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THE USE OF WILD PLANTS AS FOOD BY INDIANS.

By Tom Wilson, Vancouver, B.C.

Previous to the advent of the Christian Missionaries, the Indians of British Columbia did no cultivation, as such. They depended for their vegetable food on certain kinds of roots, shoots, leaves and berries which grew in their immediate neighbourhood, or which they might come across in their wanderings.

The coast Indians were fishermen and lived mostly in villages, but were partly nomadic as the seasons changed. The interior Indians were wholly so, and lived by hunting and trapping. Their methods of preparing vegetable stores varied with the locality and its climate. Fruits, such as saskatoon, salmon berry, etc., among the coast Indians were beaten to a pulp, partially fermented, then mixed with fish or bear's grease, and so kept, while in the dry or arid part of the country sun drying or evaporation was the method. This was prevalent among the Indians of the Lillooet, Shuswap, Okanagan and Similkameen countries, and to a limited extent among the Kootenays.

Commencing with the Service Berry, *Amelanchier florida* Lindl. and *A. Cusickii* Fern, Saskatoon, Stcokim, Sheea, or whatever happens to be the local tribe name, it is certainly the most important berry in their estimation. It grows plentifully in different parts of the province, extending up the coast as far as Alaska, and even into the interior and away beyond the confines of British Columbia. On the coast, the berry was pulped and mixed with oolachan grease, then pounded and moulded into cakes. This practice was carried on by the Tsimtsians, Tclinkets and other coast tribes. In the dry belt the berries were simply sundried.

The Soap-oolalie, *Shepherdia canadensis* L., was partially cooked by spreading on layers of damp grass after pulping and allowing it to steam over hot stones. The fruit was bitter, though not unpleasantly so. It was highly prized among the Indians, and an extensive trade existed between the people of the Thompson River and those of the coast, where it grows very sparingly. It evaporates easily, and when for any reason the people were rushed, the berries were sundried, and in this condition they kept very well. When wanted for use a quantity was put in a vessel and covered with warm water for some time; after softening it was beaten with an instrument like an egg beater, when it foamed up like soap suds (hence the name), or like pink ice cream. This would be flavoured with some fruit juice and eaten with a spoon. In other cases the berries were allowed to ferment, and a highly intoxicating liquor was the result, but the effect was not nearly so lasting or so injurious as bad whiskey.

The fruit of the choke cherry, *Prunus demissa* (Nutt.), Dietr., Zotku, according to the Thompson Indians, was gathered by the interior Indians, but this fruit is not known by the coast Indians, as the tree is not found within 80 or 90 miles of the coast. The berries were usually dried for winter use.

The Black Cap, *Rubus leucodermis* Dougl., grows luxuriantly and bears a heavy crop, which is easily picked. This fruit lends itself well to evaporation.

The Salmon Berry, *Rubus spectabilis* Pursh., is by far the most handsome of this genus. It grows luxuriantly all along the coast, and to a distance inland of about 80 miles. The fruit is large, sometimes of a deep crimson colour when ripe, at other times of an amber colour. As it is largely composed of water it will not dry up and is apt to rot. The Indians were in the habit of mixing the berries with bear's grease and boiling them, and so making a kind of jam.

The "Salal," *Gaultheria shallon* Pursh., which grows abundantly on Vancouver Island, and also on the coast of the mainland, some places forming an impenetrable jungle, bears heavy crops of a very wholesome berry, which was picked in large quantities by some tribes. With other tribes the berry was not a favorite. If the weather was favourable attempts were made to evaporate the fruit, otherwise the berries were cooked with grease.

The common wild crab apple was gathered to a limited extent by some of our Indians.

In the foregoing remarks mention has only been made of some of the fruits gathered and eaten by our Indians. In addition there is a long list of roots which were gathered and stored for food.

On the south-east end of Vancouver the favourite bulb, "La camas," *Camassia esculenta* Lindl., as well as several of the wild onions, are still largely gathered, and form an important item of vegetable diet. In Lillooet, also, the wild onion is gathered; in fact, the name Lillooet means "wild onion."

Among other bulbs and roots I may mention: *Lilium parviflorum* (Hook.) Holz, "Makaoeza," in the Thompson language, and "Skamiz," *Erythronium grandiflorum* Pursh.; "Spitlum," *Lewisia rediviva* Pursh., or Bitter Root; all were eagerly sought for. The latter, which is extremely nourishing, was eaten either fresh as it was dug, or threaded on a piece of string and dried, very much as apples were in Canada in olden times.

One root known by the name of "potato" was frequently collected. This was the corm or root-stock of *Claytonia lanceolata* Pursh. These roots vary in size from that of an ordinary marble to that of an egg. They are very rich in starch, and contain a good deal of nourishment. This plant furnished the principal root crop. Certain families looked on certain pieces of ground as their own potatoeilihie (potato ground), and I know an Indian to-day whose sole title to his land is owing to the fact that his mother, grandmother and other generations had been in the habit of digging "potatoes" on that patch. The "potatoes" are all gone now, but some of the land is growing wheat, and part is in orchard.

