JOURNAL OF THE COLLEGE OF SCIENCE, IMPERIAL UNIVERSITY, TŌKYŌ, JAPAN.
VOL. XXVII., ARTICLE 12.

Journeys through Korea

(Contribution II.)

The Geology and Ore Deposits of the Hol-gol Gold Mine, Su-an District, Korea [1]

By

B. Kotô, *Ph. D., Rigakuhakushi*

Professor of Geology, Science College, Imperial University, Tôkyô

With 4 Plates

The following brief description[2] is based upon the investigations of Messrs. K. NAKASHIMA [3] and T. Iki [4]. I myself have not

1) When this paper was on the point of being sent to the printer, I received from Herr Oberbergrat Professor Dr. R. BECK a copy by friendly gift of his well-known standard work, "Lehre von den Erzlagerstätten", Dritte Auflage. On hastily running over the pages on the contact-metamorphic ore-deposits, I found on p. 165 brief notes of a written communication from Herr Bergingenieur L. Bauer on the same gold deposit on which the present paper is intended to make a short contribution. With the statements made there I generally agree; but I am unfortunate in not being able to find in the specimens at my disposal a sure trace of tremolite in coarse marble. However, I found ilvaite or lièvrite in large quantities.

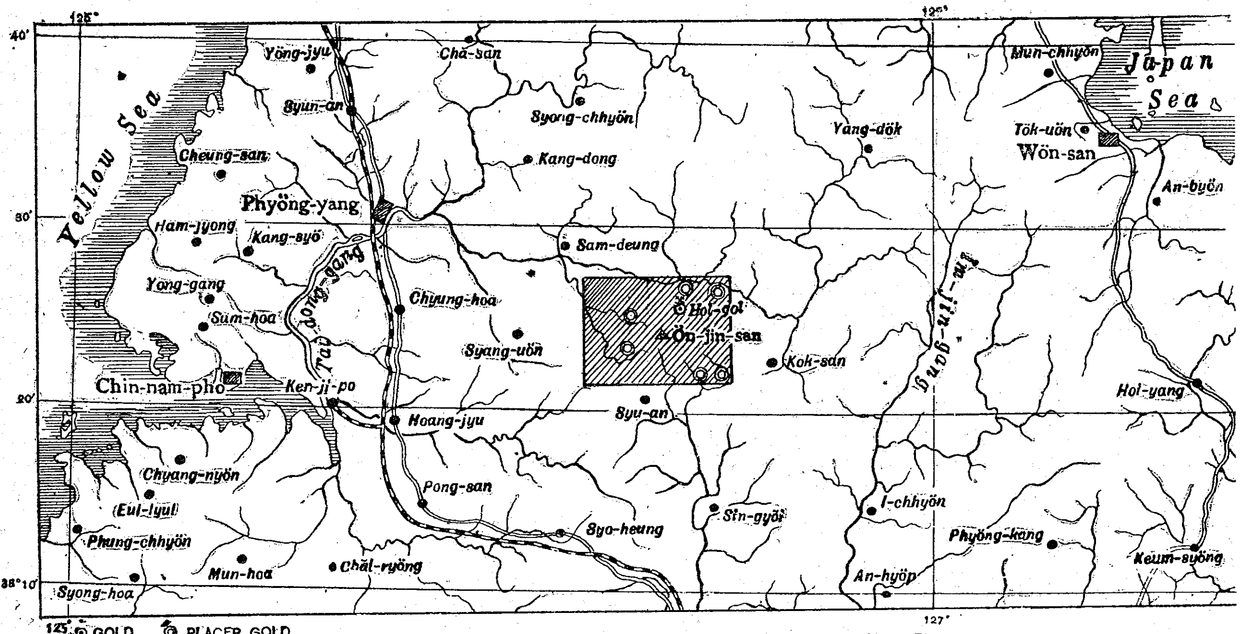
2) This paper was nearly ready in March, 1907, and was originally intended to be embodied in my series of papers entitled "Journeys through Korea", the first number of which has just appeared in this *Journal*, Vol. XXVI., Art. 2, 1909. As further contributions, touching north Korea, must long remain unfinished, and as meanwhile the state of things in the peninsula is speedily changing, it seems better to let the present short paper appear independently; otherwise my account would soon be out of date.

3) "The Ore-deposit of the *Hol-gol* Mine in *Su-an, Hoang-hai-Do*, Korea." 1905. (MS.) Dr. K. NAKASHIMA, an expert of the Mitsui Mining Co., of this city, allowed me the free use in the present paper of numerical data from his manuscript, for which I return my warmest thanks.

4) "Report on the Mineral Rosources of Korea. The *Hoang-hai-Kyŏng-sang-Do* Division" (in Japanese). Mining Bureau, Tokyo, 1906.

been at *Hol-gol*, my journeys in Korea having taken me no nearer than a region 15 *km* west of the mine.

Situation.—The mine is situated in the north-eastern portion of *Hoang-hăi-Do*, lying to the north of *Su-an* [1], and to the east of *Phyöng-yang*, the latter being the well-known ancient capital of the country. The mine is 32 *km* from the first place, 68 *km* from the second, and 20 *km* from *Pam-mi-jang* [2], this last being the nearest market-place, and supplying it with food and other necessary requisites.



MAP OF PORTION OF NORTH KOREA, SHOWING AREA TREATED
1 : 1,500,000

---

1) 遂安邑笏洞金山 2) 栗里場

A. Topographic Features

The mining region (see Pl. IV.) lies in a hilly interior, rising barely 300 *m* above sea-level, at the northern foot of the granitic *Ön-jin-san* [1], 1117 *m* high, which forms a prominent land-mark of the district. The granitic stock, now being dismantled in the general process of denudation, stands out above the surrounding country, and its eruptive mass has an intimate relation to the economic resources of the region as the "ore-bringer" of the metalliferous deposits.

The country around the eruptive stock is much disturbed. Tilted and uplifted edges of blocks of the earth's crust form the series of lengthwise and crosswise ridges which characterizes this part of the peninsula [2]. The general strike of the rocks is N. 60° W. with variable dips to the N. E., and the strata are all tilted up to the S. and faulted down on the same side. The series of these tectonic lines finds its expression in the *equatorial ridges*. These are old lines of dislocation, and were crossed later by another series of dislocations which lifted up the western and sometimes the eastern margin throwing down the blocks on either side. The younger ridges so produced are here designated the *meridional ridges* and trend N. 20° W. The network of the above-mentioned tilted edges of crustal blocks determines the fundamental elements of the topography and the drainage of the area.

The *Sing-gyöi-gang* [3], a large tributary to the *Tai-dong* [4] river, follows a course parallel to the equatorial ridge. At about the middle of its course, there is located on its northern bank the large

1) 彦眞山
2) This *Journal*, Vol. XIX. Article 1, Geotectonic Map.
3) 新溪江 4) 大同江

village of *Sam-deung* [1]. About thirty kilometers upstream, it receives a small affluent, the *U-gang* [2], which comes from the south. The upper course of this branch lies in the drainage area which constitutes the mining district under consideration. A map (see Pl. IV.) of the mining region clearly shows the relation between the geologic structure and the drainage system. Rivulets take a long equatorial course in somewhat widened dells, turning suddenly in the meridional direction in a short defile. Such is the small stream, the *Ugang*, which flows along the south of the *Hol-gol* mine. It turns abruptly northward at *Tol-kogăi* [3], and again to the east along *Sök-tari* [4] in order to join the *Sin-gyöi-gang* already mentioned. Generally speaking, therefore, the courses of the brooks in the neighborhood of the mine are equatorial and meridional, draining the waters of the hilly interior lying about 300 *m* above sea level.

The gold mine of *Hol-gol* is located on the north flank of a range of hills running W. N. W. to E. S. E., being separated on the south from the already-mentioned *Ön-jin-san* by the valley of *Morai-chhi* [5], which takes a course nearly parallel to the hill range. The mining office is on the south side of the *Morai-chhi* valley. On the west and north-west of the mine, the ground rises showing topographical features somewhat resembling those of a terrace, the elevation being the remnant of a tilted crustal block dislocated meridionally, in the process of which the ground on the eastern side was thrown down. The edge of the break lies west of, and parallel to, the *Hol-gol* valley, which consequently is itself a tectonic depression. See Pl. IV.

On the east the ground again rises into a steep, meridional

---

1) 三登 2) 禹江 3) 石峴 4) 石達 5) 沙峙

hill which forms a barrier between the valley just mentioned and that of *Păi-chhi-gol*[1]. On the north side alone, the ground is open for a certain distance along a fine gorge stream which, rising in the southern hill range of the mine, discharges its contents into the *U-gang* river near *Sök-tari*. The latter, as already stated, runs eastward parallel to the northern equatorial hills for about 12 *km* (30 *li*), and joins the river *Sin-gyöi-gang*. On the south of the *Morai-chhi* valley, the ground rises considerably, culminating in the *Ön-jin* massive about 4 *km* from the mine.

B. Geology of the District

The geology of *Hol-gol* and its neighborhood is composed of highly metamorphosed argillite, calcareo-siliceous slate and limestone, porphyritic granite and basalt. The siliceous and argillaceous metamorphics mainly occur on the west side of the *Hol-gol* valley, which separates them from the thick limestone (230 *m*); the latter extends through the hill range on the east side of the valley for a considerable distance, covering the whole of the *Păi-chhi-gol* and *Kul-lyang-kol*[2].

The line of demarcation between the schists and the limestone is the trace of meridional fault of *Hol-gol*, as is proved by the slickensided face often visible along the plane of contact exposed in cuttings near the mine, as well as by the sudden change of topographic relief on both sides of this tectonic line.

The schistose complex together with the limestone constitutes the basement of the region, of which brief descriptions will be given in the following :—

1) 梨峙洞 2) 軍糧洞

a) Slaty Mica-schist. (Pl. I. fig. 2.)

Composition : Essential : Quartz, albite, sericite.
Accessory : Rutile, hematite, magnetite, graphitoid, biotite, tourmaline, hematite.
Macrotexture : Thin crystallization-schistose[1], even, cleavage plane fine-wrinkled.
Microtexture : Homeoblastic, granoblastic, lepidoblastic.

The schist is an aluminosilicate rock of a light-gray color, weathering a rusty brown, its fresh schistose plane being a glistening white with a silky lustre. It is the true *Thonglimmerschiefer* of the Germans. The ground is composed of interdigitate grains of quartz and albite (?) with consertal (mosaic) fabric. I have not succeeded in distinguishing the two kinds of grains by the staining method. On the ground, the confused, tattered lamellæ of sericite are arranged in thin laminæ. The sericite is full of black dust which is only partially dissolved away by HCl, while the rest disappears only after ignition, thus betraying the presence of both magnetite and graphitoid. The sericite also houses superabundant needles of rutile, which are a little *larger* in size than those of SAUER's clayslate-needles (see fig. 2.). A few knee-shaped twins of rutile are also observed.

