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THE LIVING GLOBE*

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Dynamics is the soul of the problem.
—*T. C. Chamberlin.*

During the nineteenth century, geology, dependent on physics, knew but one ultimate terrestrial force—gravity. Gravity, the conservator of established relations, was the cause of all disturbances in any effort to restore any dis-established relations. He held continents and ocean basins in balance, in spite of erosion and sediment; he raised mountain chains by contracting the earth and wrinkling the crust; he pulled the globe constantly toward the center and transformed the energy of in-fall into heat; and since the heat escaped he thus cooled the earth, pointing to a dark and chilly future. Similarly, he was the source of all heat in the sun, and the life-giving energy of that luminary was definitely limited. There was enough truth in these ideas to command credence, and yet they so narrowed the possibilities of pre-historic geology and cosmogony, not to mention the denial of future opportunity, that they were found wholly inadequate. When Chamberlin challenged Lord Kelvin's estimate of twenty to forty million years as the probable past of the earth he argued for the strength of geologic evidence as opposed to the weakness of imperfect, incomplete knowledge of natural forces.[1]

The discovery of radioactivity and of the general occurrence of radioactive minerals throughout the accessible rocks, though in very minute quantities, opened new possibilities to geologic theory. Here was a source of atomic energy, quite independent of gravity and abundantly able to supply heat for indefinite periods of time. Geologists were slow, however, to avail themselves of this potent energy. Chamberlin in 1911 welcomed the opportunity thus afforded for

* Address of the retiring president of the Pacific Division of the American Association for the Advancement of Science, Los Angeles, California, June 25, 1935.

[1] T. C. Chamberlin, Science, n. s., Vols. 9 and 10, 1899.

development of alternative hypotheses of earth history, but did not formulate a comprehensive theory.[2] Arthur Holmes, of Durham, in 1915 essayed to reconstruct the thermal history of the earth on the assumption that it is a cooling globe, which has been losing heat for 1,600,000 years. He discarded the idea that the earth might be getting hotter and was obliged to assume that radioactive elements had become concentrated chiefly in the crustal rocks. The well-known work of Joly, "The Surface History of the Earth," appeared in 1925. It presented an argument for repeated melting and alternate solidification of a shell below the outer crust and is a very suggestive work. In 1928 Holmes, having found his ideas of 1915 untenable, proposed a new theory, which recognizes the presence of radioactive elements beneath the crust, to a depth of 2,900 kilometers, uniformly distributed but in very minute quantities. To dispose of the accumulating heat he assumes a stirring by convection currents and escape by conduction through thin portions of the crust.[3] Among American thinkers Barrell and L. H. Adams have offered constructive ideas. Both inclined to recognize an irregular distribution of radioactive elements and reasoned that the effects of heating would be local, not general. Barrell's thought unfortunately never attained development as a complete working hypothesis, and Adams has not generalized beyond the statement that variations in radioactive content would result in local melting and might maintain a locally high temperature almost indefinitely.

In 1931, on reviewing the hypotheses framed to elucidate the possible thermal history of the globe, I suggested that the difficulties which Holmes, Joly and some others had encountered were due to the assumption that radioactive elements were so distributed as to produce uniform heating in the mass or in some particular shell. It seems to me quite unnatural and inconsistent with geologic and geophysical data to assume homogeneity of constitution for any considerable mass or shell of the earth and therefore more rational to start with the assumption of heterogeneity.[4]

In the meantime our knowledge of conditions in the interior of the earth has grown apace. Those swift and penetrating scouts, the elastic waves from earthquake shocks, bring word of the conditions they have encountered in coursing through the depths or in traversing an outer shell. From them we learn that the going is good anywhere between the surface and a depth of 1,770 miles (2,850 km).[5] Rocks to that depth are highly elastic. But beyond is something different. They can not get through the central sphere, the substance of which is inelastic.