Bracken roots were occasionally boiled and eaten, but only in extreme cases, though a fairly nutritive food could be made even out of that unpromising article. Fungi of different kinds were also eaten, sometimes raw; very often they were sundried for winter use.

I come now to one of the strangest-looking materials for food purposes, namely, the lichens of the dry belt, which hang like old men's beards from all the coniferous trees, *Alectoria jubata* L. The process of preparation was something like this: A large pit was dug in the ground and the inside made as smooth as possible. A fire was then built inside, and the pit thoroughly heated. The ashes were then thrown out and the pit received a lining of damp grass, on which was laid a layer of "moss," (lichen). Another layer of damp grass, then more lichen, and so on till the pit was full. It was then topped off by more grass, and hot stones were laid around and over the whole mass, and it was kept as hot as possible for a day or more, when it was then supposed to be cooked. If not well prepared it was apt to mildew, but I have eaten it a month after cooking and it was quite good.

Among the Indians of the interior the most important, I may say the only plant used for cordage purposes, was Spatsum, *Apocynum cannabinum* L. The fibre was treated very much the same as hemp, and from it was made fairly thick rope and the finest thread. This was usully spun by the women, between the palm of the hand and the naked thigh.

What would the coast Indian be without the Cedar? Literally lost. Out of the mighty logs he chipped, hewed and burnt his great war canoe, often sixty feet long, and in which he did not hesitate to brave the wild waters of the Pacific, when he went off on a foray on some of the other weaker or less prepared tribes, after which he brought back the spoil, and sometimes captives, to the great potlatch house, sometimes one hundred and fifty feet long by fifty feet wide, all built of cedar—even the great totem pole that stood in front, telling maybe of the owner's pedigree, or perhaps the story of some adventure that he had had. And then the dance, which would be sure to succeed the successful foray. Why, the dancers themselves were ornamented with ceremonial masks of grotesque-looking animals, and these again had been cut out of cedar wood, while the clothes they wore were for the most part made from the inner bark of the tree. And while the dance was going on an old crone might be seen spinning a fishing line from the same material. A great tree the cedar, *Thuja plicata*, Donn.

Three different plants were smoked before the Indians had access to T. & B. or Old Chum. Among the Kootenays the inner bark of the Red Willow, *Cornus stolonifera* Michx., was used sparingly, and very probably the custom was borrowed from the Indians of the plains when they went through the passes to hunt the buffalo.

The leaves of the *Arctostaphylos uva ursi* (L.) Sprengel, were smoked under the name kinnikinnick; the name certainly was borrowed from the east.

The third plant was a veritable tobacco—albeit of poor quality, *Nicotiana attenuata* Torr. This was gathered in bundles and dried, and so smoked; it must have been very hot smoking.

Of the medicinal plants I shall only mention one, and not attempt to write the name that the Squamish Indians call it. It is difficult enough to pronounce. The plant I refer to is "Cascara," *Rhamnus Purshiana* DC The bark of this tree has been known to the Indians for ages as a medicine, and from the Indians it was adopted by the old miners and prospectors. No "old man of the mountains" would think of being without a bottle of the decoction made from barberry bark and Oregon grape when far from a drug store. It is less than thirty years since Cascara became such a popular medicine among the whites. Usually a clump of *Rhamnus* may be noticed near an Indian village. It will be seen that though strips of bark have been removed that they have been taken vertically, and the tree is never entirely girdled, but is treated, in a crude way, very much the same as the Cinchona is treated in Ceylon and Java. And yet the trees grow vigorously.

There is an old saying that "he who takes what is to hand will never want." This was true of the Indians before the white man came among them. They always had enough to eat, such as it was. Now they sometimes suffer from hunger. Once they had the whole country to roam over, to hunt, fish, pick berries and gather roots. Now the area is circumscribed, and the habits of a people cannot be changed in one or two generations. An Indian friend of mine made this remark: "I'm afraid we are trying to be white men too rapidly."

The list of plants given above is not by any means complete, but enough has been given to show that the "poor Siwash" took what was at hand.

SOME NOTES ON FOSSIL COLLECTING, AND ON THE EDRIOSATEROIDEA.

BY GEORGE H. HUDSON

The timely and valuable paper by Dr. E. M. Kindle on "Fossil Collecting," which appeared in THE OTTAWA NATURALIST for January, 1916, has led me to present certain notes and problems belonging to the same subject.

We may group the history of fossil collecting into three overlapping periods or stages. At first specimens were saved out of simple curiosity, and in the "cabinet" they found themselves associated with minerals, archæological specimens and objects of recent historic interest. In this stage only the more showy or curious forms were preserved, and a trilobite might find a setting within the coil of a hangman's rope.

In the second stage the principle focus of interest was also the "cabinet," but this reflected more of the developing individuality or intellectual advancement of the collector, in that it showed a more restricted field and a devotion to its amplification. Certain persons limited themselves to fossils only, and came to value their collection by the number of markedly distinct species presented, and by the perfection of the specimens. Duplicates were saved principally for purposes of exchange, and closely allied species or varieties were rejected as not being *typical*. The idea of the fixity of species was responsible for this attitude. This stage was of the same type as that displayed in coin or postage-stamp collecting, save that it was less discriminating; for in the latter groups an exceedingly slight change in die or plate often enhanced the value of the specimen. As the principle interest shown by second-stage fossil collectors was a "stock-taking" of ancient life, we might call this the inventory stage. This "inventory," however, necessitated the giving of names, the description of types, and the classification of the whole—it was in consequence a "systematic" stage.