The rutile-needles together with the above-mentioned dusts make the rock, even in thin slices, appear like a graphite-schist. Hemimorphic tourmaline is also found, showing that the rock is a contact-metamorphosed one. Brownish hematite and biotite complete the list of components. Locality : *Kullŭi-kogăi*[2], north of *Sang-uön*[3].

b) Chlorite-Muscovite-schist.

Composition : Essential : Quartz, clinochlore, muscovite.
Accessory : Magnetite, tourmaline, rutile,

1) The nomenclature used in the following pages is that inaugurated by Professors F. BECKE and GRUBENMANN, GRUBENMANN : "Die Krystallinen Schiefer." Berlin, 1904–1907.

2) 屈内峴 3) 祥原

Macrotexture: Thin-schistose, stretched.

Microtexture: Porphyroblastic, helicitic, lepidoblastic.

The rock is a thin-lamellar, fine-wrinkled, greenish-gray schist, the schistose plane of which is a glistening silver-white owing to the presence of muscovite. It is minutely dotted with ilmenite (magnetic) which is, when seen under the microscope, distended into blade-like shapes, presenting the appearance of skeletal crystals. This bluish-gray, opaque ilmenite is seen at the *thin edge* to consist of a typical *sagenitic aggregate* of rutile veiled under brownish lamellæ. The characteristically bi-axial muscovite has a ragged lamellar form, enclosing sagenitic needles of rutile. Its transverse section is sharply outlined by its base, and the mineral is wrapped in a deep bluish-green, rather thick-lamellar clinochlore. The latter is biaxial with the optical angle $2E=54°$, and positive. The absorption is strong in the direction parallel to the lamellæ; the difference of it between $\mathfrak{a}$ and $\mathfrak{b}$ is slight, and the refraction and double-refraction are rather strong. The ground is built up of interdigitate grains of quartz. The muscovite and clinochlore constitute the main bulk of the schist. The light-brown, hemimorphic magnesium-tourmaline occurs in various dimensions. Yellow and colorless anhedrons of epidote are seen enclosing rutile-needles. A little idiomorphic apatite is also observed. The blastic series is rutile, tourmaline, epidote, apatite, ilmenite, muscovite, clinochlore, and quartz. The rock seems to be primarily derived from an igneous rock. Locality: the *Yang-kogăi* [1], 2 *km* east of *Sang-uŏn*.

c) **Chlorite-schist.** (Pl. I. fig. 1.)

Composition: Essential: Quartz, clinochlore, muscovite.
Accessory: Magnetite, tourmaline, rutile, apatite.

Macrotexture: Thin-schistose, stretched.

Microtexture: Porphyroblastic, helicitic, lepidoblastic.

1) 兩峴

This is a grayish-green, even-schistose and silky-lustred rock, mainly composed of an extremely thin-lamellar, optically anomalous chlorite, which is arranged parallel on a ground of dust-filled plagioclase with interdigitate, granoblastic structure. The vitreous plagioclase is sometimes simple-twinned extinguishing light from 12° to 15° with reference to the suture of the twins [1]. The magnetite is both automorphic and xenomorphic, and dissolves in HCl. Iron-pyrite is found intermixed with the magnetite. There occurs abundantly an inequigranular mineral resembling epidote (fig. 1.), the microscopic grains of which have sometimes an acute rhombic shape. It extinguishes light diagonally, and has a high double-refraction. The grains of the mineral resemble the drop-like granules which compose leucoxene. Absolute identity with common epidote is not proved. They may perhaps be either *Titanite* or *Orthite*. We find the same in piedmontite-schist [2] and chlorite-schist near Tokushima, Awa Prov., Japan. One finds something similar in shape to the present mineral in ROSENBUSCH-WÜLFING'S "Physiographie", Bd. I. Tafel IX. fig. 3, where it is identified as quartz. There is also found a colorless, microscopic megaphenocryst of unknown mineralogical nature with low birefringency.

The rock is simple in mineralogical composition, and no accessories except hypidiomorphic tourmaline and problematic titanite, are seen in the slides. Locality: *Neureum-kogăi* [3].

d) **Argillite.** (Pl. I. fig. 4.)

Composition: E s s e n t i a l: Albite, quartz, sericite.

1) This agrees well with the albite-twin after the albite law cut nearly at right angles to a. P. ROZLOZSNIK: "Ueber die metamorphen und paläozoischen Gesteine der Nagybihar." *Mittheil. aus dem Jahrb. d. Kön. Ung. Geol. Anstalt*, Bd. XV., 2. Heft, S. 150, 1906.

2) I intentionally omitted to mention this microscopic component (Pl. I. fig. 1.) in my paper on "Some Occurrences of Piedmontite in Japan (this *Journal*, Vol. I. Part III. 1887) as the nature of it was entirely unknown to me. Since, then, I have seen not infrequently the same mineral in metamorphic schists of this country, and, no doubt, it may also be found in analogous rocks in other countries.

3) 楡峴

Accessory: Graphitoid, rutile (clayslate-needles), magnesium-tourmaline, magnetite.

Macrotexture: Thin-slaty.

Microtexture: Granoblastic, lepidoblastic.

The dark-gray rock has a weak lustre on the perfectly even cleavage-plane which is faintly dotted with non-lustrous black spots. The spots are merely local accumulations of graphitoid. After digestion in HCl and ignition, the graphitoid [1] is entirely removed, and then the section appears to consist entirely of crystalline components—a plexus of long rounded albite (?) arranged in one prevailing direction cemented by xenomorphic quartz which probably crystallized out from colloidal silica. The quartz has haggled, concave faces, adapting itself to the interstices of the plagioclase grains, and is blastoleptomorphic. Fibrous-lamellar sericite is present in thin laminæ made dirty by magnetite and coal dusts. Clayslate-needles (Pl. I. fig. 4) are abundant though *small* as compared with those of slaty mica-schist (see page 6, and Pl. I. fig. 2), and the rudely hemimorphic magnesium-tourmaline (see fig. 4) is present in a meagre quantity. The blastic series is tourmaline, rutile, albite, sericite, quartz, graphitoid and magnetite. Locality: *Tol-kogăi* [2] to *Tol-tari* [3].

e) **Contact-Metamorphosed Limestones.** (Pl. I. figs. 3, 5, 6; Pl. II. figs. 1-4; Pl. III. figs. 1–2.)

Composition: Calcite, diopside, garnet, muscovite, ilvaite, magnetite, chrysotile, bornite, chalcopyrite, iron-pyrite.

Macrotexture: Fine-saccharoidal.

The country limestone has a tabular structure and light-gray color. The specimens at my disposal are the contact-metamorphosed

1) The black dust to which argillite usually owes its color, is mainly of graphitoid with very little, if any, of magnetite.

2) 石峴 3) 石達

limestones of various degrees of alteration, and the compact modification is the lime-silicate-hornfels impregnated with sulphide ores and black ilvaite.

Microscopically, the calcareous rock has an equigranular, millimeter-grained, equant, equiform fabric.

e_1) The less metamorphosed rock (Pl. I. figs. 3, 5 and 6) contains a little diopside and an *uniaxial*[1] serpentine (c parallel to the axis of lamellæ). Into the latter the calcite rhombohedrons project with idiomorphic outline (Pl. I. fig. 3, in the right corner). The long prismatic diopside is decomposed into *another* serpentine, leaving fresh cores like a partially altered olivine (Pl. I. fig. 5). The diopside is formed first and the serpentine last (fig. 3). The staining method with the LEMBERG solution gives negative results with regard to dolomite or magnesite. A few crystals of chalcopyrite were seen, but none of ilvaite. The rock is properly speaking an *ophicalcite*.

e_2) The second modification (Pl. II. figs. 1 and 2) consists of about equal volumes of calcite and contact-metamorphosed minerals. This is impregnated with *sulphide* ores containing *gold*, besides diopside and ilvaite[2]. Muscovite is normal. The ilvaite forms acicular

1) There seem to exist various kinds of serpentines, some occupying an intermediate position between normal serpentines and chlorites. The serpentines are lamellar and antigorite-like.

All the serpentines found in the contact-metamorphosed limestones of the region seem to me to be *genetically related to the diopside*, as may be judged from their modes of occurrence and their transformation from one to the other. This is well seen in Pl. I. figs. 3 and 5. In the *former*, a prismatic crystal of diopside is seen entirely changed into a serpentinous mineral, and is enclosed in a *dirty calcite*. I could not make out why the enclosing calcite has a dirty, weathered aspect in contrast with the main mass of crystalline aggregate of the fresh calcite. From their modes of association I can, however, surmise that the fresh anhedra of the calcite are later in the order of crystallization than the dirty ones. In the *latter* (fig. 5), a six-sided crystal of diopside is seen greatly altered into a serpentinous matter leaving some intact cores in the centre and periphery. A similar case is reported to occur in the *skarn*-like mass of the contact-metamorphic deposit of Daschkesan in the Caucasus. Beck: "Lehre von den Erzlagerstätten" Dritte Auflage, S. 153.

The serpentines are found in such a form that the rocks present macroscopically an *eozoonal structure*.

2) The ilvaite-bearing limestones are the ore-body of the Hol-gol mine.

A peculiar paragenetic relation was observed in the course of the examination of the radiating needles (figs. 1 and 2). It is opaque and submetallic, appearing just like stibnite for which it has been taken. The cleavage toward (001) is distinct (fig. 2), especially after partial solution. Before the blowpipe the isolated ilvaite gives no reaction for sulphur, but a reaction for manganese. On careful examination of the thin needles the mineral turned out to be *transparent* breislakite-like, emerald-green needles. Absorption pronounced ; $\mathfrak{c} > \mathfrak{a}$ or $\mathfrak{b}$, $\mathfrak{a}$ brown, $\mathfrak{c}$ sap-green ; and on account of strong absorption the needle becomes black in the latter direction. The optical character is positive. The refraction is high ; but the double-refraction weak.

e_3) The extreme modifications (Pl. II. figs. 3 and 4 ; Pl. III. figs. 1 and 2) of contact metamorphism are represented by the diopside-rock and garnetite, both being parts of the ore-body. The (*a*) *diopside-rock*[1] is a compact, fine-granular variety of a light grayish-yellow and sometimes pistachio-green color. Under the microscope, it is entirely made up of prismatic-granular, grayish-white diopside (Pl. II. figs. 3 and 4). It is frequently twinned after (100), and has the coarse but distinct prismatic cleavage of augite. From the outline of the basal section the crystal seems to be bounded by both pinacoids truncated at the four corners by prismatic faces. Extinction-angle $c : \mathfrak{c}$ is over 40°; double-refraction strong. Prismatic termination is resolved into stiff needles which are colored light-green and show differences

---

slides. The *diopside* usually avoids *proximity* to ilvaite (Pl. I. fig. 6) which in turn seems to prefer the presence of calcite (see the same figure). The diopside and copper sulphide (Pl. II. figs. 3 and 4), the ilvaite and sulphide ores occur in association, so also the diopside and muscovite. There is no iron-pyrite in the present ore-body; but if both iron-pyrite and copper-pyrite are present at the same time, the latter serves as a cementing matrix for the crystals of the former, as is well seen in the ore-body of the Hitachi (日立) copper mine in the province of Hitachi, Japan.

