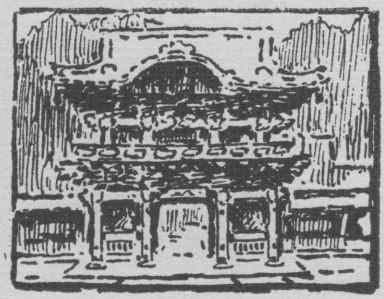
GUIDE-BOOK EXCURSION B–1

(Oct. 26th–27th, 28th–29th, 1926)

NIKKO



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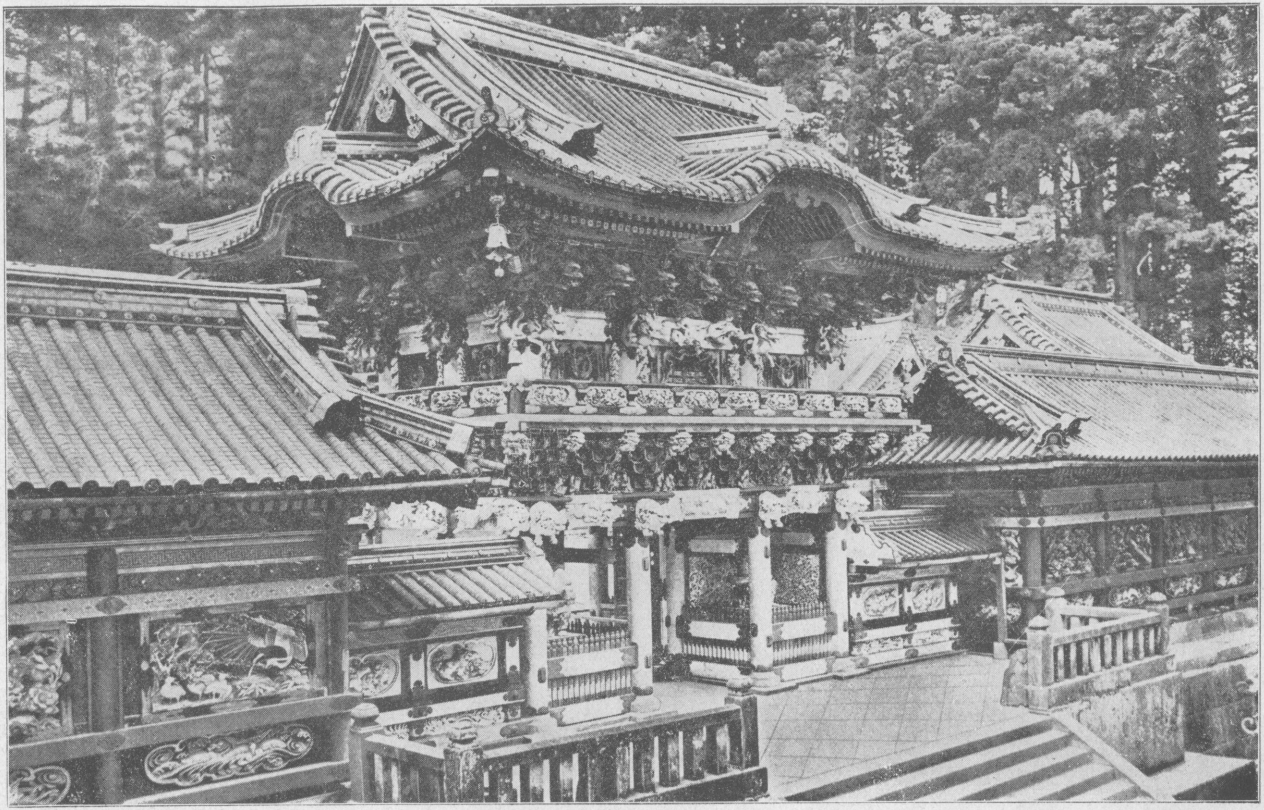

Yōmeimon, Nikko Shrine.

NIKKŌ

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SHRINES AND TEMPLES AT NIKKŌ

By Chūta Itō

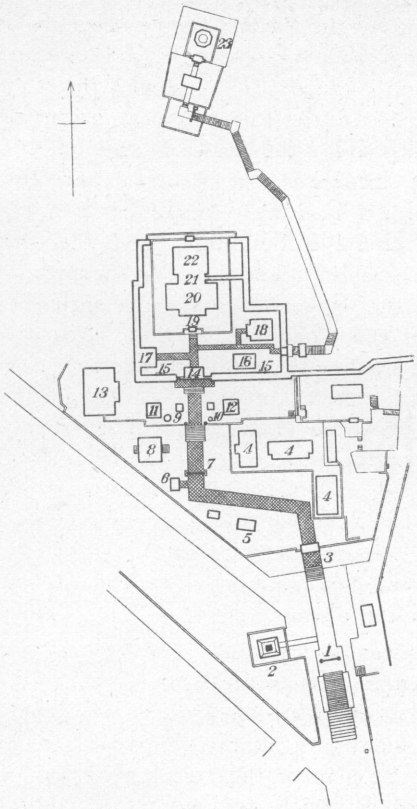
In the second year of Genna, or A. D. 1616, Tokugawa Iyeyasu, the first Shōgun of the Tokugawa régime, died and posthumous honors, including the appellation of *Tōshō-Daigongen*, were graciously granted by the Emperor to the deceased statesman and military commander. This posthumous appellation was afterward altered to *Tōshō-Gū*. The body of Iyeyasu was interred at first in Kunōsan, Suruga Province, but in the following year, it was taken to Nikkō in Shimotsuke Province. The temple of Rinnōji had been founded there in the second year of Tempyō-Jingo, or A. D. 766. In the third year of Daidō, A. D. 808, the patronage of Futarasan Shrine was invoked, the god to whom the Shrine was consecrated being thus made the Patron Saint of the temple. The temple at Nikkō has since been venerated as the most sacred sanctuary in the Kwantō district.

The third Shōgun, Iyemitsu, grandson of Iyeyasu, was noted for his courage and valor. He rebuilt the sanctuary in its present magnificent form in commemoration of the great achievements of his grandfather. The design for the mausoleum of Iyeyasu was drafted toward the eighth year of Kwan-ei, or A. D. 1631; and in accordance with these plans, construction was started in the autumn of the eleventh year of the same era, or 1634. The architect who supervised the work was Kōra-Bungo-Munehiro. It was specified on the completion of the work that the buildings should be repaired every twenty years, but this rule, providing for periodical repair, has not been adhered to. The repairs effected in the third year of Genroku, A. D. 1690, were on a comprehensive scale, so that the repairing then was called rebuilding.

The buildings of the *Tōshō-Gū* were specially designed. Shrine though the group of structures is called, a design peculiar to Buddhist temples was skilfully adapted to blend with the style characteristic of Shintō shrines. Due to the topographical features of Nikkō, which limit the building area, the scale of the buildings is small, but nevertheless the structures are of varied and diverse types. The plan though complex, is exquisite in composition. There is harmony throughout the group of buildings, and the shrine presents an appearance of aesthetic grandeur. A conspicuous feature is the workmanship of the ornamentation. The shrine is a treasury of the exquisite skill of the Tokugawa Period. Nearly all parts of the buildings are covered with beautiful lacquer of varied hues,—vermilion, red ochre, black and white. The glory of the whole is enhanced by the presence on the lacquered columns, beams and walls of ornaments, paintings, carvings, engravings, sculptures and gilt decorations, all executed according to different methods. Skill in detail and in color blending, and a certain elaborateness in design pervading the whole construction, together with the daring spirit in which the complicated plan has been executed, constitute the essential features of the Nikkō Shrine.

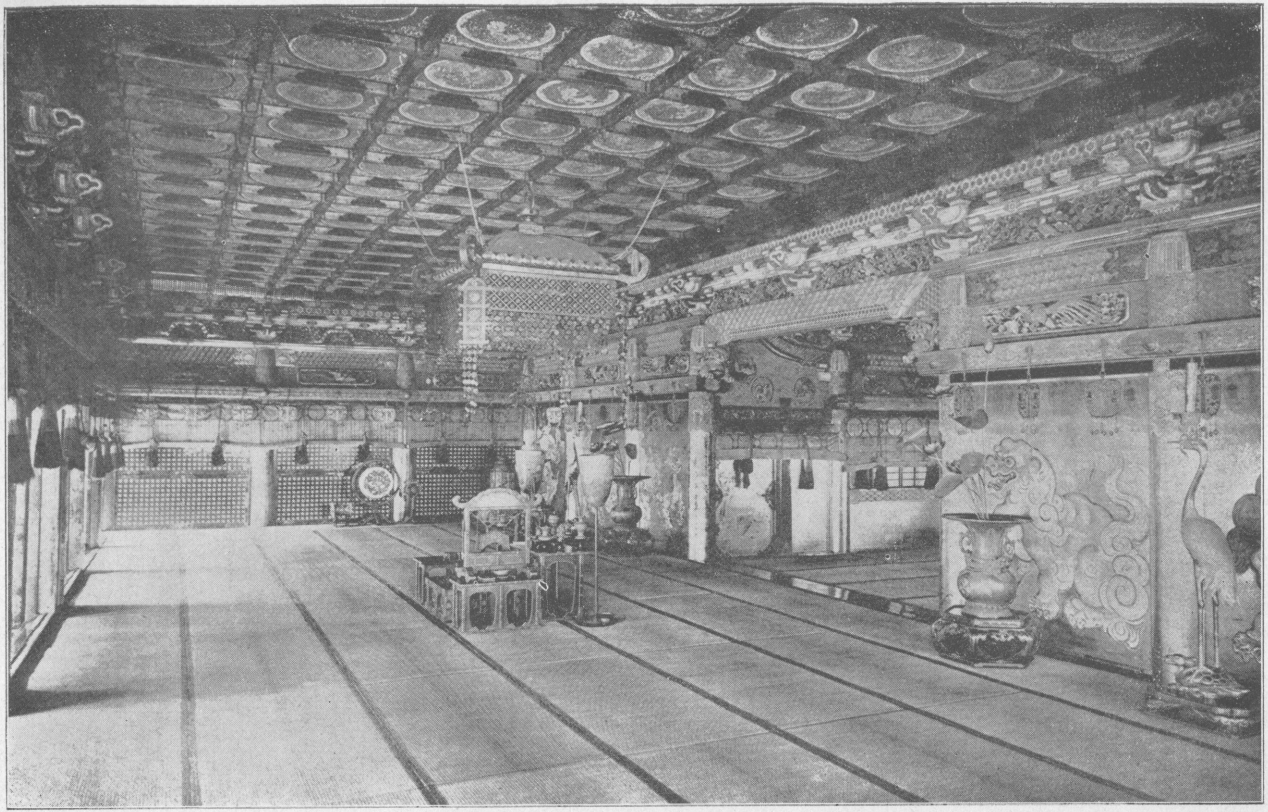
The shrine was constructed in perfect accordance with the instructions of Iyemitsu, whose intention, it seems, was to overshadow the splendor and elegance of the Palaces of Juraku and Momoyama which the great Hideyoshi, the preceding ruler of the land, had built. Architecturally, the plan of the buildings is, therefore, too complex to accord in all respects with architectural demands ; but it is unjust to regard the structures as being entirely out of harmony with architectural principles on this account. Minute descriptions of all parts of the buildings are impossible.