We have no word to describe a state of matter which is characterized by inelasticity except we say fluid. But the core of the earth—for that is what the sphere in question is—is so dense and so stiff that "fluid" conveys a false notion of mobility. The material is nearly as heavy as lead, probably flows much less easily and is supposed to consist chiefly of nickel, iron and other heavy elements. The inelastic condition of such substances is attributable, so far as our experience goes, only to melting, and a molten condition under the enormous pressure of the interior requires very high temperature. Hence we may conclude that the core is very hot.

How did the core become so hot? Here we begin to speculate less surely, and the paths of thought diverge backwards as well as forwards. If we incline to follow the astronomers and mathematical physicists, who argue that the globe once passed through a completely molten condition, we may recognize in the molten core of the earth a residual body which has never cooled. Or, if we think, as Chamberlin did, that the globe was solid from the beginning of its growth as a planet, we may reason that the interior has become heated by compression by gravity or that it has grown hotter through the disintegration of radioactive elements.

The assumption that the globe was once wholly molten is still generally accepted, though it is no longer so imperative as it seemed to be before radioactive heating was recognized. It appeared to get a setback when L. H. Adams suggested that any crust which had formed by cooling of the surface must sink into the lighter melt and accumulate in the depths, so that the globe would solidify from within outward. But even so, the depth to which blocks of crust might sink would be limited by still heavier, though molten layers, and the core might become enclosed in a solid shell, as it now is. I see no cogent objection to that view, although I do think Chamberlin's analysis of the conditions attending the separation of the earth from the sun was more complete and accurate than that which leads astronomers to infer a molten globe in lieu of the solid one that he conceived. But that is another question. The molten core may be a residual molten body, enclosed in an outer shell that is thick enough to have prevented the escape of heat, or it may have been so supplied with heat by compression and feeble radioactivity that any escaping energy was replaced and the body has not been cooled.

On the other hand, if the globe assembled by the gathering of sun-dust according to Chamberlin's planetesimal hypothesis, the core presumably con-

[2] T. C. Chamberlin, *Jour. Geology*, 19: 673–695, 1911.

[3] Arthur Holmes, *Trans. Geol. Soc. Glasgow*, 18, Pt. III: 559–606, 1928; *Jour. Wash. Acad. Sci.*, 23: 169–195, 1933.

[4] Bailey Willis, *Am. Jour. Sci.*, Vol. 23, 1932.

[5] B. Gutenberg, *Gerland's Beiträge*, Bd. XVII, p. 365, 1927; J. B. Macelwane, S.J., *Bull. Seis. Soc. Am.*, 14: 81–89, 1924.

sisted of heavy elements, among which radium and other radioactive substances would be expected to occur. Whatever its initial size might have been and however small the proportion of heat generators, the temperature of the central body would be raised after it had become sufficiently mantled to prevent escape of heat as fast as it accumulated, and a molten condition would eventually ensue. It appears from the estimates of Holmes, Joly and Jeffries that the two thousand million years which the solid earth surely counts would have afforded quite sufficient time to melt the core. Any such calculation is, of course, a guess, for we can assume such a proportion of radioactive elements as will nicely have done the work, or we can assume less favorable conditions. The essential fact is that the melting can be attributed entirely to radioactivity without postulating improbabilities.

Whatever the past may have been, I regard it as probable that the melting process has not ceased in the interior. The reason for thinking that it continues is the sharpness of the boundary that separates the core from the elastic shell which surrounds it. Earthquake waves of the elastic type locate the limit to which they can penetrate and beyond which they fade away into the inelastic core within 12 to 20 miles (20 to 30 km). That is to say, they fix the radius of the core within 1 per cent. Inside of that very thin transition shell is a molten sphere. Outside of it is the mantle of highly elastic, solid rock. The latter is no doubt hot, but not melted. The condition can not be a stable one. The dynamic core is either losing or gaining heat, is either shrinking or increasing in diameter.