1) The diopside rock or diopsidite, which is usually called salite rock by our economic geologists, is not necessarily a lime-silicate-hornfels, though in a majority of cases it is a product of contact-metamorphism produced upon limestone by a salic eruptive. The writer once saw it occurring in a lenticular shape impregnated with workable copper-sulphides in graphite-schist at the Yoshioka Mine (備中吉岡鑛山) in the province of Bitchû (Japan). At the Sasano Mine in the same mining region we find an extensive development of a light-greenish, flinty diopsidite as the country-rock of the copper ore-body at its contact with graniteporphyry. The diopsidite here seems to be a contact-metamorphosed *slate*.

of absorption ; $\mathfrak{c} \gtreqless \mathfrak{a} > \mathfrak{b}$; $\rho > v$. This may be due to secondary enlargement, being represented by a kind of amphiboles.

The greenish color of the rock is mainly due to the presence of serpentine. Xenomorphic, pistachio-green epidote occurs associated with diopside, giving a greenish yellow tinge to a certain portion of the rock. Our rock in point of mineralogical composition has the combined characters of regional (serpentine) and contact metamorphisms (diopside).

The (β) *garnetite* (Pl. III. figs. 1 and 2) is, like the preceding, a light-grayish, fine-granular and hard rock, being composed of andradite (the lime-iron garnet), calcite and diopside, besides small quantities of epidote, titanite and (?) axinite. The dominant component is andradite. The *garnet is remarkable* in showing the well-defined divisions of the optical field owing to anomalous double-refraction (Pl. III. fig. 2). BRÖGGER says that anomalous garnet occurs in veins, dykes and contact rocks, and the present garnetite is a special case in his category. It is also said that anomalous garnet often appears in connection with zonal structure and isomorphic shells [1]. The Korean garnet has a faint zonal [2] structure (Pl. III. fig. 1) in some optical fields, but *in the majority it is devoid of it.* The lime-iron-garnet shows not only an anomalous behavior, but also very pronounced optical pyramids which, when seen between crossed nicols, appear exactly like a tessellated mosaic work (figs. 1 and 2), each part ranging from 3 to 5 *mm* in size. The optical checkered work makes up a large part of a slide, and it is entirely impossible to set a limit to the grains that compose the main bulk. The phenomenon of double-refraction corresponds to the rhombic dodecahedron type, with homogeneous extinction of light parallel to the diagonals of the rhomb. There are, however, oblique triangles which extinguish light also

1) Z. X., **16**, 1890, S. 172. Also ROSENBUSCH-WÜLFING, "Physiographie", Bd. I., 2. S. 21.

2) A specimen lately received from Mr. KOCHIBÉ has a beautiful zonal structure, but shows no signs of optical pyramids. The anomalous optical field and the zonal structure seem to exclude each other, at least in the Hol-gol specimens.

obliquely to the sides, and these may belong to either the icositetrahedron or the topazolite type. Interference-colors range from grayish-blue to yellow. The optic axial plane, though faintly indicated, corresponds to the longer diagonal of the rhomb. The rhomb itself, as seen orthoscopically, consists of two pairs of optic fields limited by the diagonals, extinguishing light symmetrically at about 4° with reference to the shorter one.

The andradite *encloses* diopside when both occur together producing a poicilitic structure, and the polygonal interstices are filled with calcite [1]. Then the rock has microscopically an appearance like that of eclogite, the ground of brownish-red garnet being speckled with greenish augite.

There is a *trapeziform* mineral in the slide with the color and pleochroism of schorl. Extinction is always oblique. It is probably a triclinic mineral resembling *axinite*, though the latter is never reported to occur in twins The problematic mineral is frequently twinned with its suture-line corresponding to the longer diagonal of trapezium, and extinguishes light symmetrically at about 20° with reference to that trace of the twinning plane. If the mineral be assumed to be axinite, the twinning plane should correspond to (010).

The preceding complex (*a*–*e*) was tilted and dislocated to its present position, and was later intruded by eruptives, of which the following play important rôles.

f) **Porphyritic hornblende-granite.** (Pl. III. fig. 4.)

Composition: Essential: Orthoclase, oligoclase, quartz, green hornblende, biotite.

1) This fact may be attributable to a decrease of molecular volume during crystallization of the original limestone, and to a later importation through some channel of chemical substances from the exudation of cooling granitic magma in a hydro-thermal way. Then, by recombination and crystallization were formed many microscopic drusy holes which are later filled with calcite.

Accessory: Magnetite, titanite, allanite, zircon, apatite, iron-pyrite.

Macrotexture: Porphyroid.

This light rose-colored, alkalic granite has a coarse, inequigranular, skedo-porphyritic fabric. The flesh-colored megaphenocryst of orthoclase is flat-prismatic, 2 *cm* in length, carlsbad-twinned, and partially decomposed. It is optically normal, and encloses zircon, apatite and patches of *anorthoclase* (?) (extinction, 3° 40′ to M), the last is oriented parallel to (010) of orthoclase. Prismatic green hornblende (3 *mm* in length) is fibrillated, and occurs associated with idiomorphic, nearly uniaxial biotite and hypidiomorphic magnetite (1 *mm*). The biotite contains an octagonal, highly double refractive, colorless basal section of zircon or cassiterite with pleochroic halo, and bleaches green. The oligoclase is hypidiomorphic with zonal and reticulated lamellar structures, extinguishing light symmetrically from 4° to 5°. The relation of dull orthoclase and quartz is eutectic[1]; the former is idiomorphic with reference to the latter. The xenomorphic, highly pleochroic allanite is rather abundant; the hypidiomorphic apatite and zircon, and the xenomorphic titanite are present in small quantities. The idiomorphic iron-pyrite occurs *enclosed* both in orthoclase and quartz, showing that the sulphidic ore is not formed secondarily during the post-volcanic period, nor by the circulation of underground waters. The order of crystallization is zircon, apatite, allanite, titanite, phenocrystic orthoclase and oligoclase, magnetite, biotite, hornblende(!), iron-pyrite, quartz, and lastly, xenomorphic orthoclase. The rock shows no signs of cataclastic structure, which is a feature rarely missing in Korean granites.

Locality: Peripheral portion of the granitic stock of *Ön-jin-san.*

1) In a specimen at the contact with the contact-metamorphosed limestone, the quartz plays another rôle with respect to a dirty orthoclase. Here the quartz has rounded edges, sometimes with embayments, and the substance of the quartz is also fritted and fractured (Pl. III. fig. 4); in short, it shows evidently many signs of magmatic corrosion, indicating at the same time that time has elapsed between the formations of the quartz and the infilling orthoclase. This state of aggregation of components is characteristic of porphyritic eruptives.

g) **Basalt.** (Pl. III. figs. 5 and 6.)

Composition: Essential: Plagioclase, violet augite, olivine, ilmenite.
Accessory: Quartz, barkevikite, apatite, datolite (?), pleonaste.

Macrotexture: Aphanitic, porphyritic.

Microtexture: Hypocrystalline, percrystalline.

Blackish-gray, compact feldspar-basalt with the idiomorphic megaphenocryst (2–3 *mm*) of magnesium-rich olivine. The microtexture is variable. It is almost crystalline-granular, being a plexus of lath-shaped, multiple-twinned plagioclase and granular, so-called titan-augite. Some specimens have an intersertal, some a rudely fluidal fabric, the latter being caused by the prismatic habit of both the plagioclase and the augite. Small patches of colorless base are seen filling up the interstices between the crystal components. The violet, low double-refractive augite is zonally colored, and often shows the typical hour-glass structure. Its form is sometimes prismatic, sometimes irregularly tabular and even granular according to the conditions of cooling in the form of either *Stielbasalt* or *flow-basalt*. Mega—and microphenocryst of idiomorphic olivine contains pleonaste. The olivine is partially and in some cases completely altered into greenish-yellow fibres, enclosing kernels of hypidiomorphic magnetite and calcite. Ilmenite is abundant, becoming transparent and brown at its thin margin. In small patches and *Schlieren*, where augite is scarce and the zeolitized base abundant, the colored component is replaced by a kataphoritic or barkevikitic hornblende [1], and here apatite is found in felt-work. Sometimes *quartz* occurs, fringed with radially arranged, violet augite needles, which become green at the contact with the quartz-eyes (fig.

1) The brown amphibole is prismatic (110, 010) in habit with imperfect fibrous terminations. The extinction $c : \mathfrak{c} = 24°$ and is too large for barkevikite; strong absorption transverse to the principal zone ($\mathfrak{b}$ brownish-red with violet tinge, $\mathfrak{c}$ greenish-yellow, $\mathfrak{a}$ reddish-yellow, $\mathfrak{b} > \mathfrak{c} > \mathfrak{a}$). The hornblende is scarcely distinguishable from the so-called basaltic hornblende. This component is the constant accessory of the Hol-gol basalt.

6). A few American and German writers advocate the primary origin of the basalt-quartz. The magnophyric xenocryst of quartz in the present rock seems to me to be the *resorption-rest* of highly heated salic *plutonics*, which have suffered magmatic invasion and also abyssal assimilation in a basaltic bath. The quartz in question is found in the basalt which is in direct contact with the porphyritic granite. Colorless, equant, highly double-refractive and cuboidal grains (fig. 5) line the walls of microscopic vesicles filled with chloritic matter and calcite. They are probably *datolite*. The quartz-bearing basalt is by no means rare in Korea and South Manchuria. Locality: *Hol-gol.*

There are at my disposal two other rock-specimens worthy of mention. They are *aplite* and *meta-diorite* (Pl. III. fig. 3).

The former is a whitish, compact, quarter-millimeter-grained rock of a granulitic fabric, composed of quartz and orthoclase, and a little muscovite. It probably occurs as apophyses of the *Ŏn-jin-san* granite and seems abundant at the contact of the stock with the country-rocks. Probably the aplite dykes have some connection with the genesis of the ore-deposits of the region. Hitherto no attention has been paid to their occurrence.