The mausoleum of Tokugawa Iyemitsu is called *Daiyū-In*, and has been placed for safe keeping in the hands of the authorities of the Rinnōji Temple. *Daiyū-In* is a posthumous Buddhist honorary title, granted by the Emperor to the third Shōgun, Tokugawa Iyemitsu. The building of the *Daiyū-In* follows in general the style of temple buildings, but some of its architectural features have been adapted from the style used for shrines. The construction of the building was conducted under the supervision of Heinouchi-Ōsumi-Masanobu in A. D. 1653. The plan is somewhat like that of the *Tōshō-Gū*, but is on a limited scale. The workmanship and orna-



Plan of Nikko Shrine.

1. Stone "Torii" (Shrine Gate).
2. Five-storied Pagoda.
3. "Omote-mon" (Front Gate).
4. Treasure Houses.
5. Sacred Stable.
6. Sacred Laver.
7. Bronze "Torii".
8. Depository of Sutras.
9. Lanterns presented by the Dutch Government.
10. Korean Bell and Candelabrum.
11. Drum-Tower.
12. Bell-Tower.
13. Temple of "Yakushi" the Healing Buddha.
14. "Yômei-mon" (Main Gate).
15. Corridor.
16. Hall of Sacred Dance.
17. Depository of Sacred Palanquin.
18. Shrine Office.
19. "Kara-mon" (Interior Gate).
20. Central Hall (Outer Shrine).
21. Hall of the Stone.
22. Main Hall (Inner Shrine).
23. Mausoleum.



Central Hall of the Daiyu-In.

mentation are intentionally far more simple, for the *Tōshō-Gū* is a shrine consecrated to the founder of the Tokugawa Shōgunate, whereas the *Daiyū-In* is but the mausoleum of his grandson. It is also likely that the designer, having learned a lesson from the complex plan of the *Tōshō-Gū*, was careful to preserve symmetrical harmony in building the *Daiyū-In*. In some points, it has more worth from an architectural point of view than the *Tōshō-Gū*. As cases in point, the *Suibansha*, or "Water basin," and the *Kōkamon*, or gate, may be mentioned.

The Futarasan Shrine, an outstanding one of its kind, is noted for its beautiful decorations; but, lying as it does between the *Tōshō-Gū* and the *Daiyū-In*, the shrine loses some of its brilliancy in comparison with the still greater beauty of these two mausoleums.

Of all the buildings comprising the Temple of Rinnōji, the most magnificent is the *Sambutsudō* or "Hall of three Buddhas." It is now in a state of ruin, yet is the most magnificent building in the Kwantō district. The *Sōrintō*, a decorated column which stands nearby, is a *stūpa*[1] of a peculiar type, such a type being rare in this country. The *Jōgyōdō* and the *Hokkedō* in front of the *Daiyū-In* and the Futarasan Shrine are connected by corridors, a mode of building peculiar to the Tendai Sect of Buddhism.

The *Jigendō* is the temple where the body of Tenkai, the great Buddhist priest who was adviser to Iyeyasu, is buried. It was at the advice of this priest that the body of Iyeyasu was brought to Nikkō from Kunōsan, where it was first interred.

Shrines and temples other than those to which reference has been made are too numerous to be mentioned in detail in these pages. However, the Chūgūshi Shrine and the Temple of Tachiki-no-Kwannon both on the banks of Lake Chūzenji, are worthy of note. The Tachiki-no-Kwannon, at Utagahama on Lake Chūzenji,—a famous image of Kwannon, the personification of Compassion,—is said to have been carved from a living tree. The period in which it was made is unknown, but if judgment is to be trusted, it may be nearly ten centuries old. It is, in any case, the oldest historic object which Nikkō possesses.

Detailed information in regard to the noted historic places and famous scenic beauties of Nikkō is given in guide books, literary productions and other works.

1) *Stūpa* is a Sanscrit word, meaning originally, the tomb or tombs erected over the remains of Buddha. The meaning was latter extended to include any kind of Buddhist monument or grave. Japanese Buddhists use the terms, *Sotoba*, *Tōba* or simply *Tō*.

GEOLOGICAL GUIDE TO THE NIKKŌ DISTRICT

By Seitarô Tsuboi and Ken-ichi Sugi

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References

(1) Geologic Sheets (1:200,000), Nikkō and Maebashi, and the Explanatory Texts to the Sheets, published by the Imperial Geological Survey.
(2) Y. Saitō, Geology of the Nikkō Volcanoes (*Japanese*), *Report Earthq. Invest. Com.*, No. 27, 1889.
(3) B. Kotô, Volcanoes of Japan, *Jour. Geol. Soc. Tkōyō*, Vol. XXIII, p. 44, 1916.

PART I

GEOLOGIC SKETCH OF THE NIKKŌ DISTRICT

GENERAL OUTLINE

The Nikkō district is the seat of a number of Quaternary volcanoes (not active at present) which form the so-called "Nikkō Volcanic Group." It comprises nine volcanoes, namely, (1) Gassan (1,287 m.), (2) Nyohō-Akanagi (2,464 m.), (3) Komanago (2,323 m.), (4) Ōmanago (2,375m.), (5) Nantai (2,484m.), (6) Tarō (2,368m.), (7) Sannō-bōshi (2,073 m.), (8) Mitsudake (1,945 m.), and (9) Shirane (2,578 m.), enumerating from east to west. None of these volcanoes are known to have been active in historic times, except the ninth (Shirane), eruptions of which are recorded in 1625, 1649, 1872, 1873, and 1889.

These volcanoes rest on the erosion-surface of the older complex consisting of the sedimentaries of the Chichibu System (Permo-Carboniferous) and the granitic rocks which intrude them. These older rocks are important geological elements, constituting the backbone of the mountainous region of northern Kwantō, which attains the height of 1,200 m. above the sea-level. But in the Nikkō district, within the area represented in the annexed geologic map, they are almost completely covered by the products of the above-mentioned younger volcanoes, so that their outcrops are confined to small areas.

THE CHICHIBU SYSTEM

The Chichibu System, the oldest formation in the Nikkō district, is developed only poorly in the area represented in the annexed geologic map. However, on the south side of the Daiya River, this system is extensively developed, occupying a large area.[1] There the formation consists of clayslate, graywacke-sandstone, quartzite, schalstein, and limestone, and is rather strikingly disturbed, fissuring, fracturing and faulting being by no means rare in the rocks of this formation.

The strata of the Chichibu System strike generally NE-SW, while their dips vary in direction and angle. To the north of Ashikaga the strata show a remarkable syncline whose axis, about 20 km. in length, runs in the direction of N30°E, pitching down to SW. The order of succession of the rocks, observed in the wings of this pitching syncline is as follows, enumerating from the lower to the upper horizons:[2]

Dark gray chert—alternation of clayslate and graywacke-sandstone—Kuzuu limestone—green chert intercalating Radiolarian chert —dark gray chert with lenses of graywacke-sandstone.

The Kuzuu limestone, so called because it occurs in the vicinity of the town of Kuzuu, contains a Lower Permian fossil, *Fusulina* (*Schellwienia*) *kaerimizensis* OZAWA, while the Nabeyama limestone, occurring near Nabeyama, about 7 km. NE of Kuzuu, belongs to a little lower horizon, yielding the following fossils, characteristic of the Upper Carboniferous.

Productus punctatus MARTIN

1) Cf. Geologic Sheets, Nikkō and Maebashi (1:200,000), of the Imperial Geological Survey.

2) K. Ebata, Graduating Thesis, Imp. Univ. Tōkyō, 1924 (MS).

Meekella eximia EICHWALD *forma majuscula* HAYASAKA
Orthotetes sinensis TSCHERNYSCHEW
Schizophoria resupinata (MART.) DAVIDSON
Spirifer aff. rockymontanus MARCOU
Reticularia lineata MARTIN

Near Hanawa, 12 km. N by W of Kiriu, *Helicoprion bessonowi* KARPINSKY, the famous fossil from the Artinskian formation of Russia, was once found in limestone associated with *F. kaerimizensis* OZAWA. The Hanawa limestone is therefore of the same horizon as the Kuzuu limestone, and they form probably two wings of an anticline, whose axis is supposed to lie somewhere near the course of the Kiriu River, nearly parallel to it. Besides the fossils above mentioned, *Neoschwagerina* (*Yabeina*) *globosa* YABE of the Upper Permian is recorded to occur in Kaminita-yama, Yamada-gun.

The southern extension of the Chichibu System is sharply limited by a fault running NW-SE, now represented by the course of the Watarase River. This fault traverses the Tertiary formation that is distributed sporadically in small patches, covering the Palaeozoic formation, while the fault is covered, on its northwestern prolongation, by the lavas and ejecta of the Akagi Volcano. The eastern boundary of the Palaeozoic terrane appears also to be a fault of the post-Tertiary age.

The sedimentary rocks of the Chichibu System are intruded by granitic rocks and are more or less metamorphosed due to igneous action. The most remarkable contact effect is observed near the Ashio Mine along the Watarase River, where large cordierite crystals (hexagonals prisms, 1-2 cm. across), now replaced by pinite for the most part, are scattered in biotite-hornfels.

In the Nikkō district, the chief outcrop of the rocks of the Chichibu System is confined to the south side of the Daiya River. They are remnants of the roof-pendant in connection with the intrusion of the granitic rocks. There the complex consists essentially of strata of clayslate, with intercalated thin layers of greenish graywacke-sandstone (consisting of angular fragments of quartz, plagioclase, and orthoclase). It strikes generally N30-40°E, and dips in most cases 30-40° northwestward. The sedimentary rocks are, as may be naturally expected, usually affected by the contact action due to the granitic intrusion, often resulting in the formation of minute biotite flakes.

Fragments of the sedimentary rocks of the Chichibu System,

both clayslate and sandstone, are often found enclosed as xenoliths in the granitic rocks which intrude them. Some of the xenoliths are of special interest from the petrological point of view, a detailed discussion of which is, however, beyond the scope of the present guide-book.