To explain this actual condition there are the two distinct lines of inference already suggested. Starting with a molten earth we may imagine the blocks of crust sinking to a certain depth, remelting there and thus absorbing heat. Continued formation of the crust and continued remelting of sunken blocks would in time solidify an outer shell, while the interior would cool very slowly. We may be observing a stage of that process.

On the other hand, if the globe had a smaller molten core originally or had initially been entirely solid but contained a small proportion of radioactive elements, the continued generation of heat would melt it from within outward. It is not necessary to suppose the heating elements uniformly distributed. Foci of energy would develop local bodies which would eventually coalesce. A molten interior, such as we observe, would result.

At this stage of speculation it becomes necessary to consider the probable manner of distribution of the radioactive elements in the beginning and the changes which have presumably occurred. In the molten state of the globe the heavier elements would sink and the lighter rise. Heavy radioactive elements would tend by gravity to assemble in the depths, but, since they heat up and thus lighten any mass in which they occur, they promote circulation and would be carried up by rising currents. Circulation is retarded by viscosity, and it appears not improbable that it might be reduced to ineffective stirring movements in the greater depths, where viscosity is very high. At higher levels any local concentrations of radioactive elements would result in foci of heat with melting of bodies large enough to be forced toward the surface and to carry out the heat generators. The suggestion postulates a heterogeneous distribution of the very minute proportion of radioactive substances, somewhat similar to the occurrence of metals in richer or leaner ores. It also assumes barren masses, in which there is no generation of excess heat.

The effect of these hypothetical processes would be to retain heat generators in the central core, to reduce their proportion in a surrounding shell of indeterminate thickness, and to enrich the superficial outer shell in the manner long since recognized by Chamberlin and Holmes.

If in lieu of the molten globe we consider the alternative of the solid one, built up according to the planetesimal hypothesis, the present condition of a molten nucleus and thick, solid shell may be deduced by similar reasoning. It would be expected that the heavier elements, including radium and its relatives, would form the core, and the proportion of radioactive substances, however insignificant, would melt the interior from the center outward to a distance dependent upon the amount of heat generated and the time elapsed. In the surrounding mass a haphazard distribution of radioactive elements in very small total proportion, but with effective concentrations at more or less widely separated foci, would result in local magma bodies, which would be forced toward the surface and would enrich it in heat generators, while impoverishing the substratum.

Thus, by either assumption of the initial state of the globe we may frame an hypothesis of thermal history which would lead up to the present state, but the criteria by which to eliminate either one or the other assumption appear to be lacking.

At this point I may, perhaps, sketch a thought on the margin of this outline of a terrestrial past. It is generally agreed, though not imperatively demonstrated, that the planets probably issued from the sun. In developing a comprehensive panorama of that event Chamberlin considered the sun an active participant. He thought with reason that its eruptive forces must have been strongly stimulated by the tidal pull of the passing star. Jeans and Jeffries did not take account of those forces. They assumed a film or body of passive gas, part of the sun's atmosphere, yielding initially to the tidal pull in separating from the parent sun and assembling subsequently in response to its own gravitative tendencies. Chamberlin also found it necessary to assemble the sun-dust or planetesimals by gravity. He conceived a process of overtake collision, rebound and repetition of colliding among the particles, by which the dispersive activity would be exhausted and in-fall toward a center of gravity promoted.

Chamberlin's concept of the dynamic conditions of planetary birth is far more complete than that of the astronomers and is not confined by the mathematical fetters imposed upon their way of thinking. Yet even his analysis now seems incomplete in view of the suggestions of modern physics and astronomy regarding the distintegration of atoms and the expansion of the universe. Everything seems to be going to pieces. Energy is dispersing beyond the outermost confines of space. But in space are millions of assemblies of energy, the stars. They are hot and they radiate energy. The thought lies near that energy, darting through the absolute cold of space where heat is powerless by contrast, may encounter conditions favorable to assembly. Possibly the sun-dust had as yet unknown potentialities for gathering to form planets.