The latter is the so-called meta-diorite intruding into the slaty mica-schist already mentioned. It is rudely schistose, being composed of hornblende, plagioclase, apatite, ilmenite and biotite. The hornblende is altered into composite needle aggregates (fig. 3.) with *secondary biotite* in their centres. The plagioclase is also altered into a mosaic of albite (fig. 3.). Xenomorphic apatite is relatively abundant. Clumps of ilmenite with leucoxene margins are seen. Microscopic inspection clearly shows that the rock is a highly altered, typomorphic one. According to Prof. BECKE, a deep-seated plutonic may be lifted up to a shallower horizon and this act gives to the rock components an opportunity for molecular rearrangement to suit the new chemical equilibrium. The present rock may have been anamorphosed in such a way together with the intruded rock—the slaty mica-schist which should have been submerged deep into the zone of rock-flowage. Another fact may be brought into harmony with the above-mentioned and this is, that the contact-metamorphosed deposit, in which the present complex of mica-slate forms the recipient of ores, is commonly supposed to have been developed only in the zone of rock-flowage, though the contrary has been recently asserted by CHAS. R. KEYES[1].

The sedimentary *metamorphics*—of which brief descriptions have been given in the foregoing, especially of chlorite-schist, slaty mica-schist, clayslate, calcareo-siliceous slate, and the apparently interbedded, two zones of limestones—all together constitute the foundation of the region, the strike being W. N. W. and the dip N. E. The age of the complex cannot be fixed exactly; but from the analogy of its occurrences in Manchuria (the pre-Cambrian, Taku-shan series) and in Japan (the Sambagawan), the writer provisionally assigns the complex to the same time-scale as the pre-Cambrian, though it resembles in petrographic characters the *Bündnerschiefer* in the Alps, which embraces all rocks from the Trias to the Cretaceous, and even up to the Eocene[2].

At the hill range rising due south of the mine, and farther south in the valley of *Morai-chhi*, the coarse *porphyritic granite* with the three-centimeter megaphenocrysts of orthoclase, is seen exposed, culminating in the latter in the rugged peak of *Ön-jin-*

1) *Economic Geology*, Vol. IV., p. 365.

2) Lorenz, "Geologische Studien im Grenzgebiete zwischen Hervetischer und Ostalpiner Facies." *Die Berichte der natur-forscher Gesell. zu Freiburg in Bres.* Bd. XII., S. 4.

san. On the north side of the equatorial dale of *Morai-chhi,* just mentioned, and just south of the mine, a mass of *basalt* makes its appearance at the junction of the porphyritic granite and the contact-metamorphosed limestones. The basalt is sometimes *quartz-bearing,* and at other times agglomeratic, being composed of blocks of the same rock and also of fragments of the porphyritic granite. Minor exposures of the volcanic are seen to occur sporadically in the same valley.

One interesting fact concerning this effusive rock is that its continuation could be traced farther east for over 1,500 feet in the form of a regular dyke, measuring from one to four feet in breadth, and looking as if it were interbedded in the limestone beds with northerly dips.

C. Ore-deposits

The ore-deposit of the *Hol-gol* gold mine occurs, as shown in the annexed geologic map (Pl. IV.), partly around the junction of the limestone with the metamorphics and porphyritic granite, and partly in the lime-silicate-hornfels that comes in direct contact with the porphyritic granite. It does not form any definite lode or fissure-veins by which a boundary line separating it from the surrounding country-rocks could be drawn. By tracing the probable limit of the ore-containing portion, the deposit is divisible into two[1] irregularly rounded ore-bodies—the e a s t e r n and the w e s t e r n. In these ore-bodies, as well as in the space between them, no definite line could be fixed separating the ore-bearing from the barren portion.

The ore occurs mainly in lime-silicate-hornfels which is ir-

1) See the accomppnying map, Pl. IV.

regularly impregnated with ilvaite, bornite, and chalcopyrite mingled with some iron-pyrite. In rare cases, some galena and magnetite may also be associated. In no case has gold been detected by the naked eye [1], while the noble metal seems to be closely associated with *copper* [2] *sulphides* in a microscopic state, or in chemical combination, but that portion impregnated with the ilvaite is poor in gold content. Nowhere have these metallic sulphides been observed to form any continuous bands or concentrated bodies. As far as is known, they always occur irregularly dispersed in a sporadic manner in the contact-metamorphosed limestones.

In the western ore-body, especially in its southern and western portions, the limestone is highly metamorphosed into the diopside-rock, colored a deep red, yellow, or even in some few cases black, most of the coloring matter being undoubtedly ilvaite and iron-oxide with which the hornfels appears to have been transfused. Where the limestone and hornfels bear no ores, it remains unaltered and unstained, and such barren portions, being mixed up without any regularity with the decomposed workable part, often remain protruding from the surface of open works.

On the western margin of the western ore-body, not only

---

1) Lately Mr. J. E. POGUE described large cubes (2 inches) of pyrite from the Snettisham District, Southeast Alaska. The crystals of gold, galena and chalcopyrite are set in the superficial part of the remarkably large cubes of the pyrite which is striated on the surfac with minute steps due to oscillatory combination of (210) and (100). The gold has crystallized out in octahedron, cube and octahedron, dodecahedron and octahedron, and trapezohedron and octahedron. These gold crystals lie half imbedded in the pyrite. The most probable paragenetic relation is regarded as this: "The pyrite, when its present size was nearly attained, sustained a deposition of crystallized gold upon its surface followed by the precipitation of a small amount of chalcopyrite which, in turn, was succeeded by the formation of galena. A further slight accretion of pyrite completes the development of the specimen". "On a Remarkable Cube of Pyrite carrying Crystallized Gold and Galena of Unusual Habit". *Smithsonian Miscellaneous Collections*, vol. 52, Part 4 (No. 1882), 1909.

From the above, we see that a part of gold at least is in native state in sulphide ores.

2) The sulphide ores associated with the sulphide of *copper* are generally said to be poor in the gold content.

does the footwall frequently show slicken-sided faces, but also the interspaces of two dissimilar rock types are filled with débris, undoubtedly derived from faulting. This débris, mainly originating from the rocks of the footwall, also contains ore though of a poorer quality than that of the contact limestone, which fact is clearly shown in the results of analyses (Nos. 4, 5, and 10 are specimens of this type) [1]. The deep yellow staining, generally visible in such débris, is evidently not a result of simple weathering, and must be attributed to the effect of infusion by some particular process after the filling up of the fault-gaps.

The western ore-body extends to the south slope of a granitic hill which separates *Hol-gol* and *Moraï-chhi.* Here for about 120–140 feet to the west of adit No. 23 the western half of the stretch is mostly covered with reddish stained earth, the ultimate product of the weathering of porphyritic granite, which was formerly worked for gold washing; while the eastern half is chiefly composed of a highly acted and endomorphically altered granitic mass [2] in which the irregularly impregnated crust of iron-oxide, and wild strings and veins of drusy quartz are intermixed with yellow and red earth. These form the outcrop of the southern limit of the western ore-body (the analyses of No. 7, A, B and C give the results of the specimens taken from this outcrop), the aspect of which closely resembles what we usually find where hot springs act on the surrounding rock mass (hydatopneumatolytic). The whole stretch seems to be the margin of the granitic stock of *Ön-jin-san,* deeply subjected to a pneumatolytic process at a later stage of the plutonic intrusion.

1) See the heading "Analyses of Ores", p. 27.

2) It seems to me to be the general rule that the intruding rock is devoid of ore-bodies large enough to be profitably worked.

Pit No. 23, already referred to, was sunk to prospect the *lower* portion of the outcrop. Following the irregularly scattered metallic sulphides in *granitic* rock, the pit goes down in a roundabout way to the heading, the direct distance from the entrance being 30 feet N. N. E. Here *iron-pyrite* is seen confusedly mixed up with quartz, both occurring in disconnected patches. Such an impregnated portion may associate some minute quantities of gold, as is shown by the analysis of specimen No. 46, taken from this spot.

There are a number of pits, some are marked in the accompanying geologic map (Pl. IV.), and these are opened in pursuit of comparatively good ores without any fixed direction or fixed level.

From the careful observations made by Dr. K. NAKASHIMA both in open works and in pits, the probable limit of the ore-yielding area is divided, as has been already stated, into the western and the eastern ore-bodies. The former measures in rough figures 350 feet from N. W. to S. E., as well as from N. E. to S. W., while the latter is about 360 feet long and 60 feet wide. If we admit the intervening space of the two ore-bodies to be uniformly ore-bearing, the total length may exceed 800 feet; but so far as his observation goes, NAKASHIMA was not able to find, along the contact of the hornfels with the porphyritic granite in this intermediate area, any actual evidences of the existence of workable ores.

Outside the two ore-bodies, outcrops have been searched for in every direction in the vicinity of the *Hol-gol* mine. To the east of the mine at the sites marked A, B, C, and D on the map (Pl. IV.), and also on the north of the mine down the *Hol-gol* valley at points E and F, we find limestones locally changed by what appears to have been the former action of *thermal springs*, being characterized by a more or less bleached aspect of the rock mass and by the change of the original color due to iron-oxide; but in no case are the pyritic impregnations visible. It is unlikely that any new store of workable ore-deposits occurs in these spots, or at the point G, where the metamorphic schist, occurring associated with limestone, contains some scattered grains of iron-pyrite.

D. Origin of the Ore-deposits

From various facts gathered during his study of the mine, DR. NAKASHIMA firmly believes that the origin of the ore-deposit of *Hol-gol* was due to the action of underground thermal springs which had a genetic relation to the basaltic eruption [1]. The writer looking at the deposit from another standpoint, assigns it to the category of contact-metamorphosed deposits. From the microscopic descriptions of rocks given in the preceding pages, there is no room to doubt the existence of contact-metamorphic phenomena in limestone in the form of lime-silicate-hornfels, produced by the intrusive action of the granitic magma that consolidated later to form the mass of *Ön-jin-san*. In thin slides are seen ilvaite [2] and the sulphide ores. The latter, which are believed to contain gold exclusively, cluster on the spots where the calcite is replaced by

1) See pages 18 and 24.