GRANITIC ROCKS

In the Nikkō district the rocks of the Chichibu System were intruded by granitic rocks, which were later brought to the surface by the removal of the overlying Palaeozoic rocks. In the area north of the Daiya River and the Chūzenji Lake, the much younger volcanic lavas and ejecta almost completely cover the erosion-surface of the granitic rocks, though the latter often crop out from beneath the volcanic rocks. On the south side, on the other hand, the granitic rocks form the surface, uncovered by the younger volcanic products.

Petrographically the granitic rocks are of several different types, which may be grouped under three main headings, namely, quartz-porphyry, granite-porphyry, and granite. These occur in close association with one another, and are evidently derivatives from the same original magma.

Petrography :—

Quartz-porphyry.—Of the three main rock-types the quartz-porphyry is the most widely distributed.

Megascopically the rock is light to dark coloured, and is commonly strongly porphyritic, with phenocrysts of quartz, feldspars (plagioclase > orthoclase), biotite (commonly chloritized), and hornblende. The groundmass through which these minerals are scattered is variable in appearance. Sometimes it is compact and aphanitic; in other cases, phanerocrystalline, the rock approaching to granite-porphyry; while in still other cases it is tuffaceous.

Microscopically, plagioclase phenocrysts are thick tabular, and are twinned as usual according to the albite and Carlsbad laws, often accompanied by the pericline twinning. They belong to oligoclase-andesine, as determined optically. Zonal structure is developed only indistinctly at the margin of each individual. Along the cracks or periphery of the plagioclase crystals, calcite is often formed, accompanied by epidote, chlorite, quartz, and magnetite. Orthoclase as phenocrysts is much less in quantity than plagioclase. It is always dull, and not infrequently intergrown with sodic plagioclase forming

a perthitic structure. Quartz phenocrysts are rounded at their margins, and often enclose the material of the groundmass besides other inclusions. Biotite is in thick plates and scales, and is commonly chloritized. Minute crystals of apatite and magnetite are often abundantly enclosed by the biotite phenocrysts. Hornblende is rather rare, and is in euhedral stout prisms, often twinned on (100). It is a greenish variety with pleochroism: X=light greenish yellow, Y=brownish green, Z=olive-green. Optical plane // (010). $c \wedge Z = 11°$ in obt. $\angle\beta$. Optically negative.

The groundmass consists essentially of orthoclase and quartz, associated with minute flakes of biotite and chlorite, and small grains of magnetite and epidote. The texture is mostly micrographic, but micrographic and spherulitic textures are also exhibited in some cases.

Granite-porphyry.—Granite-porphyry is found chiefly on the south side of Lake Chūzenji. It is a coarser-grained facies of the quartz-porphyry, to which it grades with gradual transition. A conspicuous petrographic feature of the granite-porphyry is that it often carries large phenocrysts of pinkish orthoclase, up to 4 cm. in diameter.

Granite.—Granite, the plutonic facies of the granitic intrusive mass, is found along the northwest and southwest shore of Lake Chūzenji. It is medium- to coarse-grained, and consists essentially of plagioclase (oligoclase-andesine), orthoclase, quartz, and biotite.

Feldspars of both kinds are thick tabular or nearly equant. Plagioclase commonly exhibits indistinct zoning near the margin of each individual crystal. Orthoclase shows often perthitic structure, enclosing irregular lenses of polysynthetically twinned sodic plagioclase. Quartz occurs usually as interstitial matter but frequently intergrows with orthoclase forming micrographic structure. Biotite is in thick plates. Its alteration into chlorite is very common. Besides the minerals above enumerated, magnetite, apatite, and zircon are found as accessory ingredients.

An aplitic variety of granite, deficient in biotite, is found on the north shore of Lake Chūzenji, at the southwest foot of the Nantai Volcano. In this rock, a few muscovite flakes are found under the microscope besides the minerals in the common granite.

VOLCANIC ACTIVITY IN THE NIKKŌ DISTRICT

In the Nikkō district volcanic activity began as early as in the Tertiary period with the effusion of plagioliparite. The old, much-dissected volcanoes, Maeshirane (2,377 m.), Yusengatake (2,333 m.), and others, which lie out of the area represented in the annexed geologic map, near its northwest corner, are composed of this rock. Only parts of these plagioliparite bodies are within the area of the map. These older Tertiary volcanoes rest on the erosion-surface of the granitic rocks which form the base of the Nikkō district.

Any lengthy statement of these older volcanoes is omitted here, since they will not be visited during the planned excursion. One point, however, must be emphacized, viz., *it is a quite general feature throughout the whole of North Japan, that the Tertiary volcanism which preceded the andesitic volcanism is represented by plagioliparite.*

The chief volcanic activity took place much later in the Diluvial period. It is by this volcanic activity that a number of the volcanoes of the Nikkō Group were formed. All of these volcanoes are built up of basaltic andesite. The prominent scenic features of the Nikkō district are due to these younger volcanoes.

NYOHŌ-AKANAGI VOLCANO

Toward the northwest of the town of Nikkō there is a conspicuous serrated ridge, running roughly in the E-W direction for about 5 km. Nyohō (2,464 m.) and Akanagi (2,272 m.) are two prominent elevations on the ridge.

The Nyohō-Akanagi mountain-body is of volcanic origin, and is the largest and oldest member of the Nikkō Volcanic Group. It rests directly on the erosion-surface of the complex consisting of the Palaeozoic rocks and granitic rocks. The volcano is now in a demolished condition, serrated at its top and much dissected on its flanks. However, the development of the mountain-slopes is rather regular in all directions except on the south and southwest sides, where the relief of the ground is complex due to the accumulation of later lavas from the volcanoes Komanago, Ōmanago, Nantai, and Tansei, covering the original slope of the Nyohō-Akanagi Volcano. On the whole, however, the volcano preserves the form characteristic of a *konide*.

The ridge that connects the summits of Nyohō and Akanagi forms a water divide, and on both sides of it there have developed a

number of radial valleys. They are confluent to the Daiya River on the south, and to the Kinu River on the north. Of these valleys that of the Inari River on the south is the most conspicuous. The river originates near the top of Nyohō, flows down in the SE direction, and joins the Daiya River near the town of Nikkō. At the head of the valley of the Inari River there is a precipice, 150 m. high, hemming a roughly horseshoe-shaped cirque, about 1,000 m. across and open to the south. This cliff was formed by a landslide at the time of the Nikkō earthquake in 1685. The Inari River is fed by the springs that issue from the agglomerate layers on the above-mentioned cliff-wall, forming a series of waterfalls called " Nanataki."

The much destroyed land features on the flanks of the mountain are partly due to landslips which have occasionally taken place there. The mud-avalanches and floods that attacked the town of Nikkō in 1662 were caused by landslips on the mountain-slope.

It has been mentioned that the Nyohō-Akanagi Volcano is a *konide*. The exposures on the walls of the valleys developed on the mountain-flanks also confirm this. There are exposed alternate layers of lavas and agglomerate beds. The details of the distribution of different lava-flows are, however, difficult to trace.

Petrography :—

Two-pyroxene basaltic andesite.—The lavas of the Nyohō-Akanagi Volcano are two-pyroxene basaltic andesite. They are of various types in megascopic appearance. Some lavas are strongly porphyritic (e.g. the lava found within the precincts of the Nikkō shrine), others only slightly porphyritic (e.g. the lava along the upper course of the Inari River), while still others are almost free from phenocrysts (e.g. the lava near Kiyotaki). The porphyritic minerals, if present, are plagioclase, hypersthene, and augite. The groundmass of the rock is light to dark gray, compact, and aphanitic.

Microscopically, plagioclase phenocrysts, 0.2-0.3 mm. in diameter, are euhedral to subhedral, thick tabular, and frequently form a group of two or three individuals. Zonal structure is seen but not marked. The mineral is sometimes traversed by irregular cracks, which are often filled with small calcite crystals. Hypersthene, less than 1 mm. in length, is long prismatic, and is frequently surrounded by aggregate of augite grains. Augite is stout prismatic, rather deeply coloured (greenish yellow) for this mineral but not pleochroic, and often shows

indistinct zonal structure. Both hypersthene and augite are not uncommonly surrounded by rims of magnetite grains, and sometimes are replaced completely by them. Microphenocrysts of magnetite, up to 0.4 mm. in diameter, are occasionally found scattered sporadically through the rock. Olivine is usually absent from the Nyohō-Akanagi lava, but this mineral has been once found in a specimen from the precincts of the Nikkō shrine. It is in small rounded grains, 0.1-0.2 mm. in diameter.

The groundmass is percrystalline to holocrystalline, consisting of minute laths of plagioclase, grains of pale yellowish augite and magnetite, with interstitial colourless glass. Sometimes calcite and zeolite are found as secondary minerals.

NANTAI VOLCANO

Nantai Volcano (2,484 m.) lies to the immediate north of Lake Chūzenji, about 1,200 m. above the lake level. It is a typical *konide* with a basal area of about 27 sq. km. At the summit there is a semicircular crater, about 800 m. in diameter. The highest point of the crater margin is on its south side, and its north wall is breached, probably due to explosive action. The crater bottom is 200-300 m. lower than its encircling crest line, and is filled with clasmatic materials—volcanic ashes, sands, lapilli, and other volcanic detritus. No trace of volcanic activity is observed there at present.

The outer slope of the volcano is regular in all directions, having an inclination of 30° or more near the top, but becoming gentler toward the foot. The surface of the mountain-flanks is covered with ejecta, on which grow thick bushes and trees, and the mountain is still young in dissection. The largest valley on the slope is that on the northern flank, called Yudonosawa, which originates near the summit of Nantai and joins Misawa valley at the north foot of the mountain. Besides these, there are on the flanks a number of radial gullies or furrows, dialectically called "*nagi.*" None of them are very deep, commonly not more than 100 m. in depth, and they are dry except in rainy weather.

The basement on which Nantai Volcano rests is composed, at least for the most part, probably of granitic rocks. In fact the Nantai lavas are observed to cover directly the erosion-surface of quartz-porphyry at the southeastern foot, and that of aplitic granite at the southwestern foot of the volcano. Moreover, fragments of the

granitic rocks are occasionally found among the accidental ejecta from this volcano.

The inner structure of the volcano is revealed only imperfectly from the exposures on the walls of the radial gullies, or *nagi*, on its flanks. So far as is inferred from these exposures, the volcano is a stratified one, built up of layers of ejecta—volcanic ashes, sands, lapilli, etc.—with intercalating lava-flows of basaltic andesite. The mode of stratification shows that the ejection of the materials from the volcano took place repeatedly without a long interval of quietude between any two successive periods of eruption.

The lavas that constitute Nantai Volcano are of basic nature and may be grouped petrographically into two types, namely, (i) two-pyroxene basaltic andesite and (ii) pumiceous hornblende-bearing two-pyroxene basaltic andesite. Of these the former greatly predominates over the latter, which is of quite limited occurrence.

