner surface of the bark and on the outer surface of the freshly peeled log.

After analysis of small samples of these layers, the results of which are shown in Table 1, larger portions were extracted with hot benzene, alcohol, and water. The inner bark was converted into holocellulose (*4*), which was successively extracted with a 3 per cent solution of ammonium hydroxide and a 5 per cent solution of potassium hydroxide. The various extracts have been analyzed. Although the work is far from complete, a brief report can now be made of the preliminary conclusions that were reached, and certain suggestive hypotheses may be formulated.

TABLE 1

ANALYSES OF FRACTIONS OF BLACK SPRUCE

(On the oven-dry basis)

	Outer bark	Inner bark	Cambial zone	Young sapwood	Sapwood	Heartwood
Ash, %	1.20	3.18	3.57	0.37	0.30	0.28
Nitrogen (Kjeldahl), %	0.32	0.60	1.09	0.26	0.05	0.06
"Protein" (N × 6.4), %	2.05	3.84	7.06	1.66	0.32	0.38
Pentosans, %	11.80	12.03	6.30	8.12	12.05	12.45
Uronic anhydride (CO_2 × 4), %	8.56	10.00	4.60	3.80	3.72	3.92
Lignin (Klason method) in:						
Unextracted material, %	33.9	6.6	1.83	24.9	26.3	26.1
Extractive-free material, %		9.00	6.03			
Methoxyl, %	4.00	2.19	0.72	4.73	4.89	4.75
Tannin (A.O.A.C. method), %	1.9	7.6	Neg.	Neg.	Neg.	Neg.
Starch test (iodine color)	Neg.	Pos.	Neg.	Neg.	Neg.	Neg.

The percentages of "protein" (calculated from Kjeldahl nitrogen) vary in the different layers from 0.3 in the mature wood through 1.65 in the very young sapwood and from 3.85 in the inner bark to 7 in the cambial zone. Although the layers were not separated completely, the higher percentages of "protein" in the inner bark and cambial zone presumably are due to the living material in these layers which contains the protoplasm of the tree. The amount of "protein" in the alcohol-insoluble part of the cambial zone was 19.2 per cent.

Crystalline sucrose to the extent of 33 per cent (on a dry basis) was obtained from the cambial zone. Sucrose was also found in considerable amount in the inner bark. Large amounts of alcohol-soluble sugar sirups from these two zones are yet to be studied.

The cambial zone was low in pentosans, lignin, and methoxyl. These materials are not characteristic of very young tissues but are often found in large amounts in older tissues. They were present in large amounts in the outer bark, sapwood, and heartwood. Possibly they originate in the cambial zone as metabolic products which are then laid down permanently in mature wood. Tannin was found only in the outer and inner bark of this wood.

The benzene extract of both the inner bark and the cambial zone contained a white solid, which may possibly be a glycoside, and a yellowish oil. The solid, which was difficult to separate from starch, did not dissolve in the benzene but was present in finely divided form in the solvent. It amounted to 0.5 per cent of the inner bark. This material gives intense colors with alkali and with methanolic HCl. The oil, which amounted to approximately 4 per cent of the inner bark, probably is similar to the material isolated by Wise and Moore (*3*) from black spruce wood. Fatty materials are known to originate during metabolism of sugars; it is possible that extractives, such as those reported by Wise and Moore, are formed in the living zone and transported later to the wood.

Pectic materials occur in rather large amounts in the inner bark of black spruce, where they are mixed with starch. These were isolated by successive extraction with hot water, very dilute hydrochloric acid, and 3 per cent ammonium hydroxide, and by precipitation as insoluble calcium pectate. They were also isolated from the holocellulose of the inner bark. An insoluble calcium pectate that gave 63.0 per cent uronic anhydride (as measured by evolution of CO_2) was isolated and converted to a pectic acid giving 75.4 per cent uronic anhydride. Because of their presence in greatest amounts in young tissues, it is probable that these materials are laid down during the early stages of cell-wall formation in wood.

Hemicelluloses were isolated by successively extracting the holocellulose of the inner bark with 5 per cent solutions of ammonium hydroxide and potassium hydroxide. For comparison, a hemicellulose was isolated by extracting the holocellulose of sapwood with 5 per cent potassium hydroxide. The chief difference noted between that from the inner bark and that from the sapwood is a much smaller percentage of methoxyl and pentosans in the former than in the latter. This suggests that the hemicelluloses in the inner bark are in the process of formation, whereas those in the sapwood are fully formed. In general, hemicelluloses in mature wood contain one ether-linked methoxyl group for each uronic acid group (*2*). Those from the living part of the tree, such as the inner bark, appear to have less than one methoxyl for each uronic acid group. It is possible that, as methoxyl groups are produced in the metabolic processes of the living zone, they are removed from the system by combination with uronic acids. In this connection it has been found that Klason lignin from the bark has a lower methoxyl content than that from mature wood.

This difference would be explicable if, in fully matured lignin, methoxyl groups were fixed by the lignin molecule in addition to that fixed by polyuronide. In this case, lignin from the bark may not be fully methylated. In the present investigation, Klason lignin from the inner bark contained 7.5 per cent methoxyl, whereas lignin from the sapwood contained 14.9 per cent. On the other hand, an analysis of the Klason lignin from the inner bark revealed that it was very intimately mixed with other (largely nitrogen-containing) materials that have no methoxyl groups. The presence of protein degradation products in the lignin would also account for the lower percentage of methoxyl found.

The study of the composition of the living part of wood is being continued as rapidly as possible both at The Institute of Paper Chemistry and at the University of Arizona.

References

1. ALLSOPP, A., and MISRA, P. *Biochem. J.*, 1940, **34**, 1078; WISLICENUS, H., and HEMPEL, H. *Cellulosechem.*, 1933, 14, 149.
2. ANDERSON, E., KASTER, R. B., and SEELEY, M. G. *J. biol. Chem.*, 1942, **144**, 767.
3. WISE, L. E., and MOORE, S. *J. org. Chem.*, 1945, **10**, 516.
4. WISE, L. E., MURPHY, M., and D'ADDIECO, A. *Paper Trade J.*, 1946, **122**, No. 2, 35.