2) There is another type of ilvaite or lievrite. If we compare fig. 1 with fig. 2 in Pl. II., one cannot deny the existence of the two modifications of the same mineral. The latter (the right-hand figure) represents the normal acicular type; but the former an abnormal one appearing as if black iron ore is veiled in thin leaves of amorphous silica. In dissolving the mineral, thin films of dirty amorphous gelatinous silica were left behind, which look like the membrane in question. I am in doubt whether the membrane is of amorphous silica or a lime-silicate. The latter is the more probable, as the membrane exhibits high birefringency and extinguishes light parallel to the longer direction of the original crystal, and show nagative character in the same direction.

diopside. The ilvaite crystallized out earlier than the diopside did, and the sulphide ores[1] still later, enclosing and filling up the interstices of the diopside crystals. Consequently the gold was not present at the time of the formation of the ilvaite[2]. The molecular rearrangement of $CaCO_3$ in the form of marble was the latest event in the formation of the contact-metamorphosed limestone, as may be unequivocally proved by the mutual relations of these crystals. We are therefore driven to the conclusion that the gold is *juvenile*, and must have come from deep in the interior as an exudation from the eutectic mixture of the granitic magma of *Ön-jin-san*, in association with mineralizers which at first acted as an acid upon the limestone and then afterward metamorphosed it into the lime-silicate-hornfels. The ore-bearing, deep contact-metamorphosed zone was dismantled through denudation[3] and a

---

1) During the examination of several slides of ore-rocks, it constantly recurred to my mind that the paragenetic relation of component minerals shows that sulphide ores occupy spots which otherwise calcite would fill. We are therefore driven to the conclusion either that the calcite and the ores settled at the same time, or that the latter has replaced the former. The latter suggestion is the more probable, and it is moreover certain that the replacement was not molecular or metasomatic, but an in-filling after the calcite had been removed bodily by some reagents.

2) The general order of metallization and crystallization in our ore-deposit is ilvaite diopside, garnet, sulphide ores, and the final act of metamorphosis is the recrystallization of the limestone, or is contemporaneous with the ores.

3) It is usually supposed that contact-metamorphic deposits can only be formed deep in the zone of rock-flowage—the depth of 8–12 *km* beneath the surface, corresponding to a pressure of about 200 atmospheres, but with a temperature below the critical points of water (360°C); for the transportation of materials and chemical interchanges are commonly assumed to take place in a liquid medium. Granting that these conditions are necessary for the formation of the deposits, the region under consideration must have suffered a general denudation of the lithosphere to the considerable depth of 4–8 miles. Chas. R. Keyes, however, entertains the view that the deposits may have been formed in a shallower zone than that above outlined ("Economic Geology", vol. 3, 1909).

Recently, Albert Bruns has made public a bold hypothesis on the anhydrous activities of volcanoes, which implies that the magma in the earth's interior is devoid of any trace of water. If that be the case, not only must our theories about the depth at which the contact-metamorphic deposits are said to have been developed, be recast, but the whole mass of hydro-igneous problems will be thrown into chaos.

secondary enrichment of ores took place later through oxidation (within the limit of about 450 *m* from the surface). This now affords an opportunity for economic enterprise, though not a very promising one. Whether the poor ore-deposit *within the granite* had been developed by means of the descending waters of a metallic solution, or by the decomposition of auriferous pyrite originally contained in it, could not be definitely settled.

The occurrence of *basalt* [1] in the form of a long narraw dyke at the junction of the porphyritic granite and the sedimentaries seemingly lends support to the thermal spring theory [2] of ore-deposits; but it seems to the writer that, as already stated, the ore-deposit was formed at a later phase of the granitic intrusion (its formation having been brought to an end with the final consolidation of the plutonic), and has no connection whatever with the basaltic eruption which happened at a still later geologic period. The basalt contains no ores.

E. Analyses of Ores

The sample ores contained in the contact limestone, taken by Mr. NAKASHIMA from the crushed ore heaps near the stamp mill sites around the *Hol-gol* mine, gave the following percentage contents of gold, silver, and copper according to the assay done in the laboratory of the MITSUI MINING Co. :—

Nos.	Gold	Silver	Copper
1	0.0012	0.0014	—
2	0.0130	0.0082	3.16

2) See pp. 18 and 22.

3) Dr. K. NAKASHIMA is, indeed, quite right when he says that the effusion of basalt was followed by a great development of thermal springs as elsewhere; but this rock is not usually an "ore-bringer" excepting in the case of mercury deposits as along the Pacific coast of the United States.

3	0.0044	0.0028	0.72
6	0.0016	0.0014	0.61
15	0.0034	0.0018	2.16
31B	0.0020	0.0018	—
32	0.0004	0.0014	0.61
33	0.0014	3.0018	—
53	0.0012	0.0008	0.28

Nos. 1 and 2 are ores taken from the eastern portion of the eastern ore-body and stamped at *Sök-tari*.

No. 3 is the finely pulverized ore originally mined from the eastern ore-body.

Nos. 6 and 33 are from the ore heaps belonging to the MINING Co. at *Morai-chhi*.

Nos. 15 and 31B are picked ores, the former from pit No. 14 and the latter from adit No. 4, both being of superior quality.

Nos. 32 and 53 were selected out from an old dejected débris and are partially colored greenish by the secondarily formed malachite.

Leaving No. 2 out of consideration, as it is an exceptionally rich ore, the average of the analysed samples gives **0.0019** for gold, **0.0016** for silver. However, it must be noticed that the sampled ores are those taken by native miners from the better-looking portion of the ore-body; and to select such a class of ores, it is said, they throw away ores of inferior quality to an amount ranging from 70 % to 75 % of the mined limestone.

Besides the samples of the ore-body, some *individual specimens of ores* also found in contact limestone were taken from different parts of the mine, the result of the assay made of them being as follows :—

Nos.	Gold	Silver	Copper
11	0.0002	0.0022	0.61
14A	0.0044	0.0030	2.61
14B	0.0001	0.0010	1.30
27	0.0006	0.0020	—
28A	0.0070	0.0140	3.55
28B	**0.0329**	**0.0309**	**8.05**
29	0.0018	0.0006	0.83
31	0.0026	0.0012	0.89
31A	0.0016	0.0124	5.99
47	0.0014	0.0028	—

No. 11 was taken from the south side of the western ore-body, where this ore, occurring in very hard lime-silicate-hornfels of deep green color on the hanging wall of the fault, seems to be generally of inferior quality.

Nos. 14, 31A, and 47 were taken from pit No. 14 of the eastern ore-body, No. 14A being the richest, and No. 14B being the poorest one occurring in a limited spot irregularly impregnated by chalcopyrite. No. 27 from a still untouched portion near pit No. 9. No. 28 from pit No. 9. No. 28B is characterized by the presence of *bornite* in detached form, and the specimen gradually passes into No. 28A, the portion impregnated with *chalcopyrite* and *bornite*. No. 29 from the mouth of pit No. 3 (west of adit No. 4) is the sample representing the better kind of ore found there. No. 31 is from adit No. 4.

Locally at the western side of the eastern ore-body, greenish contact (diopside-rich) rock is exposed at the footwall of a fault plane appearing there, the hanging wall being limestone. This contact rock is impregnated with chalcopyrite, and the analysis of a sample taken from it shows that it contains 0.0034 gold, 0.0070 silver, and 2.94 copper.

An assay of the *earthy ores*, occurring on the west side of the western ore-body gave the following results:—

Nos.	Gold	Silver
4	0.0027	0.0024
5	0.0001	0.0007
10	—	0.0010

Nos. 4 and 5 are the yellowish earthy ores at the mill sites of *Morai-chhi.* No. 10 is from the fault plane. All these ores differ from the *calcareous* ores, already mentioned, in being derived from the débris of metamorphic schists which fill the fissure of the longitudinal fault.

Another kind of ore is that occurring in the *porphyritic granite.* The analysis made on such ores gave the following results:—

Nos.	Gold	Silver
7A	0.0006	0.0068
7B	0.0001	0.0025
7C	trace	0.0014
46	trace	0.0008

Nos. 7A, B, and C are taken from the outcrop of pit No. 23, impregnated with iron oxide and quartz. "A" still shows an unaltered portion of the granite-porphyry, "C" a decomposed reddish, earthy variety, and "B" an intermediate stage between "A" and "C". No. 46 is a granite-porphyry containing impregnated quartz and pyrite picked up at the heading of pit No. 32.

In conclusion, it must be said in the first place that the ore-body is in the *lime-silicate-hornfels,* a metamorphosed limestone at its contact with the intrusive granite: and secondly, that it does not extend at the surface in a linear direction sufficient to make it appear worth mining. Leaving out of consideration the auriferous porphyritic granite too poor for mining under present conditions, the area of the known ore-bearing portion may be estimated as 6.6, square kilometers (2,000 *tsubo*) in all; but from the nature of the deposit, it must be taken as an admitted fact that the workable and barren portions of the contact-metamorphosed limestone are so intermixed throughout the entire area that it is a very difficult task to estimate fairly the average value of the auriferous contents. As a matter of necessity a great deal of the mined limestone will have to be thrown out in the actual working, as being either totally devoid of gold or at least yielding too little to pay for working. The dejected ore and rubbish, according to Mr. NAKASHIMA, may be as much as 60%.

F. The Working of the Mine

The mine seems to have been worked a hundred years or so ago, but no exact record was kept. It was re-opened in 1896, and a portion of it was operated for four years under the hand of a Japanese—TAHEI YAMAGUCHI—who set up wooden stamping mills of the type now in use in *Kagoshima*, Japan. In 1900, YAMAGUCHI sold all the rights he then held to the Korean Household Department under whose control the mine was in operation up 1907 when it was just passing into the hands of an American, named Collbran. In 1905, however, a syndicate, representing Japan, England, and the United States, was formed, but was soon dissolved owing to the unfavorable reports of the engineers who were sent to investigate the workable capacity of the mine.

The mine is now being worked in part directly by the Government, and in part by the people each of whom pays a royality at rates varying from 3.6 to 5 *mommé* of gold per month. The number of inhabitants living near the mine is said to be from 300 to 400. Fuel is scanty even in this hilly interior. A small bundle made up of 16–18 slender pieces of wood may be had for 10 Korean sen (5 Japanese sen), but the price will no doubt increase rapidly as soon as an extensive demand is created. The thin forest of the granitic *Ön-jin-san* yields only slender and stunted trees. The wages of a miner vary according to his ability from .70 to 1.30 yen a day. The total number of stamp mills erected on the surrounding streams is thirty-six. Each mill consists of ten stamps of 26½ kilos. The mills are operated by water power, and gold and silver are directly extracted by the process of amalgamation in the mill.

G. Auriferous Localities in the Environs of the Hol-gol Mine

In the neighborhood of the *Hol-gol* gold mine, there are a number of auriferous localities where gold washing was formerly carried on, but nearly all of them have now been abandoned.

Sang-dai [2]. About 12 *km* southeast of the *Hol-gol* mine [3], is the deserted gold mine of *Sang-dai*, situated at the junction of the limestone with the porphyritic granite of *Ön-jin-san*. On a rugged hill at the fork of two streams flowing from the north, there are remains of open works, abandoned more than ten years ago, along the strike (N. 60° W.) of the limestone with the dip to the northeast. The contact limestone is much fissured and crushed, and is

1) 1 *mommé*=3.75 gramme.