From this excursion into the realms of the stars we may return to our little planet and consider the earth beneath our feet. We will not find it lacking in unsolved problems. Take, for instance, the two familiar rocks, granite and basalt: the one is a light-colored, pepper-and-salt looking rock, commonly used in the façades of bank buildings, as an emblem of stability, perhaps. The other is almost black, dense and dull in appearance, and is associated with volcanoes and vast lava fields, like those of Washington and Oregon states. Why are these two great classes of rock different? How did their distinct masses come to form practically the entire crust of the globe?

Granite and basalt are both so-called igneous rocks; that is, they have cooled and crystallized from a molten state. A possible answer to our question is then obvious: they represent the original crust of the once molten sphere, which has cooled down, wrinkled and assumed all the features of Mother Earth. It was a good enough answer so long as we were not embarrassed by too many facts, but if true it required that all the granite and all the basalt should belong to the one rather short age during which the crust formed. We now know that different masses of granite (I am speaking of mountain ranges and large parts of continents) are of very widely separated ages. There are granites nearly two thousand million years old and others less than two hundred million years old. And there are other bodies of granite of various intermediate ages. Each one of them, from the earliest to the latest, rose from within the earth as a melted body and became inlaid in the outer, already existing crust. The same observation holds for the visible masses of basalt—they are of widely different ages. The only masses for which that can not be asserted with knowledge are those which floor the ocean bottoms. Regarding them we can say only that some, like the Hawaiian volcanoes, are very recent in origin and that they have been erupted through much larger areas of similar rock, which are certainly much older. Thus, the old idea that we might discover the oldest rock, a part of the original crust, becomes very improbable, and our first answer has to be put aside.

Among the stock phrases of works on geology is the statement that we know nothing definitely regarding the crust of the earth beyond the depth reached by mining or, in the case of oil wells, by drilling. Once true, that is so no longer. We have seen that elastic waves, earthquake waves, give us information regarding the solidity of the earth to 1,770 miles (2,850 km) below the surface. Those same swift messengers write with a pencil of light the photographic record of the speed with which they have traversed different kinds of rock. As they ascend, they come speeding through basalt, but entering the continental layer of granite they slow down. They record the distance traveled at the slower rate and thus give the thickness of the granite. It is that of a thin scum. A continent, though 3,000 miles (5,000 km) across, is generally not more than 20 miles (30 km) thick. Europe, Asia, Africa, North and South America and Australia are but patches of granite on the underlying shell of basalt that covers the whole globe.

The recognition of this fact again presents problems. What is granite and how did it form patches? If you were to ask a furnace man what slag is he might answer that it is the lighter part of the melt, which floats on the heavier matter in a furnace. The general idea applies to granite. It is lighter than basalt and floats on it. Thus, if we think of the primeval globe as having been molten it is logical to conceive that it was once completely covered by a layer of granite slag that had separated from and floated up on the molten sphere of heavier rock. That is the conception entertained by one school of geologists who imagine a primitive shell, from which later granites may have been derived by remelting. It is not a very well-authenticated notion. The initial assumption of the once molten globe is at best a preferred theory, which is on trial, and the patches of granite represent a complete shell only very inadequately. They cover not more than one third of the surface. What has become of the other two thirds? "Foundered," is the reply. Since any granite must have floated high and a complete shell must have covered the present ocean basins, that portion which is missing must have sunk. And so, by a line of doubtful postulates, geology is presented with a variety of lost continents, an embarrassing group of mythological Atlantises and Gondwana lands.

We may, perhaps, reach a sounder conclusion if we consult the experience of the furnace man. The ore and fluxes which he melts are dissolved by heat and reunite to form other minerals that are permanent at the higher temperature. The change is an illustration of the law of survival of the fit, which runs through all inorganic as well as the organic world. Then, if given time enough, the newly formed minerals separate and slag rises to float on the metal. If, however, the conditions are not well adjusted, if the process is not sufficiently prolonged or the temperature is too low or too high, the result is not that which is purposed.