The third stage we may call the problem stage, and here, for the first time, we meet with collectors whose purpose is the development and illustration of biologic laws and the modern concept of organic evolution. The material collected must throw light on derivation; on distribution in space and time; on the effect of comparatively fixed or changing environments; and on the advancement or ultimate failure of the groups under investigation. To solve these and other biologic problems, the student must acquire a more thorough knowledge of ancient structure and function, and this can only be acquired through material capable of illustrating minute anatomical detail—both external and internal. Specimens are now saved, not so much for their individual completeness, as for their evidence concerning details of structure. A display series representing this stage is rarely to be seen outside of our larger museums.

The first stage is frequently represented to-day by the contents of a boy's pocket; the second stage by the amateur collection of fossils; and the third stage by the mass of fragments and sections found in the paleobiologist's work-shop. The first stage is of little educational value to the average adult. The second stage, however, is of great value to the general public (where it has access to such collections); to the student of geology, for by its means he comes to recognize forms that enable him to identify strata of the earth's crust; and to the student who desires to enter the field of paleontology, or to become acquainted in a general way with the past evolution of life. The third stage is of vital importance to the world's progress in more ways than we have room to enumerate, and in ways yet unknown to the searchers themselves.

We should recognize the fact that collectors in their individual development usually recapitulate these historic stages, and that a collector may become arrested in his development during the first or second stages. He may branch out at one of these levels and become a "new species," but as his work is usually typical of a stage, we shall find it convenient to speak of him as a collector of the first, second or third *types*.

The work of collectors of the first and second types is, in needless ways, antagonistic to the work of those of the third type. For instance, the inexperienced collector makes a surface find, and with chisel and hammer proceeds to secure his specimen. He begins with great care to cut a groove around it to enable him to preserve it on a rectangular block, which will display well in his cabinet. Before he has completed his work a fissure develops which cuts across the specimen and removes perhaps a third of it. To his mind this specimen is spoiled. He throws away the separated fragment, and disappointedly leaves his find in order to search for another. I cannot but contrast this procedure with that of a collector I well remember. In breaking off a part of a ledge some portions of a rare trilobite were discovered. Before attempting to remove the rest of the specimen this collector first secured all fallen fragments which preserved any portion of it, and fastened them to the removed piece with a little glue. The portion still remaining in the cliff edge was next secured and the whole carefully wrapped in paper and tied together. I recall an instance in which a specimen, after being freed from its matrix in the workshop, showed the loss of a portion of a remarkably long caudal spine. In the following year the original collector made a long journey back to the quarry, found the place from which the specimen was taken, and secured the rest of the imbedded spine.

Attention is called to the destructive work of the amateur, because he outnumbers the experienced collector ten to one, and not only destroys much valuable matter in the field, but oftimes loses his interest in his own collection, and allows it finally to go the way of all waste. Particularly is this true in the neighbourhood of certain boys' summer camps, where "nature study" leads them afield with their "councillors," and where indiscriminate collecting is encouraged. The damage inflicted by the amateur is wholly unintentional, and the more experienced worker has but to take an interest in the younger collectors to make them very helpful allies.

The amateur is not the only person who injures the field in which he operates. Many experienced collectors of the "second type" still have the dominant idea that well-nigh perfect specimens are alone worth saving. This, to my knowledge, has led some of them to crush with the hammer certain finds that they had stopped to examine and found defective. This impulse to destroy in the field may arise from disappointment, or from the desire to avoid being misled at a subsequent visit.

To the above loss we must add that which often occurs when the "cabinet" is re-arranged and many specimens thrown away. Because of the great difference in point of view between collectors of the second and third types, this loss may be a serious one.

Some will doubtless think the picture overdrawn. To their minds the supply of fossil forms is practically inexhaustable.

We may grant this so far as very common species are concerned, and for most specimens taken from below the present rock surface. There are two fields, however, in which the loss is not only real but at the same time serious. I refer here to weathered surface material and to rarer species whose structure is not fully known.

Well weathered material may in a single specimen reveal many minute details, both of outer surface and interior. If the nearly complete form is preserved, such a specimen may be saved, and finally yield new truths to some paleobiologist. On the other hand any great loss of surface or of other portions of the whole may make the specimen one of little or no value to a collector of the second type, yet the fragment might show details of inestimable value to the collector of the third type. We must elaborate these statements somewhat in order to get a clearer idea of their import.