Almost all the exposed lavas of the Nantai Volcano belong to the first rock-type. It may be further divided into two sub-types: (a) olivine-bearing and (b) olivine-free.

The olivine-bearing type is met with near Sakae-bashi, on the north side of the main road between Umagaeshi and Chūzenji (cf. p. 22). There the lava, about 10 m. thick, rests on the quartz-porphyry, and is covered by a later thick lava of Mt. Tansei (p. 15). The same rock-type is found also along the southern foot of the Nantai Volcano (on the north shore of Lake Chūzenji), especially well exposed at Furunagi valley, one of the conspicuous *nagi* on the southern flank of the volcano. Here the rock is found in several thin lava layers (each a few metres in thickness) intercalated between the ejecta beds.

Lavas of the olivine-free type build up the margin of the summit crater of the volcano. The same rock-type is also found at the southeastern foot of the volcano, constituting a precipitous cliff on which hang the famous waterfalls, Kegon and Shirakumo (cf. p. 23). There two thick lava-flows (each about 50 m. in thickness) lie on the erosion-surface of the basal quartz-porphyry, in the manner shown diagrammatically in Fig. 3 (p. 24).

Petrography :—

(i) *Two-pyroxene basaltic andesite.*—Megascopically the rock is strongly porphyritic, plagioclase constituting the most conspicuous

phenocrysts. Usually they are nearly equant, averaging 1-3 mm. in diameter, but often as large as 1 cm. across. Hypersthene and augite phenocrysts are always present, but only in moderate quantities. Sometimes a few phenocrysts of olivine, less than 2 mm. in diameter, are found irregularly distributed, though in some rock-types they are entirely lacking. The groundmass ranges from light to dark gray, and is compact, free from pores and vesicles in the inner portion of each lava, but porous and slaggy on the surface.

Microscopically, plagioclase phenocrysts are euhedral to subhedral, thick tabular or equant, and vary up to 3 mm. in diameter. Frequently several individuals of plagioclase form a grouped phenocryst, sometimes accompanied by hypersthene crystals. The composition of the porphyritic plagioclase varies from $Ab_{14}An_{86}$ to $Ab_{8}An_{92}$. Three types of twinning were observed: according to the albite, Carlsbad, and pericline laws. Zonal structure is exhibited near the margin of each crystal. Commonly the outer zones are less calcic than the inner ones, but a more complex zoning consisting of alternately more calcic and less calcic plagioclases is often observed. Sometimes the mineral encloses small magnetite grains and glassy substances, arranged often in distinct zones orientating themselves parallel to the outline of the host. Hypersthene phenocrysts, next in abundance to plagioclase phenocrysts, are prismatic and are usually surrounded by aggregates of minute augite grains. So far as has yet been determined, the mineral is normal in optical orientation, the optical plane being parallel to the c-axis. Augite occurring as phenocrysts is light greenish or nearly colourless. It is prismatic, sometimes twinned after (100), and measures up to 5 mm. in length. The mineral is often intergrown with hypersthene, surrounding the latter in parallel orientation. Olivine phenocrysts are either absent or present in small quantities. When they occur, they are less than 2 mm. in diameter, and are anhedral with rounded or irregular outlines. Sometimes the mineral is stained with a limonitic substance to a reddish brown colour along the margin of the crystal or along the cracks that traverse it. Not infrequently the olivine crystals are surrounded completely by hypersthene crystals.

The groundmass is percrystalline and consists of minute laths of plagioclase, prisms or grains of augite, and grains of magnetite. Glass is present only in negligible quantities. Sometimes, rather large magnetite crystals, up to 0.4 mm. across, are scattered sporadically through the groundmass of the rock.

A specimen of a typical Nantai lava (olivine-bearing two-pyroxene basaltic andesite) collected in the Furunagi valley on the southwestern flank of Nantai was chemically analysed by S. Tanaka with the following results:

		Norm	
SiO_2	56.00%	Q	10.58
Al_2O_3	18.48	Or	5.06
Fe_2O_3	1.79	Ab	20.96
FeO	6.87	An	36.75
MgO	4.11	Di	4.43
CaO	8.63	Hy	17.88
Na_2O	2.48	Mt	2.60
K_2O	0.86	Il	1.44
H_2O+	0.20	Ap	0.25
H_2O-	0.05		
TiO_2	0.76		
P_2O_5	0.12		
MnO	0.10		
Total	100.45		

Ratios

$$\frac{Sal}{Fem} \quad 2.76$$

$$\frac{Q}{F} \quad 0.17$$

$$\frac{K_2O'+Na_2O'}{CaO'} \quad 0.37$$

$$\frac{K_2O'}{Na_2O'} \quad 0.23$$

In Qn. S. the rock belongs to *bandose* [II. 4 (5). 4. 4″].

(ii) *Pumiceous, hornblende-bearing two-pyroxene andesite.*—The rocks of this type are of quite limited occurrence, and are met with only at the Ryūzu waterfall and in the Misawa valley, respectively at the west and north foot of the Nantai Volcano.

Megascopically the rock is highly vesicular or pumiceous. It is light coloured, nearly white when fresh, but is often dark brownish in weathered part, being stained by a limonitic substance. Phenocrysts of plagioclase and pyroxenes are scattered sporadically through the rock.

Microscopically the rock is characterized by the presence of brown hornblende phenocrysts, though they are very few in number. The hornblende is stout prismatic, 0.5-1 mm. in length, twinned on (100), and is rarely euhedral. It is strongly pleochroic, from dark brown to light brownish yellow, and is optically negative. Of phenocrysts of plagioclase, hypersthene, and augite, nothing deserves special mention.

The groundmass consists almost wholly of glass, light brown in colour, rich in pores of various size, elongated more or less parallel to the direction of flow of the lava. Small magnetite crystals, up to 1 mm. in diameter, are scattered through the groundmass.

MTS. TANSEI, MITSUDAKE, TARŌ, ŌMANAGO, KOMANAGO, ETC.

At the southeastern foot of the Nantai Volcano, there is a steep-sided, flat-topped mountain, called Tansei (1,482 m.), consisting of thick lava-flows resting on the lower part of the flank of Nantai. A conspicuous lava, over 200 m. thick, of Mt. Tansei is exposed on a precipice on the north side of the road from Umagaeshi to Chūzenji (cf. p. 22). For about 1 km. northwestward from Umagaeshi along the road, this lava is observed directly covering the erosion-surface of the basal quartz-porphyry, while a little distant to the NW, a Nantai lava is intercalated between the quartz-porphyry and the Tansei lava.

To the northwest of the Nantai Volcano there is another mass of lavas, Mitsudake (1,945 m.), similar in form to Mt. Tansei. It is rather low in altitude, but is large in extension. To the north of Nantai stand a triplet of volcanoes, Mts. Tarō (2,368 m.), Ōmanago (2,375 m.), and Komanago (2,323 m.). These three volcanoes are similar to each other in morphological features, all being conical (*tholoids*) and young in topographic development.

Mt. Tarō has a top-crater, 250 m. across and 60 m. deep, whose bottom is now covered by detrital materials. The apical part of the volcano is breached on its northwest side, undoubtedly due to explosion, and a deep furrow (250 m. in depth) runs therefrom in the NW direction. A lava of the Tarō Volcano covers a hornblende-bearing pumiceous lava of Nantai at the north foot of the latter.

A small volcanic mass, called Sannōbōshi (2,073 m.), parasitic to the Tarō Volcano, lies at its west foot. The two *tholoids*, Ōmanago

and Komanago, rest upon the west flank of the *konide* Nyohō-Akanagi.

The lavas constituting Mts. Tansei, Mitsudake, Tarō, Ōmanago, Komanago, etc., are of similar petrographic types, all being olivine-bearing two-pyroxene basaltic andesite, and almost always carrying abundantly cognate xenoliths of various shapes (ellipsoidal, spheroidal, quite irregular, etc.), commonly measuring 1-10 cm. across. They all may be connate, and are the youngest[1] lavas in the Nikkō district, as is seen from their above-mentioned structural relations to the lavas of other volcanic bodies. Their extrusion must, however, have taken place before the top-crater of Nantai was completely plugged up, for pumice ejected from the Nantai vent covers the surface of these young lava-flows. The top-surface of Mt. Tansei is covered rather thickly by an accumulation of Nantai pumice.

Petrography :—

Olivine-bearing two-pyroxene basaltic andesite.—Megascopically the rock is strongly porphyritic. The most conspicuous phenocrysts are of plagioclase, reaching as large as 1 cm. in diameter. Phenocrysts of augite and hypersthene are small in size, usually less than 1 mm. across, and are moderate in quantity. Besides these, small olivine crystals, usually not exceeding 1 mm. in diameter, are found sporadically. The groundmass through which these phenocrysts are scattered is light to dark gray, and sometimes rich in pores that are evenly distributed.

Microscopically, plagioclase phenocrysts ($Ab_{18}An_{82}$) are nearly equant, twinned as usual, and show the zonal structure near the margin of each crystal. The mineral is often rich in inclusions of augite and magnetite grains and brownish glassy materials, irregularly distributed through the host. Of the porphyritic mafic minerals, hypersthene is the most predominant, though much less in quantity than plagioclase. It is long prismatic, euhedral to subhedral. Augite phenocrysts are in stout prisms of about 0.5 mm. long. Olivine is in anhedral small grains, averaging 0.1-0.5 mm. in diameter. It is often stained into reddish brown colour along the periphery of each crystal due to hydrated ferric oxide.

The groundmass consists of plagioclase laths, augite and magnetite grains, and interstitial glass.

1) It is noteworthy in the present connection that Shirane Volcano (out of the present area), the only volcano of the Nikkō Group that has historical records of eruption, is composed of rocks of the same petrographic type.

Besides the minerals above mentioned, a few rounded grains of quartz were observed in a lava of Volcano Tarō. They are traversed by numerous cracks, and are considered to be xenocrysts that came from the granitic rocks underlying the lava.

Cognate xenoliths abundantly included in the lavas of Mts. Tansei, Mitsudake, Tarō, etc. are chiefly of two types.

(i) Xenoliths of the first type are light to dark gray, fine-grained, and are vesicular. Sporadic phenocrysts of plagioclase and augite are seen megascopically. Microscopically, the groundmass consists of laths of plagioclase, 0.3-0.5 mm. in length, rounded grains of yellowish augite, and long prisms of hypersthene, with grains of magnetite. Brown glass is present filling the interstices between the component minerals.