The furnace in which granite may separate from some melting parent rock may be conceived to be a part of the globe within some scores or hundreds of miles of the outer surface. It is a mass which has been solid, but contains heating elements and has heated up until the rock is melted. It is a large mass from our point of view, a million cubic miles or several million, but a small one as a part of the earth. It takes a long time to melt, and the process of separation of the various minerals which are present in deep-seated rocks proceeds very gradually as the melt or magma heaves and stirs. The granite minerals soften first, especially in the presence of superheated steam, but basalt when melted is more fluid. The former are the lighter, however, and they must rise, either as individual bubbles or lumpy masses, eventually to gather at the top as a layer of granitic slag. This is not simply an inference based on comparison with familiar furnace practice in smelting ores. The separation has been accomplished by melting basalt in a laboratory crucible. But the processes of nature are far more complex than any we can thus observe, and petrologists find evidences of many different reactions, as we might expect.

In the older geology speculations regarding remelting of any considerable mass within the earth met with a very grave difficulty in seeking the source of heat. Gravity and conduction appeared scarcely competent to concentrate the heat energy required in the local furnace. The discovery of radioactive minerals, capable of generating heat for an indefinite period, suggested a competent source; but progress was impeded for a time by the unnecessary and improbable assumption that the radioactive elements must be uniformly distributed. The alternative assumption that they are irregularly distributed points to the hypothesis that there has been local melting and accords much more naturally with the known occurrences of geologic history.

The basic concept is that the globe had become solid. Whatever its primeval history may have been that solid condition had long been established. But radioactive elements had gradually heated masses of such magnitude that they were from time to time erupted and, intruding into the outer crust, altered and replaced it. We must conceive the eruptions to have comprised many varieties of igneous rock, but the two which occur in notable amounts and cover the globe are basalt and granite. The former constitutes the ocean beds and may be regarded as the foundation upon which the continental granites rest. The presumption is strong that it is the older rock, that eruptions chiefly of basalt had built up the outer surface before continents were born.

A strip of unexplored territory lies between this hypothetical state of a basalt crust and the supposedly later development of the crust of basalt and granite. Two feasible routes appear to lead across it, but either one or other may prove a detour or end in a blind trail. The first considered is indicated by the idea that the present distinction between the two kinds of rocks is a primeval distinction; they have always been separated and their distribution on the present surface reflects some original condition. The other thought is that the separation is the result of some process or processes acting upon a parent rock to differentiate it into these quite distinct groups of minerals. The separation has been accomplished in the laboratory and in the earth. But we are confronted with the question why should melting in the earth's body sometimes produce only basalt and sometimes, though not so abundantly, produce basalt and granite. While experimental research seeks to solve this and similar problems of rock genesis we may speculate.

The process would be one of very gradual melting, first of the more fusible minerals which go to make up granite, and later of the more refractory ones. During the ages of melting, the threads, films and bodies of hot fluid granite should rise through the unmelted portions and gather on top of heavier masses, whether they were melted or not. The process may be visualized as one of differentiation of crystalline minerals by melting and gravity, carried on during a hundred million years or so and resulting in a layer of granite above a body of modified basalt. The layer is relatively thin, since only about 10 per cent. of the parent rock separates out as granite, but it may have been twenty, fifty or more miles thick. A molten mass of these dimensions produces chemical, physical and mechanical effects upon the surrounding walls and cover which enclose it and tends to rise toward the surface. Unlike the volcanic rocks, granite does not break through, but cools as large subterranean bodies, which are subsequently bared by erosion.