A complete specimen may do no more than add a new species to our ever growing lists, while a well weathered fragment may add largely to our knowledge of the structure and function of a whole order. For example, the type of *Blastoidocrinus carcharidens* Billings, shows less than half of a complete specimen, but it reveals the character of its food-grooves; cover-plates; floor-plates; the drainage tubes situated between the outer ends of the latter and leading into the hydrospires; the outer surfaces of the hydrospire folds; the exceeding thinness of the latter, fitting the organ to perform the function of respiration; the fine corrugations on their inner surfaces, giving strength with extreme lightness; the external openings or discharge pores, showing the direction of flow to be downward (cataspires), and not upward (anaspires) as in the blastoidea; and the true basals. (See N. Y. State Museum Bulletin 149, plates I-IV.) Not one of these things was to be seen in the well-nigh perfect specimen collected by E. M. Hudson on Valcour Island, until it was sectioned, and even then the details shown were neither so numerous nor so complete as in the holotype, and in other still smaller fragments. (N.Y. State Museum Bulletin 107, plates 1-4). The holotype also demonstrates the absence of a lancet plate, and is itself clearly an example of a new order of Echinoderms, the *Parablastoidea* (last reference, page 119).

Let me refer to another specimen less than "half there." This is the type of *Protopalaeaster narrawayi*, papers on which appeared in THE OTTAWA NATURALIST in May, June, July and December, 1912, and October, 1913. In addition to these papers the species was figured in N.Y. State Museum Bulletin 164; by W. K. Spencer, in part I of his "Monograph of the Paleozoic Asteroidea," 1914; and further shown by a fine plate in Schuchert's "Revision of Paleozoic Stelleroidea," U. S. National Museum, 1915. Schuchert's additional material indicates that the type specimen had lost practically its entire apical skeleton. It, however, reveals structures not yet seen in any fossil sea-star ever collected before. This rare find of Mr. J. E. Narraway at City View should prove of interest to the readers of this magazine, and it is to be hoped that other fragments of this species will be found, as there are many points in its structure not yet satisfactorily explained.

A study of the specimen figured by Raymond, in OTTAWA NATURALIST, December, 1912, is also one of those marvellous dissections and preparations by nature which has so much to say concerning the minute anatomy or histology of an extinct subclass of Asterozoa. This specimen I have treated in an article which will appear in the Director's report of the N. Y. State Museum for 1915.

Now, we must bear in mind that Mother Nature has worked for hundreds of years on some of her surface material to prepare it in a manner that man cannot yet imitate. We might say that as a carefully dissected and preserved frog, so prepared as to display its internal organs, would have a greater money value than an ordinary dead frog, so would a dissection and preparation at nature's hands of one of her buried forms enhance its value. At the same time, however, we should bear in mind that the dissection of the frog is a much easier matter than the dissection of any fossil. The field of weathered surface is certainly limited, and collectors in any region that has been frequently visited will tell one that good finds are not so abundant as they used to be. When surface material has so much to tell, it is certainly a matter of regret to have a large percentage of it destroyed through ignorance and carelessness. It becomes a duty then to conserve this material, and to make it widely known that well weathered specimens of all uncommon species, even though very fragmentary (such as the separate ossicles of Blastoidocrinus, figured in N. Y. State Museum Bulletin 107, plates 4-7) is desired for study of external ornament, form of ossicles, or other elements of structure, manner of articulation, growth stages, etc.

Buried material is, of course, limitless so far as common species are concerned, but for all rare forms such material is desired for study through development and sectioning. In many cases fragments might be of inestimable value.

(To be continued.)

BIRD NOTES.

-An influx of Evening Grosbeaks occurred during the month of March, large flocks appearing within the city limits and in less settled d stricts n arby. The birds were so conspicuous and popular that many interesting items appeared in the daily press. A number of ignorant people either trapped or shot these birds, but the timely intervention of the proper authorities prevented what might have been a wholesale slaughter of hundreds of this beautiful species. The Grosbeaks were subsisting on a diet of mountain-ash berries. Several trees, under personal observation, were stripped bare of berries in two days. The birds have apparently gone northward again, as none have been seen since March 26th. On March 28th, on the mountain side, I noticed a dead male, which was in perfect condition and had not been shot. Perhaps this bird died of starvation, as others have been lately picked up and their crops have been empty.

The Pine Grosbeaks have been conspicuous by their absence, only one male and two females being seen during the entire winter. These were also feeding on mountain-ash berries, and would occasionally drop into a pool of water to take a bath. The birds were quite tame, allowing anybody to approach within a few feet of them.

The spring migration has set in in earnest and quite suddenly. A week ago hard winter conditions were prevailing, but now the weather is warm and summerlike. The Prairie Horned Larks were observed on March 5th. Although crows have been reported from certain farming districts a few miles outside of Montreal during the winter, the first spring arrivals in this locality appeared on March 12th, becoming more abundant each day. On March 26th a flock of Red-winged Blackbirds was noted, and one Bluebird put in an appearance. On March 28th a Song Sparrow was heard, and the day following the birds were common, about fifteen being heard singing in an orchard where there was plenty of brush and cover.

