is the account of the Bolivian tin veins. Professors Miller and Singewald were fortunate in finding fossil plants in the shales at Potosi, and as a result of this discovery were able to establish that the tin veins at Potosi were formed in Pliocene or Pleistocene time. This is a remarkable conclusion and shows that these wonderfully productive tin lodes are in a geological sense extremely youthful; in fact they are probably the most youthful economically valuable mineral deposits of first rank in the world. Professors Miller and Singewald extend this age determination to all the Bolivian tin veins and maintain that they are all of Pliocene age. This conclusion may or may not be true, for the veins of the different districts appear to be associated with igneous rocks of a wide range of texture: pegmatites, aplites, granite, granite porphyry, rhyolite porphyry, rhyolite and "true quartz porphyry." As a matter of fact, no thorough field study of the Bolivian tin veins as a whole has yet been made. The studies hitherto made have been mainly petrographic, by geologists who have not collected the specimens they studied. It is not to be expected that a very deep insight into the fundamental problems could be attained by that method. Even in such a relatively subordinate matter as the nomenclature of the igneous rocks the petrologist has felt it necessary to use such obsolescent, non-committal terms as quartz porphyry to describe some of the rocks to which certain Bolivian tin veins are genetically related. When field work becomes the main method of attack and the microscope is used as an auxiliary—a powerful auxiliary it is true—more satisfactory results will be attained, and it is therefore a pleasure to learn that Professor Singewald is returning to Bolivia in order to take up a careful study of the tin veins in their broader geologic aspects.

Another district of special interest is Corocoro in Bolivia, which like the Lake Superior district is one of the world's two productive copper districts in which the chief ore mineral is native copper. Brazil holds the distinction of having in the Morro Velho mine the deepest mine in the world, the lowest workings having attained a vertical depth of 6,128 feet. The ore on the lower levels averages nearly $13 a ton in gold and indicates an extraordinarily long vertical range of gold-ore deposition. Apparently not much is known about the geology of this remarkable ore body, however. There are many other interesting deposits described in the book, but it would lengthen this review unduly even briefly to call individual attention to them. The outstanding feature of the economic geology of the South American continent is its preeminence in the number of its geologically youthful primary ore deposits of the first order of magnitude.

Professors Miller and Singewald have placed all interested in the mineral resources of South America under a deep debt for the labor they have expended in marshalling the widely scattered information and for presenting it attractively in a condensed and easily usable form. They can be gratefully assured that they have filled a genuine want in the literature of economic geology.

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THE ECOLOGY OF NORTH AMERICAN LYMNÆIDÆ

IN a recent paper in SCIENCE[1] the following statement appears: "There are three groups of limnæas found in North America, the abysmal limnæas including *Lymnæa (Acella) haldemani* Binney, the moss limnæas including *Lymnæa (Galba) truncatula* Müll., *humilis* Say, and the marsh limnæas including *Lymnæa stagnalis, L. columella,*" etc. This classification of our pond snails is so unusual and so far from representing the true ecological relations of this group, as well as of the allied groups *Planorbis* and *Physa,* that a few observations on the subject seem necessary.

As far as known there are no abysmal lymnæas or other fresh-water pulmonates in America, comparable to the true abysmal fauna of the deep lakes in Switzerland, where *Lymnæa stagnalis* occurs in Lake Geneva at a depth of 250 meters and *Lymnæa abyssicola*

[1] SCIENCE, N. S., XLVIII., p. 578, 1918.

in Lac Leman at depths of 25 to 250 meters.[2] In the Swedish lake Vätter, mollusks, including lymnæas have been dredged from depths down to 120 meters.[3] In America no such depths have yielded mollusks in our fresh-water lakes, the deepest water from which lymnæas have been found being in Lake Michigan where several species were obtained at High Island Harbor at a depth of 10 meters.[4] It is possible that some of the deep western lakes, as Lake Pend d'Orielle, Idaho, examined by the writer some time ago, may contain a deep-water fauna.

The species cited as an example of abysmal lymnæas, *Acella haldemani* (Desh.) Binney, is really a shallow-water, swamp-loving species, when adult, in the fall, living at or near the surface attached to vegetation in water less than five feet deep. In summer (July) the young may be found in water not exceeding six feet deep, among such plants as *Potamogeton*.[5]

The present center of distribution of American lymnæas is the Canadian faunal region, where upwards of 50 species and races live. North and south and east and west of this area there is a more or less rapid decrease in number of species. It is in this area that we find the greatest variation in the ecological relations of the group. This is due in part to the effect on the topography made by the great ice sheet which swept over the territory during the Pleistocene Period, and left upon its retreat the largest number of ponds and small lakes known in any part of the world. As typical pond and lake animals, the lymnæas have reacted favorably to this profusion of small bodies of water and a large and varied fauna has resulted. This is also true of other groups of fresh-water mollusks especially the related fresh-water pulmonates, *Planorbis* and *Physa*.[6] Ecologically, our lymnæid fauna may be divided into about five types:

1. *The open shore lake type*, where the environment is an open shore of a lake exposed to the full force of the winds and waves. Here such lymnæas as *Lymnæa stagnalis lillianæ* Baker, *Galba catascopium* Say, *G. emarginata* Say, and *G. nasoni* Baker are common and typical of such a habitat.