(ii) Xenoliths of the second type are reddish brown, fine-grained, and carry phenocrysts of plagioclase and olivine, commonly 1-3 mm. in length. The plagioclase phenocrysts are fresh and clear, and show no marked zonal structure. The olivine phenocrysts are surrounded by the grains of magnetite in a striking manner. Sometimes they are almost wholly replaced by the magnetite crystals. The groundmass is holocrystalline, and consists chiefly of laths of plagioclase and grains of augite and magnetite.

LAKE CHŪZENJI, OTHER LAKES AND DAIYA RIVER

Lake Chūzenji, at the south foot of Nantai Volcano, is the largest of many lakes and plashes in the Nikkō district. It is 6.5 km long (from E to W) and 1.8 km. wide (from N to S), with an area of 12.4 sq. km. Its water-level is 1,271 m. above sea-level. The topography of the lake-bottom is as shown in Fig. 1. The temperature of the lake water at the surface fluctuates between 23°C (average of the highest point in August) and 4°C (average of the lowest point in January); while it is constant (4°C) throughout the whole year at the depth of 100 m. below the lake level.

Lake Chūzenji must have been formerly of much larger extension. Senjōgahara, a flat marshy area on the west side of Nantai, is evidently a fossil-lake, previously connected with Lake Chūzenji but later filled up by the deposition of ejecta from Nantai Volcano. The plashes, Kōtoku-numa, Aka-numa, and Semmon-ike, found in patches on the flat of Senjōgahara are remnants of the former extensive lake.

The formation of small lakes near the village of Yumoto (at the northwest corner of the annexed geologic map), Yunoko, Tatenoko, Kirikomi, and Karikomi, is related to the extrusion of the Mitsudake lava. These lakes lie just at the junction of the old plagioliparitic bodies (Maeshirane and Yusengatake) and the young Mitsudake lava, and are depressions left uncovered by the Mitsudake lava, which were afterwards filled with water.

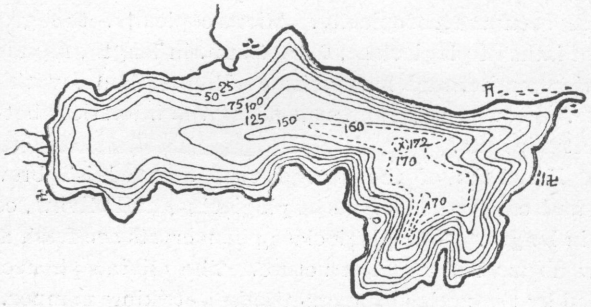

Fig. 1.
Topography of the bottom of Lake Chūzenji. Depth in meters.
Scale: 1/100,000. (After A. Tanaka.)

The level of Lake Yunoko is 207 m. higher than that of Lake Chūzenji. The water flows out from Yunoko making a waterfall called Yutaki, which hangs on the plagioliparite of Maeshirane, runs southward through Senjōgahara, and flows into Lake Chūzenji. Where the water passes over the pumiceous (hornblende-bearing) lava of Nantai it forms a waterfall called Ryūzu. There is another inlet at the west end of Lake Chūzenji.

The water of Lake Chūzenji flows out from the east end of the lake to supply the source of the Daiya River. About 500 m. east of the outlet there is the Kegon cataract, famous for its magnificence. It hangs over one of the Nantai lavas which covers the erosion-surface of the quartz-porphyry. Before this Nantai lava flowed here, Lake Chūzenji and the lower course of the Daiya River were connected by another channel, but afterwards the Nantai lava-flow cut off this connection and dammed up the water from the lake, resulting in the formation of the Kegon waterfall. The manner in which the Nantai lava dammed up the water of Lake Chūzenji is well illustrated by the photograph (Fig. 2).

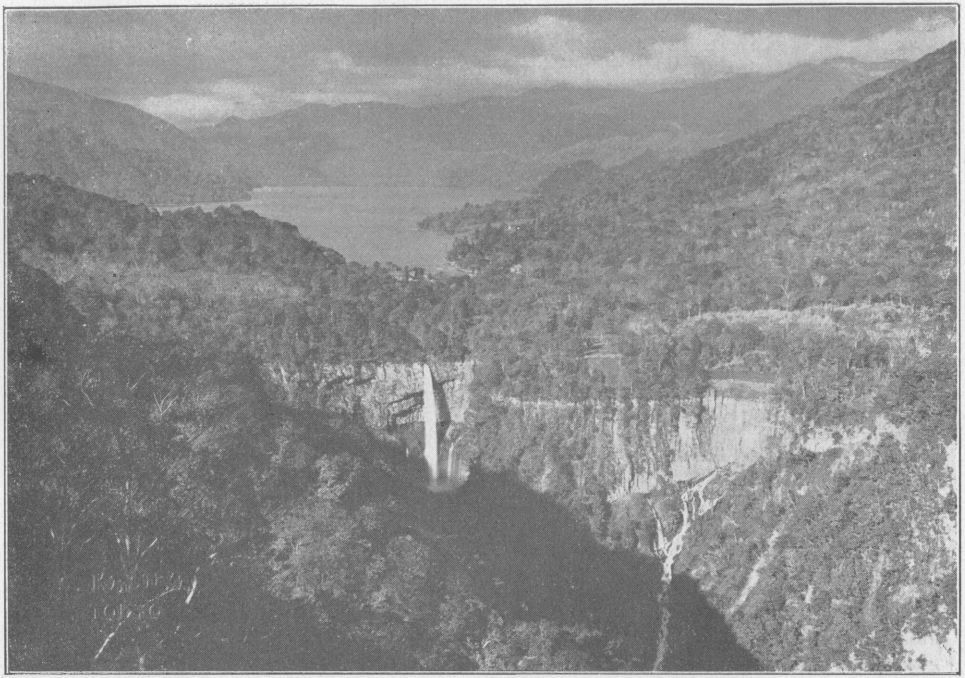

Fig. 2. Lake Chūzenji and the Kegon water-fall as viewed westward.
Photo. by S. Kasuya.

The Daiya River runs further down through a deep gorge excavated in the quartz-porphyry and then along the junction between the terrane of the younger volcanic rocks (on the north) and that of the older basal rocks (on the south), receiving water from both sides on the way. Near the town of Nikkō the river receives the tributary waters of the Inari (cf. p. 10), and further runs eastwards to conflow with the Kinu River at a point 20 km. east of Nikkō.

Along the Daiya River as well as the lower course of the Inari River there develop fluviatile beds, consisting of gravels of andesitic rocks, mostly rounded, varying from a few centimeters to a meter or more in diameter, which are cemented by fine volcanic materials. These fluviatile beds are covered by the younger deposits of pumice and other ejecta from the Nantai Volcano.

SUMMARY OF THE GEOLOGICAL HISTORY OF THE NIKKŌ DISTRICT

The geological history of the Nikkō district may be summarized as follows:—

(1) The district now occupied by the young volcanoes of the Nikkō Group was, before they came into existence, a terrane of granitic rocks (quartz-porphyry, granite-porphyry, and granite) intruding the sedimentaries of the Chichibu System.

(2) The first volcanic activity began in the Tertiary period with the effusion of plagioliparite. This rock was the forerunner of andesite, and built up the older volcanoes, Yusengatake, Maeshirane, etc., which are mostly outside the area now concerned.

(3) The *konide* of Nyohō-Akanagi is the first-formed of the andesitic volcanoes in the Nikkō district. The lavas constituting this volcano are of two-pyroxene basaltic andesite free from olivine (cf. p. 10).

(4) After the formation of Mt Nyohō-Akanagi, there was formed on its southwestern foot the *konide* of Nantai, which was built up of alternately accumulated layers of lavas and ejecta. The Nantai lavas are of two types: (i) two-pyroxene basaltic andesite, often with a few olivine crystals and (ii) hornblende-bearing pumiceous basaltic andesite.

(5) In the declining phase of the volcanic activity of Nantai, satellitic lava-extrusions took place, giving rise to Mt. Tansei on the southeast, Mts. Ōmanago, Komanago, Tarō, and Sannōbōshi on the

north, and Mitsudake on the northwest. The lavas constituting these volcanoes are olivine-bearing two-pyroxene basaltic andesite, comparatively rich in mafic minerals and commonly with abundant inclusions of segregation products. These cognate xenoliths have probably come from the early crystallized portion of the injected magma reservoir, which was broken at the time of eruption to be included in the extruded lavas.

(6) At the time of the extrusion of these satellitic lavas, the apical crater of Nantai had not been completely plugged up, but continued to be active, ejecting quantities of pumice which is now found extensively distributed throughout the whole Nikkō area as a surface-veneer.

(7) The present physiographic features of the Nikkō district are well explained as results of the above-outlined geological history of the district.

The Daiya River, which has developed along the junction between the younger volcanic rocks and the basal rocks, forms a natural divide between the physiographically contrasted areas. The south side of the river is a terrane of the older basal rocks (chiefly quartz-porphyry and the Palaeozoic sedimentaries), where the ground is much dissected; while on the north side of the river the original features of the land due to the structure are still preserved. Even the oldest Nyohō-Akanagi Volcano, though rather strikingly demolished at the apical part, preserves the general form of a *koníde*. The original features of the Nantai Volcano and the still younger mountains Tansei, Ōmanago, Komanago, Tarō, Sannōbōshi, and Mitsudake, which are satellitic to Nantai, have been but little modified.

PART II

ITINERARY FROM NIKKŌ TO CHŪZENJI

Nikkō The town of Nikkō is situated at the southeastern foot of Mt. Nyohō-Akanagi, where the volcanic rocks are in contact with the basal rocks (the sedimentaries of the Chichibu System and the quartz-porphyry which intrude them). The main part of the town is on the south side of the Daiya River, at the north foot of the Palaeozoic mass, while the famous shrines and temples of Nikkō are on the lowermost part of the southeastern flank of Mt. Nyohō-Akanagi.

A general view of the topography

A general view of the topography of the Nikkō district is commanded by ascending half-way up the mountain at the back of the Kanaya Hotel at Nikkō. There one can see the contrasts in morphologic features of the different volcanoes. The oldest *konide*, Nyohō-Akanagi, is in an advanced stage of dissection and is serrated at the apex. Nantai is young in dissection, and preserves the original form of a *konide*. Still younger mountains, Tansei, a flat-topped, steep-sided lava-mass, and Ōmanago, a small *tholoid*, both satellitic to Nantai, are little dissected. The distribution of the veneer of pumice can also be traced from the characteristic topographic features—smooth surface—of the parts covered by it. The gentle smooth slope toward the foot of Mt. Nyohō-Akanagi is due to the veneer of pumice.

A general idea of the geology

A general idea of the geology of the Nikkō district may be obtained during the excursion from Nikkō to Chūzenji.