2) 上岱 3) See Pl. IV.

locally rich in quartz veinlets. The assay on the specimens from an altered, porous limestone of an earthy aspect colored with iron oxides, gave the following results :—

Gold	Silver	Copper
0.0002	0.0032	1.05
0.0002	0.0010	0.09

The gold washing seems to have been carried on not only on the placer gold, but also on the earthy product which occurs intermixed with the solid limestone.

Salku-chhi [1] ,and *Kullyang-kol* [2]. To the east of the *Hol-gol* mine within the massive limestone terrane of *Salku-chhi* and *Kullyangkol* (J and H on the map), precipitous cliffs often show red and yellow stainings with iron oxides. Heaps of débris, once worked for gold dust, are seen along the valleys.

Neureum-kogăi [3]. About 4 *km* northeast of *Hol-gol*, the *same kind of* rocks as those of the preceding could be noticed in the limestone at *Neureum-kogăi.* Near a river, gold washing was formerly in operation.

Sök-tari [4]. About 600 *m* upstream from *Sök-tari,* we see one large mass of milky white quartz by the road side. An assay was made of a specimen from here and gave 0.0001 for gold, and 0.0015 for silver, but it was not fully ascertained whether the quartz occurs in the form of a vein or a lenticular rock-mass intercalated in stratified rocks.

Heung-kol [5]. Gold washing was carried on until ten years ago in the valley of *Heung-kol,* which lies 8 *km* west of the *Hol-gol* mine. The home of the placer gold here as elsewhere seems to be in the limestone.

---

1) 杏峙 2) 軍糧洞 3) 楡峴 4) 石達 5) 興洞

Keum-hoa[1]. After crossing a low pass to the west of *Heung-kol,* and passing the village of *Keung-hoa,* we come down to the main valley which runs from the south to the north. Precipitous cliffs of limestone are seen, bearing some doubtful traces of gold.

Song-hyön[2]. To the south of the last-named valley in the environs of *Song-hyön,* gold washing was formerly carried on, the spot K to the northeast of the village deserving special notice. Here the metamorphic argillite containing lenticular quartz mass, and the overlying and underlying limestones are much fissured; and the calcareous rocks are stained with ferruginous products, and often decomposed into red earth. The placer gold came no doubt from these rocks. To the north of this auriferous locality, a basaltic dyke and granitic mass are seen intruding through the limestone, thus showing geologically a very close analogy to that of *Hol-gol.*

From what has been stated in the foregoing as regards the occurrences of gold outside of *Hol-gol,* the *original home of the metal seems to be in the limestones* into which most likely it was carried by intruding granitic magma, though the impregnation is poor and not yet secondarily enriched so as to make it worth working.

---

3) 金華　　4) 松峴

CONTENTS

PLATE I.

PLATE I.

Fig. I.—Chlorite-schist. The cover-glass of a slide of the rock was removed, washed with ether, and treated with hot HCl which dissolved away the magnetite, and then the photomicrograph was taken. The ground is a mosaic of albite grains, veiled with irregular membranes of clinochlore. There are a great number of subangular or rounded rhomb-shaped colorless crystals with high refraction and also strong birefringency. They are of minute size, have the appearance of leucoxene, and are here identified as either titanite or orthite. They are also present in almost all chlorite-schists elsewhere, in which they are accompanied with somewhat large yellow granular anhedra, which no doubt belong to epidote. Pp. 7–8. Magnified 90 diameters.

Fig. 2.—Slaty mica-schist. The preparation was first digested with HCl which dissolved away the magnetite, and the remaining black dust disappeared only after ignition when the slide become clear. There are superabundant needles of rutile, some showing the characteristic knee-shaped twins. Hemimorphic magnesium-tourmaline is also found among them as in fig. 4. P. 6. Magnified 50 diameters.

Fig. 3.—Contact-metamorphosed limestone (ophicalcite). Calcite with mosaic structure, enclosing patches of dirty calcite which always embrace slender diopside, the latter now entirely changed into a serpentine. There is besides an antigorite-serpentine into which the calcite-rhombohedrons project with idiomorphic outline. P. 10. Magnified 50 diameters.

Fig. 4.—Argillite. The dark-gray phyllitic rock was cut to a thin slice, and digested in HCl and ignited, thus entirely removing the graphitoid. Interlarded in lamellar sericite are clayslate-needles which are small as compared with those of slaty mica-schist (fig. 2). Tourmaline is also present. P. 8. Magnified 84 diameters.

Fig. 5.—Contact-metamorphosed limestone. A six-sided crystal and the grains of diopside as shown in the photomicrograph have been changed for the greater part into fibrous serpentine leaving cores of the intact mineral. We can here trace the various stages of serpentinization from diopside. P. 10. Magnified 50 diameters.

Fig. 6.—Contact-metamorphosed limestone. The small acicular needles of ilvaite are enclosed in calcite-crystals of an early generation; but the anhedra of diopside in the immediate neighborhood are peculiarly free from the enclosures of ilvaite. Pp. 10-11. Magnified 50 diameters.

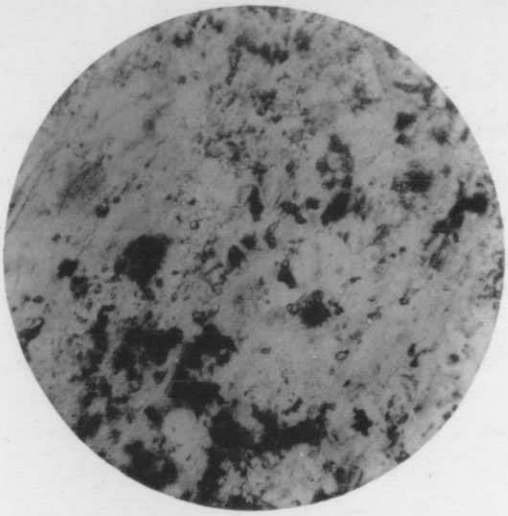


Fig. 1.

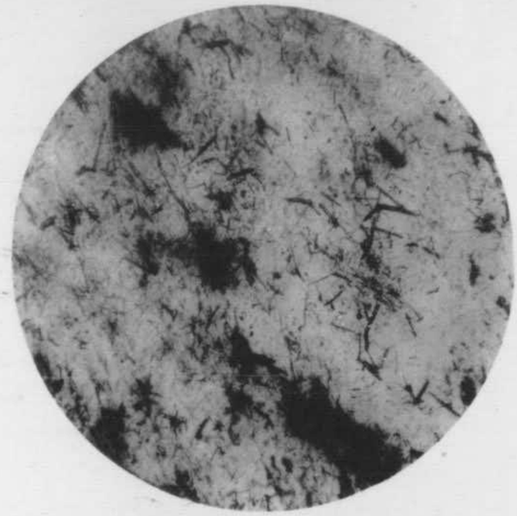


Fig. 2.

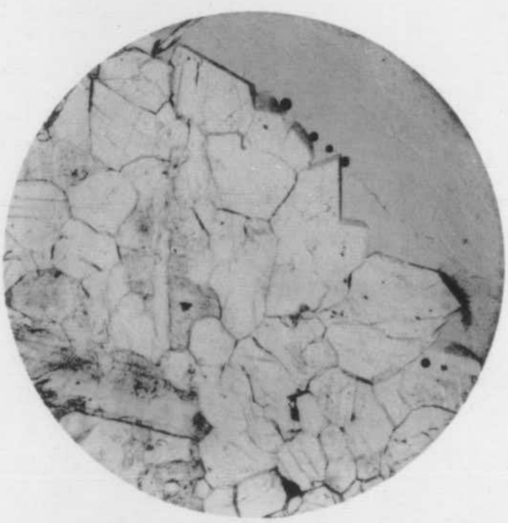


Fig. 3.

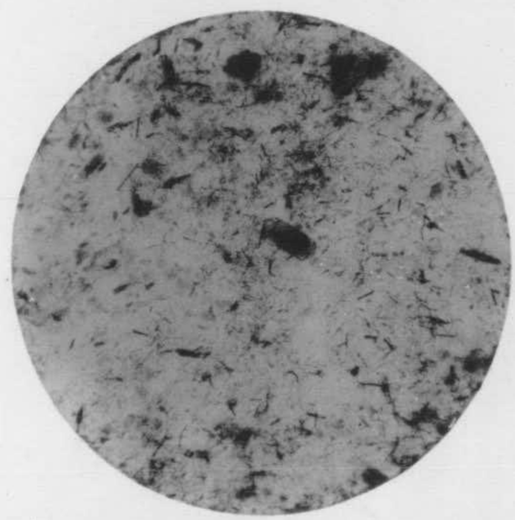


Fig 4.

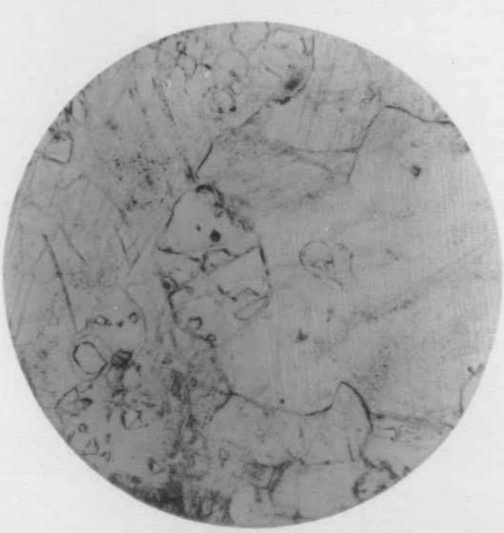


Fig. 5.

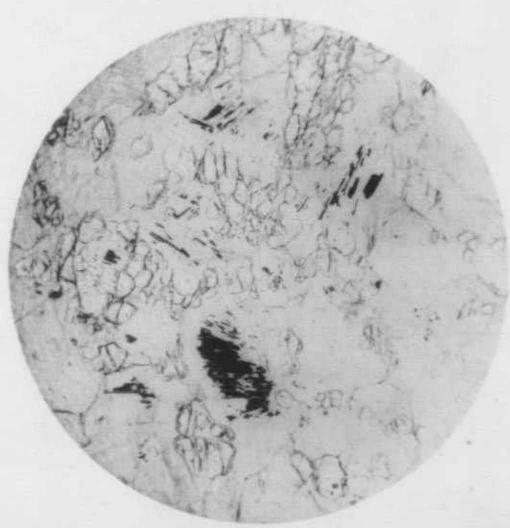


Fig. 6.

Anthor, Photo.

B. Kotô: *The Hol-gol Gold Mine*

PLATE II.