We may thus conceive the formation of the nuclei of continents and the building up of continents themselves by successive eruptions from the depths; but still the question recurs: why not always granite? It is evident that the process which has been suggested is complex and involves several variable conditions. The original composition of the parent rock, the more or less heterogeneous occurrence of several types in layers, fingers or bodies, the rate of heating up and consequently the time available for separation, the distribution of heating elements and the development of convection currents, the greater or less viscosity of the molten body and the total time that might pass before the process was interrupted by upward movement and escape—all these and other variables would need to be appropriately adjusted to produce a given result. It is apparent that the separation of granite, which is a complete stage of the process requiring long time and perhaps several meltings, was a somewhat special case, in contrast to the more common association of conditions favorable to the eruptions of basalt.

Among the effects of modern eruptions is that of the "plateau basalts," as they are called. They are very extensive fields of basaltic lava covering hundreds of thousands of square miles. We may imagine the earlier outflows from the most ancient solid earth to have been of that type and to have resembled the present ocean beds in flatness. The surface built up by such flows would then be comparatively smooth and would have differed from the actual condition in that it would not have been diversified by continents and ocean basins, but would have been covered by a universal ocean.

Evidence of a once universal ocean covering the globe may be found in the curious problem presented by the amount of salt in the sea. Salt is being carried down by rivers, which take it from the land at a rate that can be estimated. Thus, knowing the total amount in the sea, we can calculate how long the rivers have been at work. The calculation involves various guesses, but when all is said and done it seems difficult to allow more than one or two million years for the accumulation of salt in the ocean waters, provided the lands were formerly anything like as extensive as they now are. But two hundred million years is only about one tenth of the known age of some rocks. Hence we are led to infer that the accumulation of salt must have proceeded at a much slower rate, that the lands were for a long time much less extensive and that there was a very long period during which a practically fresh-water ocean covered the entire earth. In a fresh ocean lime-secreting organisms could have developed but scantily, and it may be that the earliest organic limestones will eventually, when their age is determined, tell us when the seas first became somewhat saline and thus indicate the beginnings of continents.

In a universal ocean marine life only could have evolved. Think of the result. We would all have been clams, crabs, sharks or kingfish. But the atomic energies were not to be denied, even though they required hundreds of millions of years to melt and separate the granite slag of which continents consist. Little by little they produced it; mass by mass it was thrust up into the outer crust and lifted to the position where by reason of its lightness it continues to stand out above the heavier basalt that forms the ocean beds. Thus the earth's surface became uneven, the ocean basins were divided and the continents grew to their present size.

The growth of lands was the development of opportunity for evolution of living creatures. Life in the restricted sense may have been born in a crevice in warm, moist soil, during the earliest stages of our planet, and multiplied in the world-wide ocean, evolving from plant cells or bacteria to mollusks or fishes. But the stimulus toward higher organization and mentality was found in the varied climates and aspects of the islands and continents. Variety is not merely the spice of life. It is its incentive.

Let us now sum up the sequence of suggestions that the atomic energies evoke. We start with a solid globe, which contains radioactive elements of great potentiality but in very minute proportion and unequally distributed. Wherever they occur, they generate heat and melting ensues. Any individual molten body tends to rise toward the surface, either forcibly or by melting its way out, and may succeed in rising, bringing the contained radioactive minerals with it. Thus the shell to the depth from which escape is possible becomes impoverished, and the outer crust becomes enriched in heating elements. To them we owe the activity of the external crust. It would seem, however, that the possibility of escape does not extend to the center. A molten mass developing in the central region would become spherical, would be bounded by a spherical contact between molten and solid rock, and pressing equally in all radial directions outward would be held in equilibrium. This seems to be the case. Elastic earthquake waves, which have traversed the 2,000-mile mantle that surrounds the core, are mostly lost in the inelastic core, and the boundary between the shell and the core can be fixed within as short a distance as 20 miles. So far as we can judge of the state of matter under those extraordinary conditions of temperature and pressure, the core is melted and its diameter of 4,000 miles is that of the sphere which has become molten since the earth acquired sufficient size to retain the melting mass. That was certainly more than two billion years ago. The heating has progressed very slowly. It is possible that the heating elements are exhausted and the molten core is no longer growing. But it seems more probable that the persistent release of atomic forces is continuing and will continue to supply heat and to melt the surrounding shell, with the result that Mother Earth may eventually take her place among the shining stars.