The basal rocks

The basal rocks (cf. p. 5) of the Nikkō district are exposed on the south side of the Daiya River. The mountain at the back of the Kanaya Hotel is composed of sedimentary rocks of the Chichibu System (cf. p. 5). There the formation consists essentially of black slate with intercalating thin beds of grayish graywacke-sandstone, with the general strike N 30-40°E and dip of 30-40° northward. The sedimentary rocks are usually altered into compact hornfels (biotite-hornfels) near their contact with the quartz-porphyry or granite-porphyry, due to the effect of the intrusion of the latter. Dark gray sandstone in direct contact with quartz-porphyry is found at a river side, near Shinkyō (Sacred Bridge), Nikkō. Here, however, the contact effect of the quartz-porphyry on the sandstone is not remarkable.

Nyoho-Akanagi lava

About 1.3 km. westward along the main road to Chūzenji from Shinkyō, a road branches off leading to the waterfalls Jakkō and Haguro. On this branch road one can see an exposure of a Nyohō-Akanagi lava covered by later ejecta layers. It is two-pyroxene basaltic andesite free from olivine (cf. p. 10).

The first stage of the trip from Nikkō to Chūzenji, i.e., up to Umagaeshi, may be covered by tram or motor car. The road is along

the north bank of the Daiya River and runs chiefly on the fluviatile deposits, but often crosses over younger beds of ejecta of Nantai. The south side (left-hand side) of the river is the terrane of the basal quartz-porphyry, and its north side (right-hand side) that of the volcanic rocks.

From Umagaeshi, the terminus of the electric tram line, a road of easy walking grades leads to Chūzenji, and there are many interesting geologic features to be seen on the way.

Tansei lava For about 1 km. from Umagaeshi, along the gently ascending road, there is exposed on the right side quartz-porphyry covered by Tansei lavas. The manner in which the Tansei lava rests on the erosion-surface of quartz-porphyry is best seen by looking northeastward from Saiwai-bashi, the first bridge across the Daiya River, about 1 km. from Umagaeshi.

The basal quartz-porphyry is gray and porphyritic, with abundant phenocrysts of quartz and feldspar, and contains often angular blocks of Palaeozoic slate (cf. p. 7).

The Tansei lava is exposed on a precipitous cliff over 200 m. high, with columnar joints well exhibited on its side. It stands straight like a screen, covering the quartz-porphyry, and is commonly called "*Byōbu-iwa*" ("Screen Rock"). Petrographically the Tansei lava is olivine-bearing two-pyroxene basaltic andesite and carries abundantly subangular cognate xenoliths of various size and shape (cf. p. 16). These xenoliths may probably be fragments of the early segregated products which formed the marginal parts of the magma reservoir but were afterwards shattered and caught up by the Tansei lava when it flowed out.

Nantai lava Proceeding further northwestward from Saiwai-bashi, a lava, only a few meters in thickness, is observed on the north side of the road, near Sakae-bashi, the second bridge about 200 m. NW of the first (Saiwai-bashi).

This thin lava came from the Nantai Volcano and is intercalated between the basal quartz-porphyry and the Tansei lava. Petrographically it is olivine-bearing two-pyroxene basaltic andesite.

After crossing Sakae-bashi, the road leads away from the Daiya River, whose upper course runs through the terrane of quartz-porphyry, excavating a deep gorge. From Misawa-bashi, the third

bridge over a branch stream of the Daiya River about 200 m. west of Sakae-bashi, the inclination of the ground becomes steeper and the road ascends in a winding course. On this ascending road, exposures of the Nantai lava are often met with, from beneath the veneer of pumice and other ejecta.

Hannya and Hōtō waterfalls

From the Kengamine resting house on the way, two waterfalls are seen toward the north at a distance, the Hannya fall (36 m. high, 1 m. wide) on the right and the Hōtō fall (30 m. high, 5 m. wide) on the left. These waterfalls owe their source to water issuing from the mountain side of the Nantai Volcano. The Hannya waterfall hangs over one of the Nantai lavas, while the Hōtō waterfall flows over an agglomerate constituting the volcano.

Further upward the road passes over the quartz-porphyry which forms the base of the Nantai Volcano. This rock is covered by deposits of Nantai ejecta (mostly pumice) in the lower part, but it is directly exposed in the upper part.

Structure of the Nantai Volcano

The winding road over the quartz-porphyry comes repeatedly to the edge of the precipitous cliff which forms the wall of the valley along the junction of the quartz-porphyry and the Nantai volcanic body. There, good opportunities are afforded to observe the exposures on the walls of radial valleys, or *nagi* of the Nantai Volcano and to obtain an idea of its structure. It is revealed that the volcano consists chiefly of fragmental materials accumulated in layers, often intercalating thin sheets of lava.

Kegon and Shirakumo waterfalls

Going on further, one comes at last to a flat area on the southeastern skirt of Nantai. There the ground is thickly covered by the ejecta of the volcano. A view of the famous waterfall of Kegon may be enjoyed from a tea-house standing on this flat area south of the main road to Chūzenji. To inspect closer the cataract, descend a path toward the bottom of the valley, and there one can see the whole length of mighty Kegon. There is another waterfall, Shirakumo, about 300 m. ENE of the Kegon fall.

The exposures that are observed on the path to the bottom of the valley are shown diagrammatically in Fig. 3. Two lava-flows

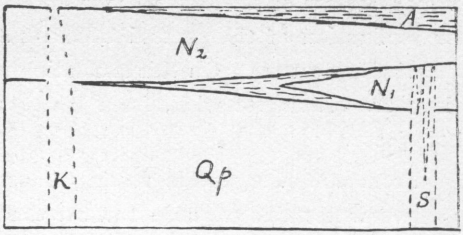

Fig. 3.
Qp—Quartz-porphyry. N_1 & N_2—Nantai lavas.
A—Ash bed. K—Kegon waterfall.
S—Shirakumo waterfall.

(N_1 and N_2) of the Volcano Nantai rest on the quartzporphyry in the manner shown by the figure. The lavas are black, strongly porphyritic with abundant phenocrysts of plagioclase, but are very poor in those of mafic minerals. They are free from olivine (cf. p. 12).

The Kegon waterfall hangs over a precipice, consisting of a Nantai lava (N_2), some 50 m. thick, resting on the quartz-porphyry. The whole height of the Kegon fall is about 100 m. and its width measures about 10 m. at the top. The basin at the foot of the fall, formed by the dashing of the water is about 20 m. in depth. The lower surface of the lava N_2 is scoriaceous. The underground water issues through this scoriaceous part of the lava along its junction with the basal quartz-porphyry and falls down in several stringers beside the main waterfall.

The Shirakumo waterfall owes its source mainly to the water issuing from the gap between the two Nantai lavas, N_1 and N_2.

Before the lavas, N_1 and N_2, here exposed were extruded, Lake Chūzenji was connected with the lower course of the Daiya River by another channel, but these Nantai lavas cut off the connection and dammed the water of the lake, resulting in the formation of the waterfalls here (cf. p. 18).

Chūzenji The town of Chūzenji (1,280 m. above the sea-level or 680 m. higher than Nikkō) is situated at the east extremity of the lake of the same name. It is a well-known summer resort, with a mild temperature, rarely exceeding 25°C. even in the hottest season. For a description of Lake Chūzenji, see pp. 17-18.

GEOLOGICAL SKETCH-MAP
OF THE
NIKKŌ-CHŪZENJI
DISTRICT

1:50,000

1000m 500 0 1000 2000 3000 4000m

町 10 5 0 10 20 30 1 里

1926

Chichibu System

Quartz-porphyry and Granite-porphyry

Granite

Plagioliparite

Nyohô-Akanagi Lava

Nantai Volcanic Body

Nantai Lava α

Nantai Lava β

Nantai Ejecta

Lavas of Tansei, Tarô, etc.

Fluviatile Deposits

Talus

NOTES ON THE FAUNA OF THE NIKKO DISTRICT

By Tokio Kaburaki

Popularly known as the pearl of Japan, the Nikko district presents not only a beautiful array of natural scenery including mountains, lakes, cascades and forests, but also preserves the highest type of the Japanese arts and crafts in the mausolea of the Tokugawa Shōguns. In its zoological aspect this region is of special interest, and exhibits some peculiarities in the altitudinal distribution of animal life. In accordance with the data on the distribution of some animal groups, it may be divided into certain altitudinal life zones, corresponding to the latitudinal belts of this country, though the contrasts in faunas are nowhere very sharp. The majority of the Eastasian types, in association with some that are Oriental, find a favourable habitat in the district which includes the towns of Nikko and Chūzenji, extending from an altitude of 590 m. to one of about 1,350 m. above sea-level. The adjoining highland is a zone which is the habitat of the majority of distinctively Eurasian or northern elements.

Of mammals the monkey (*Macaca fuscata*) is a species which may be supposed to represent a southern type, and occurs in fair abundance in the rocky district extending from Umagaeshi to the magnificent fall of Kegon, but does not make its appearance on the highland. Frequently met with on the mountains is the bear (*Ursus torquatus japonicus*), which belongs decidedly to the Himalayan type and is found all over Honshū.

The species with Eurasian affinities, though ranging over to the highland, flourish in the region that extends from the town of Nikko to Chūzenji. Some representatives are the "tanuki" (*Nyctereutes viverrinus*), the fox (*Vulpes japonicus*), the dormouse (*Glirulus japonicus*), the large flying squirrel (*Petaurista leucogenys nikkonis*), and the small flying squirrel (*Sciuropterus momonga amygdali*). High up on the mountains may also be observed the goat-antelope (*Capricornis* (*Capricornulus*) *crispus*).

In the region above Chūzenji are found to thrive some species

with Eurasian affinities. Much commoner than other forms is the hare (*Lepus brachyurus etigo*) which changes from gray to pure white in the winter season. With it associates the ermine (*Mustela erminea nippon*) which is grayish brown above and white beneath. In winter this, too, becomes white with the exception of the black tip of the tail. Remaining secure in the hollows of trees by day is the long-eared bat (*Plecotus auritus sacrimontis*), which also inhabits Mt. Fuji. Though not common, the squirrel (*Sciurus lis*) is often seen in some heavily timbered localities. The deer in this region is *Cervus matsumotoi*, which ranges northwards to Hokkaidō. Some interest attaches to the existence in Nikko of its cross with a European species, *C. elaphus*. Several species of rats and mice may also be observed on various sides, especially on the grassy plain of Senjō-ga-hara.

Here it should be mentioned that the boar (*Sus leucomystax*), though not known at the present day, was an inhabitant of this district. Some years ago it was altogether exterminated by a certain epidemic disease.