March 30th was a fine, warm spring day. At 4 p.m. I visited an area of low ground some 400 yards square, and flanked on one side by a small stream and a thin growth of alder and willow bushes. This locality was covered by snow and water, and I was immediately attracted by a flock of about 50 Robins, which were probably going further north, and six Bluebirds running over its surface. The Bluebirds would fly into the bushes and quietly d op to the snow again, with an occasional soft call note. The birds were evidently feeding on spiders or insects, but after floundering through slush and water over boot tops, the food question still remained a mystery. At 5.30 p.m. three Robins perched in trees and started warbling, and continued so for ten minutes. The movement of the Robins and Bluebirds over the surface of the snow was an interesting sight. In the hardwoods adjoining, two Yellow-bellied Sapsuckers, one White-breasted Nuthatch, one Downy and one Hairy Woodpecker were seen. As I lingered about a Slate-coloured Junco joined the group on the ground.

Westmount, Que. W. J. BROWN.

ABERRATION IN *HEPATICA ACUTILOBA*.

BY BRO. M. VICTORIN, OF THE CHRISTIAN SCHOOLS, LONGUEUIL COLLEGE, QUE.

The common Liverleaf of our western Quebec woods, *Hepatica acutiloba* DC., is not only a very handsome plant, but also the subject matter of more than one interesting morphological problem. It can be, for instance, asserted that nearly every beginner in botany has been misled by the three-bracted involucre subtending the flower, thus encountering much trouble in using the keys of the manuals.

That this pseudo-calyx is stricIty an involucre is evidenced by the fact that the parts of it show, in certain teratological specimens, a tendency to cleave after the manner of a well-known group of Anemones, of which *Anemone canadensis* L., is a good example. Holsted (1) hints at the fact, and Goffart (2) after a careful study of the leaf anatomy, holds that *Hepatica* cannot be separated from *Anemone*.

We wish to record here some particular instances of abnormality in *Hepatica*. Figure 1 illustrates a specimen collected in Lougueuil, Que., during the month of May, 1914, in which the bracts make a partial return to the leaf form. One of them is nearly perfect in outline, though of small size; the other two are merely enlarged, retaining their original form. The flower itself, markedly depauperate, is dioecious.

In April, 1916, we observed on the St. Bruno Mountain, among a luxuriant growth of *Hepatica*, specimens departing from the type in the following particulars: flowers of an infrequent

(1) Holsted, *Bull. Torr.Bot.Club*, 14: 121.
(2) Goffart Jules. *Recherches sur l'anatomie des feuilles dans les Renonculacées*. Arch. Inst. Bot. Univ. Liège, III, 1901.

rose colour, depauperate, dioecious; involucre composed of 4-5 bracts, one of them sometimes bifid.

The abortion of the stamens and the reduction of the petaloid sepals seem to account well for the increased luxuriance of the vegetative organs. Indeed, a mass of observations point to the fact that, in the metabolism of plants, vegetative and reproductive activity behave in inverse ratio.

The affinity of the genus *Hepatica* with *Anemone* is an interesting problem, and observers should be on the lookout for deviations that may open lines of research.

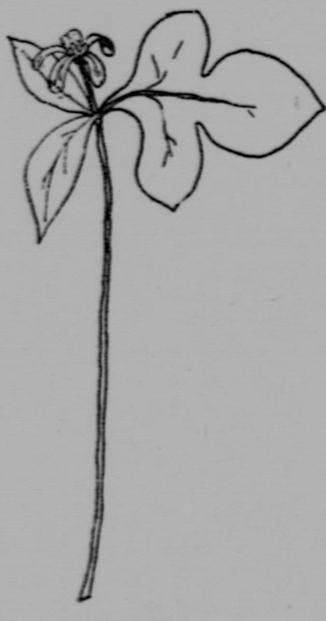

Fig. 1.
Abnormal involucre of *Hepatica acutiloba* DC.

A PRELIMINARY PAPER ON THE ORIGIN AND CLASSIFICATION OF INTRAFORMATIONAL CONGLOMERATES AND BRECCIAS.

BY RICHARD M. FIELD, AGASSIZ MUSEUM, CAMBRIDGE, MASS.

INTRODUCTION.

The term intraformational in contradistinction to interformational was first proposed by Walcott (1) in 1894. He writes: "An intraformational conglomerate is one formed within a geologic formation of material derived from and deposited within that formation." In the same paper he remarks upon the importance of determining the time element or sequence of events in the formation of a sedimentary or clastic rock, by a study of the shapes and textures of its constituents. Thus, in his introduction he writes (p. 91): "Usually the presence of a conglomerate in a stratigraphic series of rocks is a matter of considerable importance to the geologist. He naturally infers the presence of a break in the continuity of sedimentation; an orographic movement of greater of less extent; erosion of pre-existing formation." In other words the term conglomerate by its definition conveys to the mind of the stratigrapher a great difference between the ages of the pebbles and the cement. It is proposed to show in this paper that there is often a nice distinction between the ages of the constituents in most conglomerates and in intraformational conglomerates in particular. It is true that we arrive at a knowledge of the sequence of the events which have taken place in the formation of any given clastic by describing the texture and shape of its constituents, but the writer believes that the tendency has been too strong among students of the sedimentary rocks to express their findings in purely textural and structural terms without special thought as to their history and origin. Thus, any rock, be it limestone or otherwise, which is formed of coarse and apparently water-worn materials, is dubbed a conglomerate, and its natural history, even if recognized, is lightly passed over in its classification.