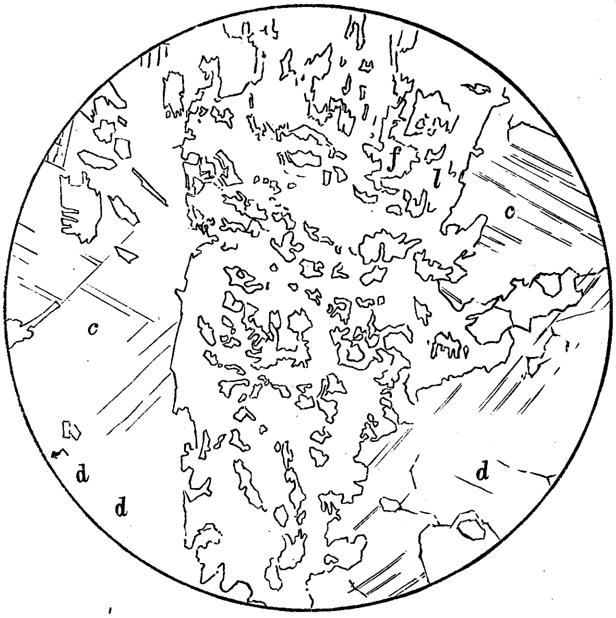
PLATE II.

Fig. 1.—This and also the next figure are microphotographs of the second modification of contact-metamorphosed limestone, which is usually called lime-silicate hornfels. Ilvaite here occurs as black radiating needles (*l*) appearing as if black iron ore were veiled in thin membranes of colloidal silica. The membranes are probably of a lime-silicate extinguishing light parallel to the direction of ilvaite needles, and showing high birefringency. Pp. 10 and 22. Magnified 50 diameters.

Fig. 2.—The same as in fig. 1. The ilvaite forms acicular radiating needles, and is opaque and submetallic, appearing just like stibnite for which it has been taken. Basal cleavage is distinct as may be seen in the sharp dismemberment of the needles. This is the normal type of ilvaite in contrast to the one in fig. 1, and encloses diopside (*d*), but is enclosed by calcite (*c*). P. 10. Magnified 50 diameters.

Fig. 3.—This and fig. 2 as well as Pl. II. figs. 1 and 2 are microphotographs of the third modification of the lime-silicate hornfels. The rock represented is diopsidite, and the mineral diopside (*d*) builds up the great bulk of the mass, sometimes showing traces of the characteristic augite-cleavage. Chalcopyrite (*p*) fills up the interstices left by diopside. P. 11. Magnified 50 diameters.

Fig. 4.—The same as in fig. 3. The mode of association of both diopside and chalcopyrite shows that the first was corroded and dissolved away, and then replaced by the latter. P. 11. Magnified 50 diameters.


f
l
c
c
d
d
d


c
d
l
l
d
l
c
d


d
p
d
d
d
p


p
d
d
p

Fig. 1.

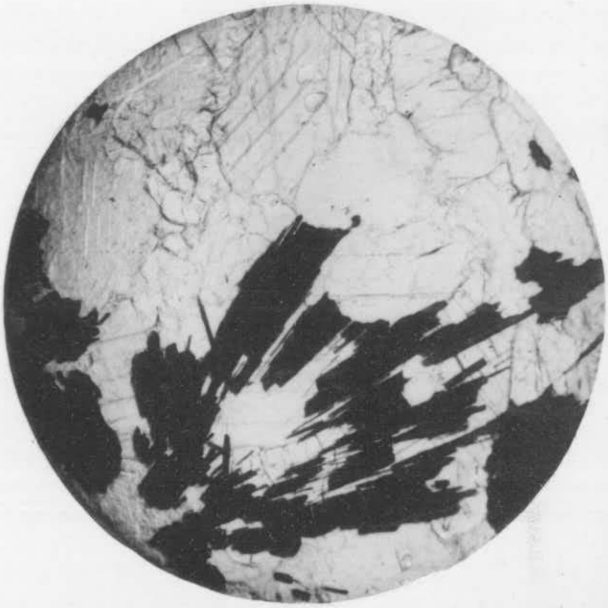


Fig. 2.

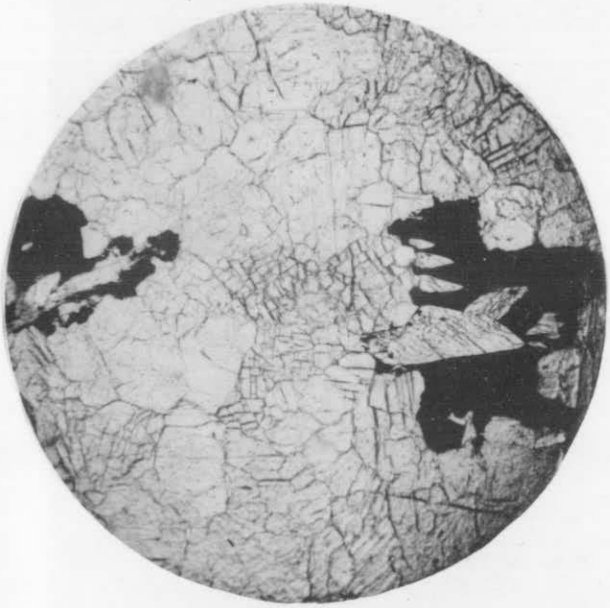


Fig 3.

Fig 4.

Anthor, Photo.

B. Kotô : *The Hol-gol Gold Mine*

PLATE III.

PLATE III.

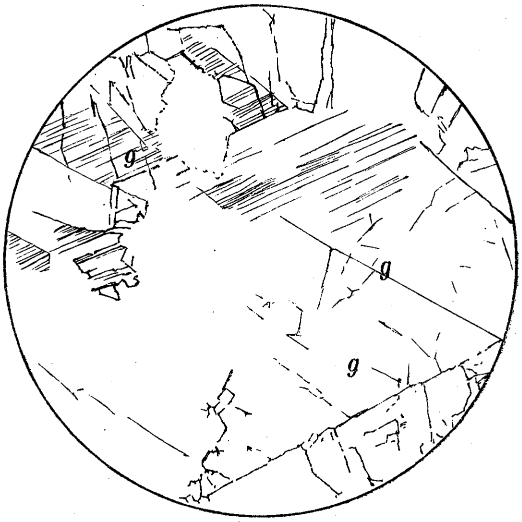
Figs. 1 and 2.—A variety of the third modification of lime-silicate hornfels built up almost solely of andradite. The name garnetite or garnetfels is given to such an aggregate. The garnet, as may be seen in the figures, shows well-defined optical fields of the rhombic dodecahedron type. Fig. 1 exhibits a combination of optical pyramids and isomorphic shells—a case rarely observed in anomalous garnets. P. 12. Magnified 15 in fig. 1, and 50 diameters in fig. 2.

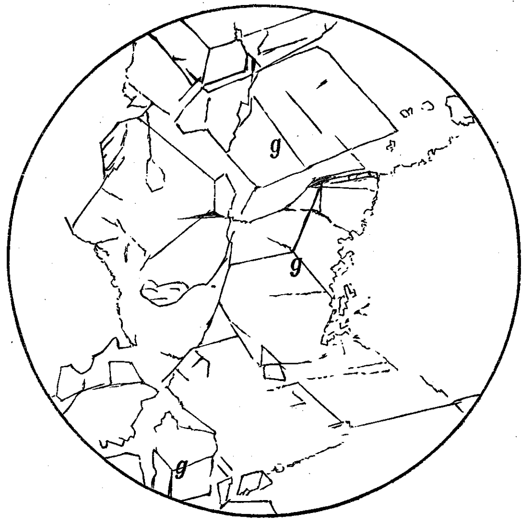
Fig. 3.—Meta-diorite. Slide of an amphibolite-like rock intruding into slaty mica-schist (Pl. I. fig. 2). It is mainly built up of reedy hornblende with secondary biotite in its centre as if both minerals were derived from augite. The whitish patch is a mosaic of albite. The whole aspect of the rock in the slide is typomorphic. P. 16. Magnified 63 diameters.

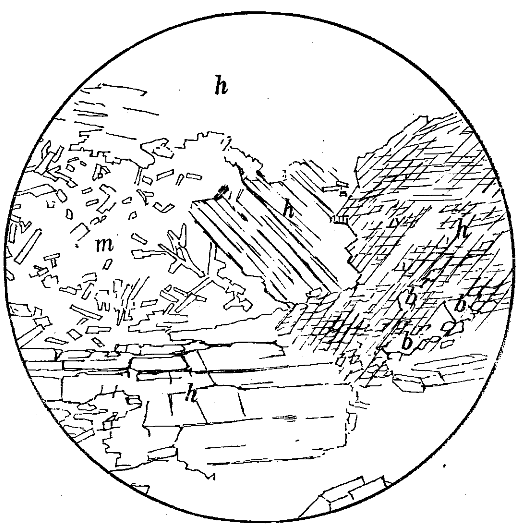
Fig. 4.—Porphyritic hornblende-granite, forming the mass of *Ön-jin-san.* It is the 'ore-bringer' and the originator of the contact-metamorphism of the Hol-gol region. A noteworthy feature of this rock is the corroded aspect of the quartz which is moulded to orthoclase. This texture is characteristic of the porphyritic granite. Pp. 13–14. Magnified 18 diameters.

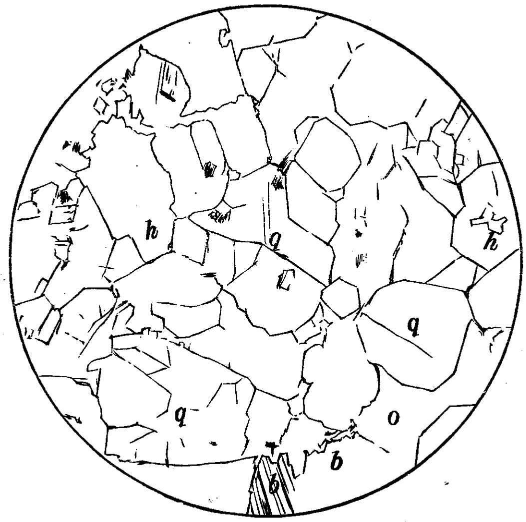
Fig. 5.—Flow-basalt. The white patch in the centre of the figure is a vesicle lined with highly birefringent cuboidal grains of datolite. P. 16. Magnified 50 diameters.