2. *The quiet bay or pond type*, where the environment is protected from the force of the waves and wind by barriers of one kind or another. The water is shallow and there is usually an abundance of vegetation, such as *Scirpus, Potamogeton, Castalia, Nymphæa, Typha* and filamentous algæ which provide much of the food of these snails. Such species as *Acella haldemani* (Desh.) Binn., *Pseudosuccinea columella* (Say), *Bulimnea megasoma* (Say), and *Lymnæa stagnalis* Linné are typical of such a habitat.

3. *The marsh type*, where the water is shallow, seldom more than three or four feet deep, and where there is an abundance of swamp vegetation such as *Typha, Pontederia, Decodon* and a few *Nymphæa*. The bottom is usually of mud or accumulated vegetable débris. Such species as *Galba palustris* (Müll.), *G. obrussa* (Say), *G. reflexa* (Say), and *G. elodes* (Say) are characteristic of this kind of a habitat.

4. *The mud-flat type*. This type of habitat may border a swamp, pond or river, where the water is quiet and where an area of wet mud is left just above the water line. Here small species of the subgenus *Simpsonia* are at home and we find such species as *Galba parva* (Lea), *G. dalli* (Baker), *G. umbilicata* (Adams), and some of the small varieties of *G. obrussa* (Say) living by thousands, simulating the marine Littorinas in their ecological relations.

5. *The intermittent pool or stream*. This is a type of habitat found in all parts of the

[2] Forel, *Bull. Soc. Vaudoise des Sci. Nat.*, X., p. 217; XIII., p. 1 (1869, 1874).

[3] *Internationale Revue der gesamten Hydrobiologie und Hydrographie*, Band 7, Heft 2–3, pp. 146–204, 1915.

[4] Walker, *Nautilus*, IX., pp. 3–5, 1895.

[5] For the life history and ecology of this species see Baker, *Nautilus*, XXX., pp. 135–138; Tech. Pub. No. 9, N. Y. State College of Forestry at Syracuse University, 1918.

[6] Baker, "Monograph Lymn. N. A.," pp. 52–67, 1911.

United States, but especially common in the west and southwest, in the more arid parts of the country, where water stands for but a small part of the year and where the lymnæas, and other mollusks must be able to withstand the period of drouth by hibernating in cracks in the bottom of the pond or stream. Such species as *Galba caperata* (Say), *G. cubensis* (Pfr.), and *G. bulimoides* and its varieties are typical of these habitats. *Galba palustris* and some other species normally living in marshes may at times be compelled to adopt this hibernating type of habitat during unusual periods of drought.

The writer has not found lymnæas as a rule inhabiting moss, although the little amphibious species (*parva, dalli,* etc.) may do so in some places and have, indeed, been collected from such a habitat. All lymnæas as well as other fresh water mollusks, whether in lake or marsh habitats, prefer a location where there is a quantity of vegetation and where there is an abundance of filamentous algæ (*Cladophora, Œdogonium,* etc.) upon which they largely feed, in some cases to such an extent as to give a green color to the shell. The relation of algæ to molluscan and other life has recently been rather fully stated by the writer.[7]

It is interesting to note that fresh-water mollusks, the lymnæas in particular, respond quickly to changes in environment, a species characteristic of a marsh adapting itself to a rough lake shore habitat if compelled to make the change. Thus typical *stagnalis* is characteristic of quiet, pond-like bodies of water, while the variety *lillianæ* lives on a shore exposed to the full force of the waves. The change in habitat has resulted in a larger aperture and foot in *lillianæ* the better to resist the moving power of the waves. In Oneida Lake, a large colony of *Galba palustris* was forced by a change in the environment, caused by the barge canal construction, to change from a shallow swampy habitat to that of an open rocky shore exposed to violent wave action. The effect of this change has been to produce a shell with a wide, flaring aperture and a larger foot area, a direct response to the environment which demands a larger foot area for resisting the waves.[8] The lymnæas are not, as generally supposed, mollusks chiefly of ponds and ditches, as might be thought from reading the paper in SCIENCE, but also of the larger inland lakes, in fact a greater variety is found in the lakes than in any other kind of habitat.

The fossil lymnæas, as well as other freshwater fossil groups, are in need of careful revision in the light of modern work on the existing species. As the shell in a measure reflects the internal structure, this revision ought not to be difficult with ample material of fairly well-preserved specimens. The twenty-five or more species described appear to represent the larger groups recognized among the recent forms. Several of these species, as mentioned by Hannibal, are problematic and may belong to other groups, but more perfect material is needed for this purpose. Some confusion of species has occurred in figuring and describing a few of these lymnæas, attention to which has already been directed by the writer.[9]

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[7] Tech. Pub., No. 9, N. Y. State College of Forestry, Syracuse University, 1918.

[8] Baker, Tech. Pub. No. 9, N. Y. State College of Forestry, p. 180.

[9] "Mon. Lymn. N. Am.," pp. 89, 95, 96.

SPECIAL ARTICLES

SOUND AND FLASH RANGING[1]

THE location, by means of sound, of active enemy batteries and the direction of the fire of the friendly artillery on these and other enemy objectives is new; has been successfully practised by the Allies and has been clumsily practised by the Germans. The location and ranging by visual observation (flash ranging) is an outgrowth of standard artillery methods and differs from these chiefly in the extent of front covered by a single group of observers and by the adoption of certain electrical devices and

[1] Abstract of paper presented before the American Philosophical Society, April 26, 1919.