It is not proposed in this paper to attempt a classification of all conglomerates on such a basis as outlined above. A study of certain Paleozoic limestone conglomerates, and especially of certain structural and textural phenomena as exhibited in the limestone formations at Trenton Chasm, Chambersburg, Bellefonte and elsewhere, has led to the belief that a compilation and discussion of the evidence of the so-called intraformational "conglomerates," breccias, or "corrugations," is needed if we are to arrive at exact conclusions regarding certain common phenomena associated with the history of the ancient seas.

Grabau (2) states that intraformational brecciation is "probably in all cases an extreme of subaquatic-gliding-deformation." The writer does not feel that most of the phenomena observed by him in the Appalachians will bear out this statement. The principal example of folding and brecciation cited by Grabau as due to this cause, is the one at Trenton Chasm, New York. Hahn (3) described the folds as due to "subaqueous solifluction." Grabau (sp. cit. p. 785) states that "Deformation through gliding may result in complete brecciation of the deformed layers. The fragments may lie in all positions, as in the ordinary intraformational conglomerates, or they may consist of thin cakes, many of which in the gliding process have assumed a vertical position in the mass. This forms the so-called 'edgewise conglomerate,' common in the Ordovician limestones of the Appalachian region. The characteristics of all these formations seem to point to rather shallow water as the place of deposition of these strata, and the possible periodic exposure and hardening of the surface layers." The writer has been able to prove to his own satisfaction that some of the edgewise conglomerates in the Bellefonte section are certainly not due to subaquatic-gliding-deformation, neither does he believe that any one hypothesis is able to account for the formation of all intraformational conglomerates, whether the orientation of their fragments be "edgewise" or not. He feels convinced that the folds and edgewise conglomerates exposed to view in the gorge at Trenton Falls are, as previously supposed, truly of tectonic origin, and, therefore, not, in the sense of Walcott's definition, "intraformational conglomerates" at all, since they were not "deposited in the formation." A recent study of the Trenton Chasm, in company with Drs. Raymond and Shuler, produced evidence which points conclusively to the tectonic origin of the folds and edgewise conglomerates, as is amply set forth in Miller's (4) recent paper.

It was only a few years ago that ripple-marks and mud-cracks in limestone were considered rare and unusual phenomena. Indeed stratigraphers and paleontologists did not expect to find and did not hunt for such structures in the Paleozoic limestones. To-day the investigators of the Cambrian and the Ordovician calcareous rocks are reporting such data from the

St. Lawrence valley to the Cretaceous boundary of the Paleozoic in Georgia and Alabama. Thus there is gradually being amassed more and more material significant of the diagenesis of the Cambrian and Ordovician rocks, and relating to the history of the seas from and under which they were deposited. It will not do, in this study, to dub all coarse, clastic, intraformational rocks, whose constituents may or may not be rounded, as simple conglomerates all of similar origin. It is believed that a more careful examination of these intraformational structures in the field and laboratory will greatly aid in deciphering the history of the original limestone sediments. Upon the rock-walls of the Bellefonte quarries have been observed many of the structural phenomena which are to be found on shallow water areas, mud-flats and beaches of to-day. Ripple-marks, mud-cracks, edgewise conglomerates and breccias are disclosed in close stratigraphic sequence wherever exposure and subaerial erosion have been able to develop the hidden structures. The conclusion has been reached that nearly all of the intraformational conglomerates and breccias seen at Chambersburg, Bellefonte and Tyrone, Pennsylvania, are of extremely shallow water origin; in fact, their formation postulates an emergence from the sea such as is common under tidal action. That mud-cracked beds and intraformational breccias are in certain cases one and the same thing is, perhaps, the only original contribution to the origin and classification of intraformational structures.

GLOMERATE AND PHENOCLAST.

Before proceeding with the classification of intraformational structures, it seems best to analyze the term conglomerate.* Indeed the study of intraformational "conglomerates" requires a more careful consideration of all conglomerates than has heretofore been deemed necessary. A review of the literature, as well as certain examples studied in the field, has shown that not all intraformational conglomerates are made up of water-worn materials; in fact, certain of them are composed of distinctly brecciated fragments which show no signs of attrition by water transportation, a common characteristic according to most geologists. Walcott (op. cit. p. 192) recognized this diffi-

* Most stratigraphers would certainly agree that true breccias cannot be defined under the general term of *conglomerate*, yet if we refer to the Century Dictionary we discover that although a conglomerate is defined as "a rock made up of the rounded and water-worn debris of previously existing rocks", a breccia is defined as "a conglomerate in which the fragments, instead of being rounded or water-worn, are angular". No less an authority than J. D. Whitney is responsible for these definitions but most geologists would probably refuse to accept them as they stand. Quotation is taken from the Century Dictionary only to show that there is some confusion at least at present in regard to just what *conglomerate* means.

culty when he wrote: "Care is to be taken that intraformational breccias are not to be confounded with intraformational conglomerates. The former have a wide geographic distribution, and owe their origin to local disturbances within the beds affected, without pre-supposing elevation above sea level and erosion." As will be pointed out later, limestone breccias can be formed under other than truly tectonic conditions. It may seem strange at first to consider a mud-cracked limestone as a brecciated rock, and yet viewed in cross section, or at right angles to the bedding plane, the hand specimen or field section will often show a characteristic brecciated structure. It is, therefore, proposed in the present classification to introduce two new terms, glomerate and phenoclast, in describing all those rocks (glomerate) which are of sedimentary origin, coarse, or psephitic in texture, whether or not their "show" constituents (phenoclasts) give signs of attrition and transportation.