The Nikko district is a veritable paradise for birds and bird-lovers, especially in the warmer season. The list of its bird-denizens is long, and comprises a number of forms belonging to the Passeres. Known for their pleasing notes are a few flycatchers, such as *Hemichelidon sibirica sibirica*, *Alseonax latirostris latirostris*, *Zanthopygia narcissina narcissina*, and *Cyanoptila cyanomelana cyanomelana*. On the grassy plain of Senjō-ga-hara appear some species, of which the most prominent is *Saxicola torquata stejnegeri*. It is of interest to note that the sparrow (*Passer montanus saturatus*) is found to extend up to this plain but not beyond. Near the fall of Kegon, flitting in flocks on easy wing, we find Blakiston's martin (*Delichon urbica dasypus*). Of other species of this order the following are those which frequent some of the timbered localities and occasionally are found elsewhere: the skylark (*Alauda arvensis japonica*), the blue-tail (*Janthia cyanura*), *Erithacus akahige akahige*, *Larvivora cyanea*, the willow-warbler (*Acanthopneuste borealis xanthodryas*), *Troglodytes troglodytes fumigatus*, the minivet (*Pericrocotus cinereus japonicus*), the bull-headed shrike (*Lanius bucephalus*), the coal-tit (*Periparus ater insularis*), *Chloris sinica minor*, *Pyrrhula pyrrhula griseiventris*, the gray-headed bunting (*Emberiza fuscata fuscata*), etc. Uttering her melancholy notes, generally from the thickets, is the little cuckoo (*Cuculus poliocephalus poliocephalus*) which is found from Honshū in the north to Formosa

in the south. Frequently heard near the lake of Yunoko and elsewhere is the goatsucker (*Caprimulgus indicus jotaka*). There may also be found the white-rumped swift (*Apus pacificus*), the woodpeckers (*Dryobates major hondoensis*, *D. leucotos stejnegeri*), and many others.

On the approach of autumn, the birds become fewer and fewer. As early as the middle of October some species of *Merula* make their appearance. They are *M. obscura*, *M. pallida*, *M. sibirica davisoni*, and others. More rarely met with is the brown-eared bulbul (*Microscelis amaurotis amaurotis*) which appears in fair abundance in the warmer season. Uttering more or less jarring notes, generally from the thickets, is the Japanese nightingale (*Horornis cantans cantans*) which has a wide range from the Kuriles in the north to as far south as Formosa. Flitting about between the banks of the river Daiya are the wagtail (*Motacilla alba grandis*) and *Cinclus pallasii pallasii*, of which the former ranges from Korea to Hokkaidō, and the latter to the Kuriles. The eastern tree-pipit (*Anthus trivialis hodgsoni*), the titmouse (*Parus major minor*, *Sittiparus varius varius*), the meadow bunting (*Emberiza cioides ciopsis*), the jay (*Garrulus glandarius japonicus*) and others are also found in this district.

Snakes are widely spread over a large proportion of this district, and include such species as *Elaphe climacophora*, *E. quadrivirgata*, *E. conspicillata*, *Dinodon orientale* and *Agkistrodon blomhoffii*. They abound both in timbered localities and on the grassy plains. *Eumeces latiscutatus* is a common lizard which is found on stone walls or under stones.

Ranging up from the town of Nikko are frogs, such as *Bufo vulgaris formosus*, *Rana temporaria ornativentris*, *Polypedates buergeri*, *Poly, schlegelii arborea*, etc. Of these the last named species inhabits the lakes of Chūzenji, Yunoko and others, and lays its egg-mass so that it hangs down from the leaves of trees. Thriving on the lowland below the town of Nikko are *R. nigromaculata* and *R. rugosa*, of which the latter is found to extend up to Umagaeshi but not beyond.

Passing on to salamanders we find two interesting species, *Hynobius peropus* and *Onychodactylus japonicus*, whose distribution in this district calls for a little attention. The former appears to be restricted to the highland above Chūzenji, whereas the latter finds a favourable habitat on the lowland. Extensively distributed throughout the district is also the newt, *Diemictylus pyrrhogaster*.

Abundant in the lake of Chūzenji and the rivers connected with

it are some food and game fishes which have all been brought from other lakes and rivers, such as Biwa, Shikotsu, Towada, etc. They are *Oncorhynchus nerka*, *O. masou*, *Salvelinus malma*, *S. kundscha* (Salmonidae); *Misgurnus anguillicaudatus* (Cobitidae); *Sarcocheilichthys variegatus*, *Richardsonius phalocrocorax*, *Cyprinus carpio*, *Carassius auratus* (Cyprinidae); and *Anguilla japonica* (Anguillidae). Some years ago attempts were made to introduce the rainbow trout (*Salmo irideus*) and the white fish (*Coregonus*) from America. Of the species just mentioned, *R. phalocrocorax* is very closely related to *R. hakuensis* found in Hakoné Lake. It breeds in May, and deposits its eggs on the sandy shore. As is well known, this fish is commonly infested with *Ligula*, whose final host may be considered to be the ducks which come over in winter and feed largely on it.

In order to propagate salmon experiments are now being carried on in Chūzenji Lake.

Extremely common in Chūzenji Lake is a little shrimp-like crustacean, *Xyphocardina compressa*, which has been introduced from some other locality. The only crab known in this district is *Potamon dehaani*, which is found near the water.

The lower crustaceans are extremely plentiful in the lakes, comprising various species which belong to the genera *Diaptomus*, *Sida*, *Daphnella*, *Scopholebris*, *Daphnia*, *Ceriodaphnia*, *Chydorus*, *Lymnadia*, and others.

The great variety in plant associations tends to give variety and richness to the insect fauna. From a consideration of the distribution of some insects it may be said that the highland is the habitat of the majority of the distinctive forms, which differ in most cases from those of the adjoining lowland, but are occasionally related to lowland forms in the northern territories.

So far as I can learn, the species of various groups which are at present known from this district amount to enormous numbers so that it is almost impossible to enumerate them. Amongst the beetles water-frequenting forms are commonly represented by *Hydrocyclus lacustris*, *Philhydrus umbratus*, *Cercyon placidus*, *C. rotundulus*, and others. Of land-frequenting forms the carabs are exceptionally plentiful, including such species as *Leistus alecto*, *Carabus tenuiformis*, *Damaster pandurus* var. *cyanostola*, *Harpalus leptopus*, *Eucalathus aeneolus*, *Colpodes bentonis*, *Trephionus nikkoensis*, *Platynus subovatus*, *Stomis prognathus*, *Trigonognatha cuprescens*, *Allotriopus hoplites*,

Pterostichus asymetricus, *Bembidium aeneipes*, *B. nikkoense*, *Dytiscus marginalis*, etc. The Nitidulidae are represented by *Epuraea apposita*, *Meligethes haroldi*, *Cychramus dorsalis*, *Eugoniopus lewisi*, *Strongylus ater*, *Pallodes umbratilis*, etc. Numerous also are the species of the Carambycidae, for example *Grammoptera aegrota*, *Leptura cometes*, *Eustrangalis distenioides*, *Callidium maaki*, *Anaglyptus niponensis*, *Demonax transilis*, *Acanthocinus stillatus*, etc. Of other families the following species can be seen : *Prismognathus angularis*, *Macrodorcas rubrofemoratus*, *Aesalus asiaticus* (Lucanidae) ; *Mesolycus puniceus*, *Platycis nasutus*, *Lucidota vitticollis* (Cantharidae) ; *Plesiophthalmus laevicollis*, *Pseudocistela haagi* (Tenebrionidae) ; *Syneta adamsi*, *Crioceris lewisi*, *Nodostoma ruficolle* (Chrysonulidae) ; and many others.

Butterflies are numerous, and most of them are exquisitely beautiful. Especially attractive are species of the Nymphalidae, such as *Pararge achine*, *Melentis leda*, *Neptis excellens*, *Argynnis aglaia*, *A. adippe*, *A. ruslana*, *A. laodice*, *A. paphia*, *Vanessa io*, *V. xanthomelas*, *V. antiopa*, etc. Amongst species of other families the following are those which frequent this region : *Parnassius citrinarius* (Papilionidae) ; *Augiades sylvanus*, *Leptalina unicolor* (Hesperidae) ; etc.

Moths are very well represented. The most common species are those belonging to the families Noctuidae and Notodontidae. The former comprise *Lycophotia praecurreus*, *Agrotis c-nigrum*, *Clavipalpula aurariae*, *Acronycta alni*, *Gortyna leucostigma*, *Dipteryga caliginosa*, *Catocala electa*, *Phytometra festata*, *Pangrapta trimantesalis*, *Capnistis albonotata*, etc. The latter are represented by *Lophocosma atriplaga*, *Stauropus perdix*, *Pydna pallida*, *Lophopteryx velutina*, *Semidonta biloba*, *Statalia doerriesi*, *Microphalera grisea*, *Ochrostigma punctatella*, etc. There may also be seen a number of other species, such as *Dasychira pudibunda* (Lymantridae) ; *Cosmotrichae potatoria* (Lasiocampidae) ; *Macrauzata fenestaria* (Drepanidae) ; *Schistomitra funeralis* (Callidullidae) ; *Dilina christophi*, *Hylocuis caligeneus* (Sphingidae) ; and *Parapsestis albida* (Cymatophridae).

Coming to flies, we find a number of interesting species. Of the Syrphidae the following forms have been recorded : *Leucoma lucorum*, *Nephomyia bombiformis*, *Criorhina apicalis*, *Brachyopa nikkoensis*, *Chrysotoxum japonicum*, and *Pycnopogon nikkoensis*.

Of leeches several highly interesting species are found in the water, clinging to the under side of stones or other sunken objects. They are *Glossiphonia complanata*, *Herpobdella octoculata*, *Mimobdella*

japonica, and others. On moist land, together with earthworms, is found the land leech, *Orobdella ijimai*, which, on account of similarity in colour, is very liable to be mistaken for an earthworm.

Coming now to the turbellarian fauna we find a number of land planarians, which are most abundant under logs in places where the earth remains moist, or are found creeping on mossy stone walls. The species hitherto recorded are *Geoplana bimaculata*, *Perocephalus fulvus*, *Bipalium fuscolineatum*, *Rhynchodemus ijimai*, *Microplana ruteocephala*, and others.

Extensively distributed in this region are three freshwater planarians, *Planaria gonocephala*, *Pl. vivida* and *Polycelis auriculata*, the distribution of which exhibits some interesting features. So far as my observations go, four subregions can be distinguished. The first subregion is represented by the vicinity of the town of Nikko, which affords an habitat favourable to *Pl. gonocephala*, which is very abundant in the streams flowing through this locality. The second subregion extends from the preceding to an altitude of about 833 m., and in it the three species are found together, and present an aspect similar in distribution to what we find in Central Europe. *Pl. vivida* thrives in the upper parts of the streams, *Poly. auriculata* in the middle courses, and *Pl. gonocephala* in the lower parts. Ascending the mountains we enter the third subregion in Chūzenji where *Poly. auriculata* flourishes. We come next to the last subregion near Yumoto, where *Pl. vivida* occurs in fair abundance in cool running brooks. Here also is to be seen *Pl. gonocephala*, but it is confined either to the larger streams or lakes.