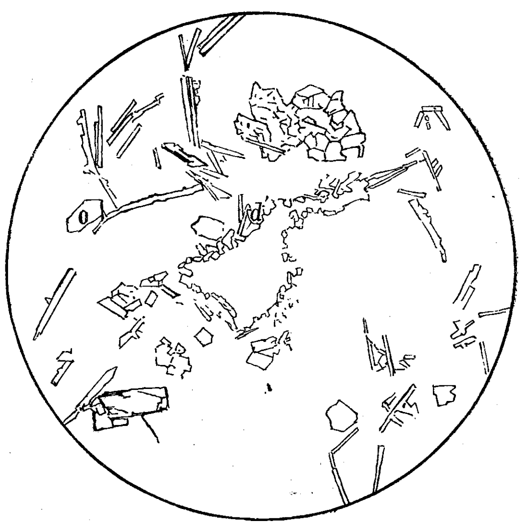
Fig. 6.—Stielbasalt. In the centre of the figure is seen a large piece of corroded quartz, internally fritted and traversed with cracks and externally fringed with radially arranged, violet augite-needles, which become green at the contact with the 'quartz eye'. Pp. 15–16. Magnified 50 diameters.


g
g
g


g
g
g


h
h
m
h
b
b
h


h
q
h
q
q
o
b


o
d


q

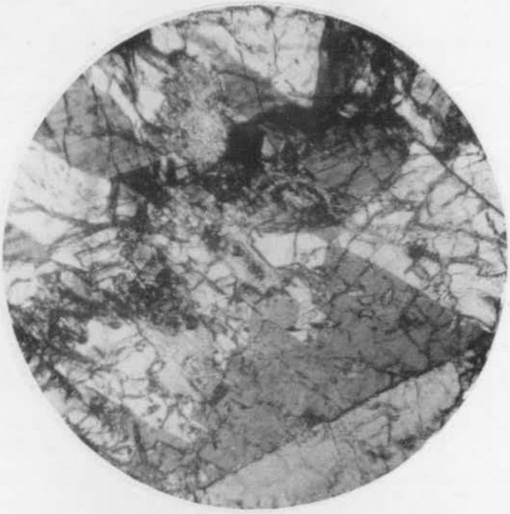


Fig. 1.

Fig. 2.

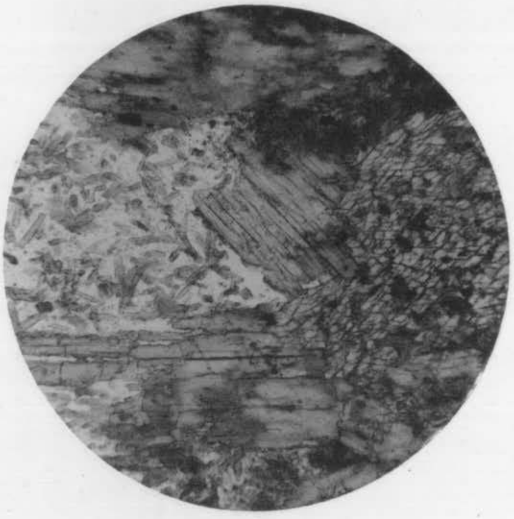


Fig. 3.

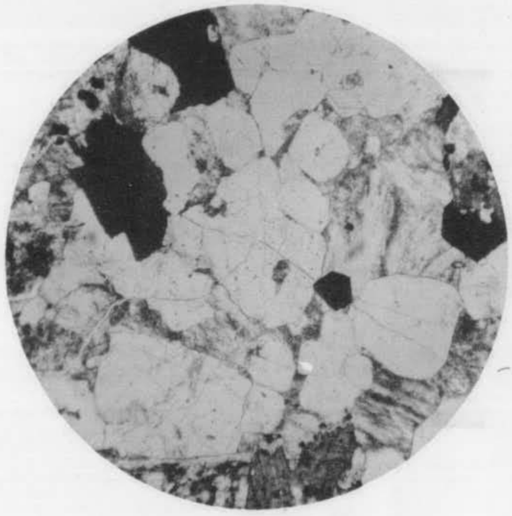


Fig 4.

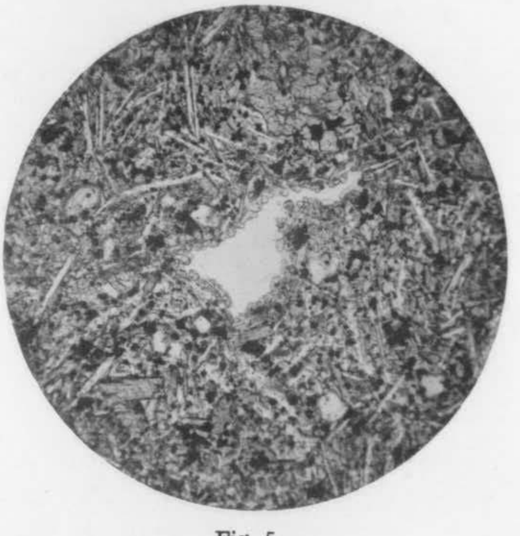


Fig. 5.

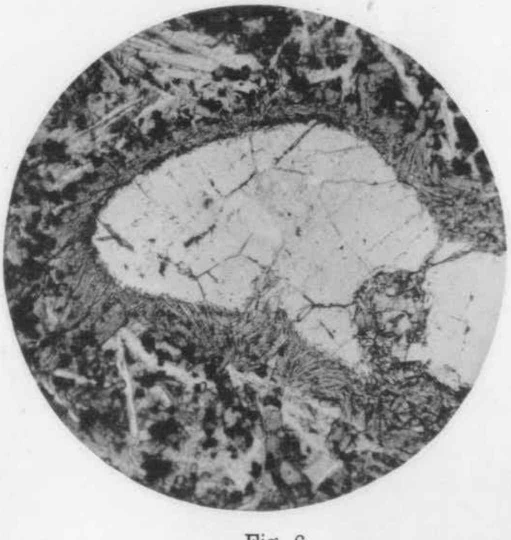


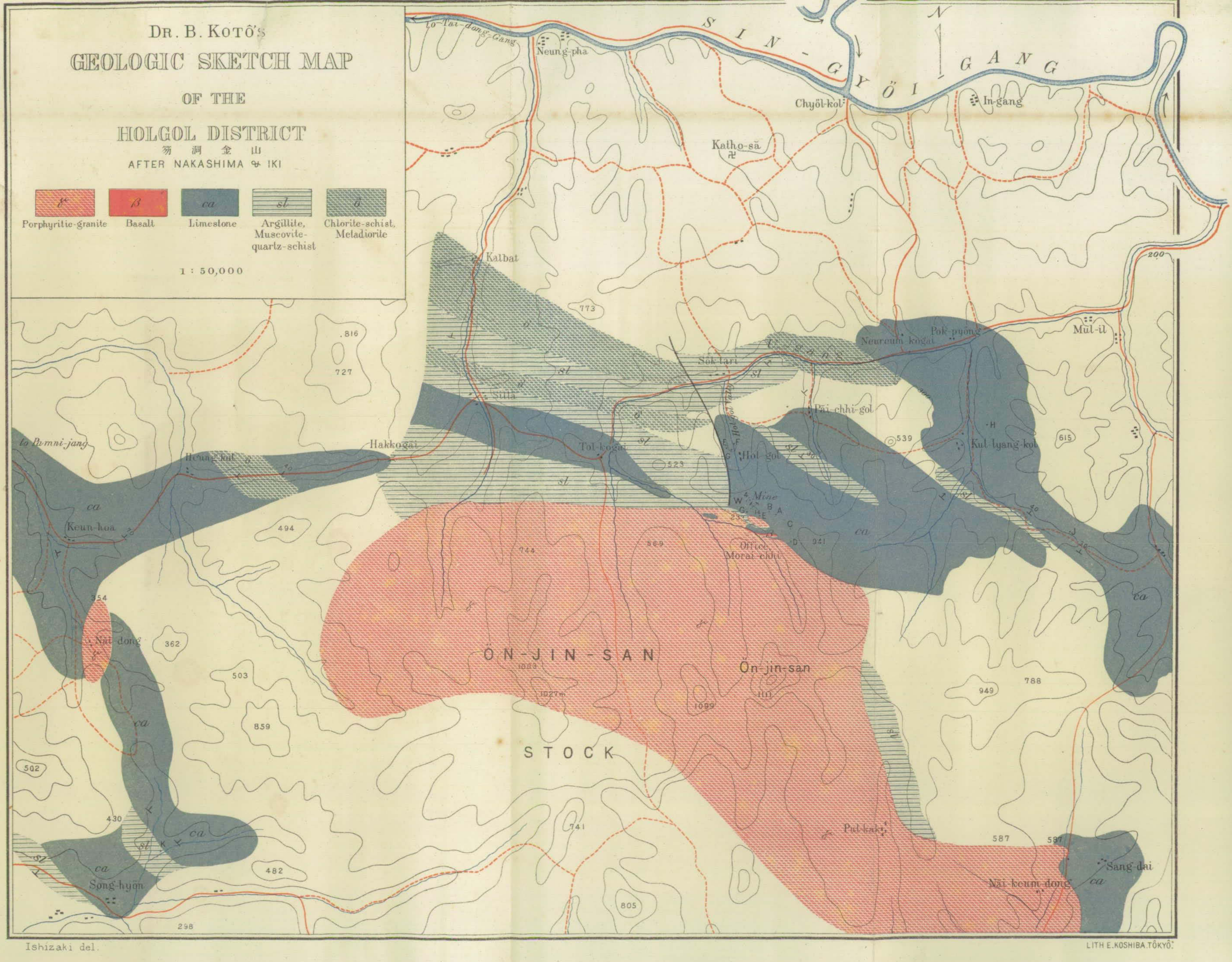
Fig. 6.

Anthor, Photo.

PLATE IV.

PLATE IV.

Compiled mainly from the manuscript geologic map by Dr. K. NAKASHIMA, with slight modifications suggested by the map appended to Messers. IKI and SUZUKI'S "Report on the Mineral Resources of Hoang-hăi-Do, Kyöng-sang-Do, Kyöng-geui-Do, South Chhyung-chhyöng-Do, and the Southern Part of South Phyöng-an-Do" (in Japanese).


Dr. B. Kotô's
GEOLOGIC SKETCH MAP
OF THE
HOLGOL DISTRICT
笏洞金山
AFTER NAKASHIMA & IKI
Porphyritic-granite
Basalt
Limestone
Argillite, Muscovite-quartz-schist
Chlorite-schist, Metadiorite
1 : 50,000
SIN-GYÖI-GANG
N
to Tai-dong-Gang
Neung-pha
Chyŏl-kol
In-gang
Katho-sä
Kalbat
Mul-il
Pok-pyŏng
Neureum-kogai
Sŏk-tari
Sulla
Hakkogai
Tol-kogai
Hol-gol
Päi-chhi-gol
Kul-lyang-kol
to Pumni-jang
Keun-hoa
Office
Morai-chhi
Mine
Nai-dong
ŎN-JIN-SAN
Ŏn-jin-san
STOCK
Pul-kaki
Sang-dai
Nai-keum-dong
Song-hyŏn
ca
sl