GLOMERATE, according to the Century Dictionary, means "collected into a spherical form or mass." It is an old English word and rarely used. Conglomerate, in its ordinary sense, is also defined as "collected or clustered together," the shape of the materials forming the cluster being undefined; while the geological term "conglomerate" is defined as "a rock made up of the *rounded and water-worn debris* of previously existing rocks, etc.," (the italics are the writer's). It is proposed to use the term *glomerate* in a geological sense to mean any sedimentary or clastic rock made up of roughly graded debris formed within itself or from pre-existing rocks. Such a term would cover breccias, conglomerates and certain other rocks of doubtful origin, and its need will be more obvious further on in this paper. Nauman, in his "Geognosie," proposed the term *Psephite*, but it has never been widely adopted, and probably never will be, although it is a useful and descriptive word in petrology and geology. Nauman defined psephite structure thus: "Die Fragmente, aus welchen die klastischen Gesteine bestehen, sind entweder gross, so dass sie als formliche Gesteinstucke erscheinen, welche theils *eckig* theils *abgerundet* sein koennen. In diesem Falle lasst die structure als psephite-structure bezeichen, weil sich die betreffenden Gestein als Agregate grossere oder kleinen Steinen darstellen" (p. 446. The italics are the writer's.)

PHENOCLAST.—There is as great a need for a term to express the order or size of the constituents in a sedimentary rock as there is for the term *phenocryst*, which designates a large crystal in the ground mass of a crystalline rock. Phenoclast, from *pheno*: show; and *clast*: clastic, broken piece or fragment, is proposed to designate the larger fragments, pebbles or allied forms which are easily distinguished from the ground mass or cementing material. They, the phenoclasts, may be of several orders of size. The term is convenient, as it is not always correct to refer to the major constituents of a conglomerate as pebbles, or even brecciated fragments. For instance, in the edgewise "conglomerates," the "pebbles" and cement are apt to be formed from the same material; also the shape of the "pebbles" is hardly pebble-like, neither are the "pebbles" true, brecciated fragments. Also, in certain types to be described later, the bioglomerates, the phenoclasts are obviously neither pebbles nor angular material. Their outline is as peculiar and distinct as is their origin. Thus we find all variations, from sand-like particles to pebbles and breccias, and all of them conspicuously distinct from the cement or ground mass.

CLASSIFICATION.

(See table on page 35.) The stratigrapher is primarily interested in the "sequence of events," as exhibited by the relative position of, and the structures and fossils within, the formations which he studies in the field. He must observe texture and structure as well as fossils—in short, he should be lithologist and structural geologist as well as paleontologist. What little the present day stratigrapher knows regarding the texture of the sedimentary rocks, he has acquired with the methods of the petrologist, methods largely developed for the investigation of the igneous or crystalline rocks. The petrographer studies his thin sections and classifies his specimens according to their macroscopic and microscopic textures and mineral contents; the resulting data, together with the structural details and occurrence of the rocks in the field, are used by the petrologist to build his classification of the igneous rocks and to promote his theories as to their history and origin. Thus, studies in "paragenesis" and "order of crystallization" within veins and hypothetical rock melts have resulted in our present knowledge, through facts and hypothesis, regarding the main, great division of the rocks which form the earth's crust. Microscopic investigation of the sedimentaries, and especially of the limestones, has not appealed to the petrographer. The supposed lack of variation in texture, and more or less homogeneous mineral composition, has failed to raise the same amount of interest in their classification and origin as in the igneous rocks. Even granting the fact that with the limestones are associated, in many cases, the relics of past floras and faunas, which should stimulate investigation as to the history of the rock's formation, yet, because of the inherent difficulty of proving anything by the microscope, the limestones have been little studied. The tendency has also been to neglect their macroscopic phenomena in the field, although enough data has now been collected to stimulate an interest in its application to causes and events. It may soon be possible to classify sedimentary rocks according to the sequence of formative events which they have undergone. Such a classification is very much to be desired, as it will eventually give us a Natural History of the sedimentary rocks. In this paper the attempt will be made to classify intraformational glomerates with the above facts in mind. Thus, all intraformational glomerates may be divided into two groups: *A*, those whose present structure is contemporaneous with their primary lithification; and *B*, those whose present structure is non-contemporaneous with their primary lithification. Again, under class *B*, the present structures may be either previous or subsequent to the primary lithification. We will examine the classification more closely when we discuss the mode of origin of each type. As stated before, field evidence strongly points to the fact that it is impossible to explain all intraformational glomerates by a single hypothesis. It has been suggested that the rapidly growing amount of data concerning the occurrences of such rocks makes it unwise to classify them all under the term *conglomerate*. This statement will be appreciated fully by those who have observed different occurrences in the field, or have even read the descriptions by the authors who have studied and described them. Laying aside for the moment the conclusions reached by each investigator as to the origin of the particular intraformational glomerates in his area, we may at least rely upon his attempt to describe what he has seen. Descriptions of intraformational glomerates are so varied that one is forced to the conclusion that the variations cannot all be the result of a single set of factors. The study of intraformational glomerates is largely a study of the phenoclasts which bring them so strikingly to the notice of the field geologist, and it is upon the size, shape, structure (if present), and composition of the phenoclasts that this present classification is largely made. The arrangement of the phenoclasts may be heterogeneous, unsorted, parallel, banded, radiate or edgewise. The arrangement, as well as the size, shape, structure and composition, of the phenoclasts is intimately connected with their origin and the depth of water under which they were deposited, the strength of tidal currents, if any, the topography of the sea floor, and character of the sediments. The presence of organisms in the slimy mud of the seas may also have proved a determining factor in their evolution.