SCIENTIFIC EVENTS

THE WESTERN DIVISION OF THE CONNAUGHT LABORATORIES

IN consequence of an arrangement which has been entered into by the Provincial Board of Health of British Columbia, the University of British Columbia and the University of Toronto, there has been established in the University of British Columbia, as of October 1, a western division of the Connaught Laboratories of the University of Toronto. The undertaking in the first instance is for a period of one year.

Primarily established as a research center, it is hoped that the coordination of activities of the department of bacteriology and preventive medicine of the University of British Columbia with those of the Provincial Board of Health Laboratories of British Columbia and of the Connaught Laboratories will make it possible to extend considerably the fields of usefulness of all three institutions.

Dr. C. E. Dolman has been appointed associate professor and acting head of the department of bacteriology and preventive medicine, and acting head of the department of nursing and health in the University of British Columbia. He has also been appointed director of the Provincial Board of Health Laboratories of British Columbia. He will, furthermore, continue as a member of the staff of Connaught Laboratories as a research member. Dr. R. J. Gibbons, of the staff of Connaught Laboratories, will be associated with Dr. Dolman, seconded for duty in the western division. At the outset the Western Division of the Connaught Laboratories will be provided with quarters in the Science Building of the University of British Columbia.

It is hoped that this experiment in inter-university and provincial health department collaboration will afford excellent opportunities for expansion of activities in the field of preventive medicine in Western Canada, especially in British Columbia.

THE LAWRENCE HOPKINS MEMORIAL EXPERIMENTAL FOREST

THE gift to the Federal Government of a 1500-acre tract of land in northwest Massachusetts by Williams College, Williamstown, Mass., to be known as the Lawrence Hopkins Memorial Experimental Forest, has been announced by the U. S. Department of Agriculture. The tract will be administered by the Forest Service as a branch of its Northeast Forest Experiment Station, and the rehabilitation of New England woodlands and abandoned farm lands which have reverted to forest growth can be studied there.

In a letter accepting the gift, Secretary Wallace wrote to President Tyler Dennett, of Williams College: "Studies on the area will fill an important gap in our program of forest research in the northeast and should be of value in providing a sound technical basis for management and restoration of woodlands and abandoned farm lands over much of New England, whether in private or public ownership."

The Hopkins Forest is in the extreme northwest corner of Massachusetts, adjoining Vermont and New York on its northern and western boundaries. It is just outside the limits of Williamstown, where the college is located. The tract is typical of the abandoned farm land in the region. The principal growth on about 1,000 acres is northern hardwoods, including birch, maple, red oak and white ash in various stages of stocking. The remainder, 500 acres, is old hayfields. The land was formerly the estate of the late Colonel Amos Lawrence Hopkins, who used it largely as a sheep and horse farm. It was donated to Williams College by Mrs. Hopkins.

C. Edward Behre, director of the Northeast Forest Experiment Station, said that investigations of the various problems dealing with the establishment, growth, management and protection of forests, plus the promotion, development and production of desirable forms of wild life in the area would be started. Such investigations are to be carried on particularly in reference to the rehabilitation and best use of such lands. Work of restoring the area to valuable forest land will include replacing poor stock with better tree species.

The forest will also serve as a field laboratory for Williams College, providing an opportunity for honor students to carry on special work in forest botany and allied subjects. The college has made available to the Forest Service for experimental use its own laboratory facilities, library and greenhouses.

Work with the forest will be initiated this winter and a CCC camp will probably be established.