THE FOREST VEGETATION OF NIKKO

By Shunsuke Kusano

The Nikko region, which has an extent of about 28 kilometers with an average width of 11 kilometers, is situated in the mountain complex of central Japan, and ranges approximately between 500 and 2,500 m. in altitude. With the exception of a small part of its lower portions, it has remained uncultivated and its vegetation is mainly of the forest kind. On account of great variations in climate, this small area has been found to represent our entire temperate region, that is, the northern half of Japan, including the island of Yezo. This

displays the similar appearance of the forests developed in both regions.

Nikko, compared with other regions of the area that it represents, is renowned for having the richest forest flora. There occur some 200 species of woody plants, or about one-fourth of those indigenous to our temperate as well as subtropical regions. The forest is characterized by numerous kinds of conifers, the Betulaceae, Aceraceae, and Ericaceae.

While a high humidity throughout the vegetative season favours the growth of the forest trees, the ground presents a character more or less unfavourable for forestation, as it consists mainly of coaser volcanic materials, very liable to the crumbling and slipping process. This has resulted in disturbing the progressive development of the forest on certain parts of the slopes. Recurring fires have also produced a similar effect on the forest at lower elevations. On the other hand, the Nikko forest has been better preserved from interference by man, so that its present state mostly exhibits a character gained under purely natural conditions.

The most characteristic feature of our temperate forest, namely, the predominance of *Sasa*, a genus of bamboo, on the floor of the forest, is typically exhibited in Nikko. It is light-demanding, and flourishes best in open places with deep soil, but it can endure a moderate shade, so that it spreads usually over the floor of the deciduous forests. *Sasa* affects the vegetation of the forest in great measure. The loose accumulation of dead leaves and culms makes the surface of the ground almost impossible as a bed for germinating seeds or as a foothold for seedlings as well. Also, its own closely overlapping leaves produce a deep shade, on account of which most herbaceous plants are excluded, while the development of undershrubs is greatly hindered. Any area denuded by fire or lumbering is soon covered by *Sasa*, and thus the reforestation is considerably retarded.

The deciduous forest is developed continuously from the lowest elevation to an altitute of 1,500 m. In the lower portion lying below 1,000 m., and extending from Nikko to Umagaeshi, the character has been much altered through human agency and most of the original forest has disappeared. The existing growth is similar, in both its components and general aspect, to that found on the hills and mountains bordering the plains in the northern half of Japan, as far north

as the island Yezo. The representative trees and shrubs are *Quercus glandulifera*, *Castanea sativa* var. *pubinervis*, *Prunus serrulata* var. *spontanea*, *Carpinus laxiflora*, *C. yedoensis*, *Acer palmatum*, *A. diabolicum*, *A. cissifolium*, *Alnus incana* var. *sibirica*, *Magnolia hypoleuca*, *Aesculus turbinata*, *Zelkowa serrata*, *Juglans Sieboldiana*, *Corylus rostrata* var. *Sieboldiana*, *Styrax japonica*, *Rhus javanica*, *Hamamelis japonica*, etc. Further, in woods that have remained long undisturbed, there are found *Fagus japonica*, *Tsuga Sieboldii*, and *Abies firma*, all of which are increasing in number. They are tolerant of shade, and if conditions admit, they will become the chief components of the forest, as seen in several other regions of corresponding climate.

The forest extending from Umagaeshi to Yumoto, between 1,000 and 1,500 m. in altitude, is quite typical. A vast majority of the trees and shrubs indigenous to the Nikko region flourish also in this district. As marking the forest zone, the principal trees found at lower elevations disappear and other species of the same genera take their places; for instance, *Quercus glandulifera*, *Fagus japonica*, *Carpinus laxiflora*, *C. yedoensis*, *Abies firma*, and *Tsuga Sieboldii* are replaced respectively by *Quercus grosseserrata*, *Fagus Sieboldi*, *Carpinus carpinoides*, *C. cordata*, *Abies homolepis*, and *Tsuga diversifolia*. This replacement begins at an altitude of about 1,000 m., a little higher up than Umagaeshi.

On the steep slopes between Umagaeshi and Chūzenji the canopy of the forest consists of *Fagus Sieboldi* and *Quercus grosseserrata* with maples and hornbeams in association. As it is rather open, plenty of light can reach the ground, and several shrubs and young trees form a bushy undergrowth. On peaks certain conifers (*Tsuga diversifolia*, *Picea jezoensis*, and *Thuja Standisi*) predominate. On open places, such as the roadsides, rocky peaks or cliffs, which enjoy considerable sunlight, occur several kinds of *Rhododendron*, viz. *R. nikoense*, *R. Kaempferi*, *R. Wadanum*, and *R. quinquefolium*. They are essential elements which mark the seasonal aspect of the forest vegetation. While in spring they burst into flowers of pink, crimson, purple, and white respectively, later on it is their varied foliage that stands out brilliantly, giving to the forest its fine autumnal tints.

The forest surrounding lake Chūzenji is more magnificent. The important forest elements are *Betula Ermani*, *Quercus grosseserrata*, *Fagus Sieboldi*, *Abies homolepis*, and *Tsuga diversifolia*, of which the former three are dominants, and the latter two exist as subdominants.

The features of the forest differ somewhat on the north and south sides of the lake ; on the south the forest canopy consists in greater part of the dense crowns of the old birch with numerous individuals of hemlock and fir of varying ages under its shelter; but on the north, that is, on the slopes of Mt. Nantai, the dominants are the oak in some places and the birch in others. On account of its sunny exposure as well as of the occurrence of denudation, the south slope of Mt. Nantai is unusually favourable to the existence of numerous kinds of trees, especially the light-demanding ones. Here, the Betulaceae and Aceraceae are of common occurrence. The former family is represented by *Betula Ermani* (already mentioned), *B. japonica*, *B. dahurica*, *B. ulmifolia*, *B. carpinifolia*, *Carpinus cordata*, *C. carpinoides*, and *Ostrya rostrata ;* while representatives of the latter are *Acer pictum*, *A. japonicum*, *A. Sieboldianum*, etc. Other trees worthy of special mention are *Ulmus japonica*, *Cercidiphyllum japonicum*, *Kalopanax ricinifolium*, *Stewartia pseudocamellia*, *Prunus serrulata* var. *sachalinensis*, *P. Ssiori*, *P. Buerigeriana*, *P. Grayana*, etc.

Throughout the deciduous forest under consideration the invasion of *Tsuga diversifolia* and *Abies homolepis* is becoming more and more conspicuous. They are tolerant of the shade, and there is little doubt that they will ultimately surpass the existing trees.

Leaving the lake and going northward to Yumoto, there stretch out in wide extent forests which have developed typically after fires. They consist of *Betula japonica*, *Quercus grosseserrata*, and *Larix leptolepis*, mostly in pure stands. The forest floor is closed usually by *Sasa* or *Osmunda cinnamomea*. Repeated fires seem to have exterminated all the other trees within this district and at present only the birch, oak, and larch exist as elements for reforestation.

At higher elevations, above 1,500 m., the greater part of the region is occupied by the coniferous forest. Of several kinds of conifers occurring in this district, the most important dominants are *Tsuga diversifolia*, *Abies Veitchii*, and *A. Mariesii*. These conifers are the chief forest elements in most of the higher mountains of Japan. When they occur together in the same region, as is the case in Nikko, their respective ranges of vertical distribution touch each other, giving rise to a continuous forest with a wider vertical extension than would otherwise occur. In Nikko *Abies Mariesii*, occupying the uppermost part of the forest, forms a zone above the 2,100 m. line. Below that lies the zone of *Abies Veitchii*. The remaining

major portion consists of *Tsuga*. The latter occurs in some places in pure stand, but usually in mixture with *Betula Ermani* in varying proportions.

In the *Tsuga* forest *Picea jezoensis*, *Thuja Standisi*, *Taxus baccata*, *Pinus pentaphylla*, *Abies homolepis*, and *Larix leptolepis* occur scatteringly. On the other hand, *Thujopsis dolabrata* is of common occurrence. Older individuals are not numerous, but the younger trees grow in great abundance in groups. This conifer thrives better in the northern mountains of Japan, where it often forms magnificent forests. While it generally occurs in the deciduous forest, it is a remarkable fact that in Nikko it grows exclusively in the forest of *Tsuga*.

At the altitude of the coniferous forest arboreous as well as herbaceous plants markedly decrease. The most common broad-leaved tree is *Betula Ermani*, which extends from the lower to the upper limit of the forest. In less abundance and in limited distribution are found *Micromeles japonica*, *Betula corylifolia*, *B. Maximowiczii*, *Salix sachalinensis*, *Prunus Padus*, *Alnus hirsuta* var. *emarginata*, *A. alnobetula*, *Sorbus sambucifolia*, etc.

Along the edges of the forest are seen several kinds of the Ericaceae, of which *Enkyanthus perulatus*, *E. campanulatus*, *Menziesia pentandra*, and *Tripetaleia bracteata* are common. Close to the upper limit of the forest *Rhododendron brachycarpum* forms thickets in open places and near the lower limit *R. pentamerum* grows under the *Tsuga*.

In consideration of the successional development of the coniferous forest, *Betula Ermani* may be regarded as a common pioneer of the forest trees appearing on bare areas. *Abies Mariesii*, *A. Veitchii*, and *Tsuga diversifolia* come to flourish under its shelter and may finally become dominants. At the elevation of both firs there exists no competitor that can surpass them, and therefore the existing zones of these conifers constitute the climax forest. The case is different with *Tsuga*. It accompanies, as already mentioned, *Thujopsis dolabrata* which is more tolerant of the shade than *Tsuga*. When the *Tsuga* forest becomes dense, the ground is so shaded that almost all undergrowth is excluded. Accordingly, the forest floor remains clean, covered by its mat of mosses, or exposing a surface of raw humus. Such a floor gives a better chance for the invasion of *Thujopsis*. Its growth is very slow but reproduction proceeds rapidly, being acceler-

ated by layering. Judged from the present state, it appears probable that the forest of *Tsuga* represents a developmental stage approaching the climax, which will later be attained by *Thujopsis*.

The coniferous forest may extend up to an altitude of 2,300 m. or near the tops of the higher peaks. Above that *Betula Ermani* and *Alnus alnobetula* predominate, and in a dwarfed form participate with some shrubs in forming the scrub growth.

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