CLASSIFICATION OF INTRAFORMATIONAL GLOMERATES.

A. Present structure contemporaneous with primary lithification.
- I. Shape of phenoclasts not dependent upon transportation and attrition.
  - *a*. Endolithic breccias (mud-crack breccias.)
  - *b*. Bioglomerates.
    - 1. Result of animal (?) activity.
      - (a) "Strephochetal" glomerates.
      - (b) "Wingia" glomerates.
    - 2. Result of vegetable activity.
      - (a) "Corosion" glomerates (formed by algae).
      - (b) Algal glomerates (formed from algae).
  - *c*. Gleitungsphenomene; sub-aquatic-gliding-deformation "conglomerates."
    - 1. Lacustrine.
    - 2. Marine.
- II. Shape of phenoclasts partially dependent upon transportation and attrition.
  - *a*. Stratified glomerates.
  - *b*. "Edgewise" glomerates.

B. Present structure non-contemporaneous with primary lithification.
- I. Present structure partially previous to primary lithification.
  - 1. Shape of phenoclasts entirely dependent upon transportation and attrition.
    - *a*. Limestone conglomerates.
    - *b*. Mixed conglomerates.
  - 2. Shape of phenoclasts not affected by transportation and attrition.
    - *a*. Cliff breccias.
- II. Present structure subsequent to primary lithification.
  - 1. Tectibreccias.
  - 2. Enterolithic breccias.
  - 3. Ice-formed breccias. Formed by
    - *a*. Icebergs.
    - *b*. Continental glaciers.
      - 1. Result of shove.
      - 2. Result of thaw.

ENDOLITHIC BRECCIATION, (see Grabau, p. 777).—Mud-crack breccias.

Mud cracks are found to be of much commoner occurrence in the Cambrian and Ordovician limestones than was formerly supposed. Where there was a shallowing of the Ordovician seas so as to permit intermittent periods of dessication, mud-cracks are well developed over wide areas, and for a stratigraphic distance of several feet. Apparently the conditions which allow of the formation of mud-cracks (see fig. 1) also postulate a slight variation in the composition of the limy muds originally deposited. Thus, a series of alternating layers, which have been successively cracked by dessication, when viewed at right angles to their plane of deposition, show a series of stratified brecciated fragments. It is interesting to note that where quarries have been opened in the Bellefonte section (at both the middle Beekmantown and Lowville horizons) so as to expose the limestone beds for some distance along both the dip and strike, great mud-cracked areas have been brought to view. The writer has seen a mud-cracked surface on the west wall of the quarries at Tyrone which was at least one-half an acre in area. Only the closest inspection, however, of the section across or at right angles to the dip will show any structure that might lead the stratigrapher to suppose that mud-cracks were present, and in such great abundance. When the filling of the cracks, or rather, the material surrounding the phenoclasts, is of a different colour or texture from that of the phenoclasts themselves, a stratified intraformational breccia often proclaims that its other name is "mud-crack." Thus, in a region such as that characterized by the Appalachian type of folds, where the rocks are usually observed at an angle of between 25 and 60 degrees, it is quite natural that mud-cracks and ripple-marks should be considered rare phenomena, except where exposed in quarries and road-cuts along the strike. The mud-crack zone may have a stratigraphic thickness of only 3 or 4 feet and yet extend along the strike a distance as great as that from Bellefonte to Tyrone (60 miles), or even farther. What the total area of such a mud-cracked surface might amount to is difficult to surmise. Owing to the fact that the dip of the limestones at Pleasant Gap, several miles east of Bellefonte, is considerably flatter than the dip of the same beds at the latter place, the writer has been unable to get, as yet, any exact data as to the geographical extent of this phenomenon, but all signs point to its being an exceptionally wide one.

In connection with this subject it might be well to mention a certain columnar structure observed and described by E. M. Kindle (5) in the Silurian limestone on Temiscouata Lake, in eastern Quebec. The occurrence of columnar structure in limestone is unusual, and very like basaltic columnar structure in general, "but the columns are perhaps less regular in the number of faces shown, five to seven being a common number."

(To be continued).

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