The Cinnabar Deposit in the Province of Yamato.

By

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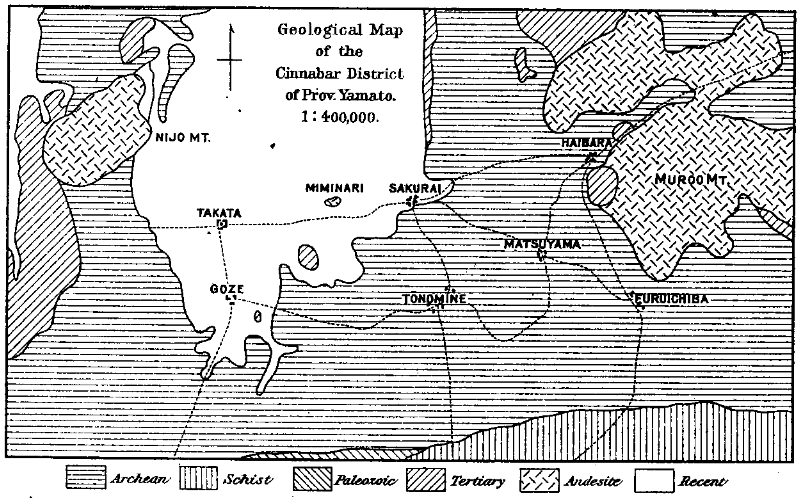
It has long been known that certain deposits of mercury existed in the provinces of Yamato, Awa, Iyo and Hizen, in the southern part of Japan. These deposits are of different geological ages and different modes of formation. All of them were mined in early days, but only for a short time, because of the small quantity of ore. Recently, one small cinnabar mine has been opened on a small scale, the Suii mine in the province of Awa, which produces a small quantity of metallic mercury. During a visit to the province of Yamato, last year, two days were spent in the cinnabar districts, where no important economic mine has been worked. The present paper may be regarded as the first of a series concerning the formation of cinnabar deposits, to be completed by a study of other cinnabar regions in the near future.

Situation.

The cinnabar districts under consideration, in the southern part of the province of Yamato, are found in Tōnomine village in Shiki-gōri and in Uda and Ugashi villages in Uda-gōri.

The village of Tōnomine is situated in the central part of the Tōnomine mountain range, about ten kilometers due south of the city of Sakurai on the Kwansai railroad, connecting Nara and Sakurai. It is well known for a celebrated shrine, "Danzan-Zinsha." The highest elevation of the mountain is about six hundred meters above sea level. The peaks are rugged and thickly covered with ceders and pines; and a brook



along which a path leads from that village to Sakurai run due north. There three cinnabar mines, Iimoridzuka, Harimichi and Kiratani, were once opened within a circle of about two kilometers, but now all are abandoned.

The villages of Uda and Ugashi are situated about ten kilometers east of Tōnomine and sixteen kilometers south-east of Sakurai. In general, this district consists of small hills, which have been cut down by erosion, and appears like depression within the high mountain region (fig. 1, Pl. I.). The altitude of these hills varies from three hundred meters to five hundred meters above sea level. The chief village in this district is Furuichiba, from which three main roads join other neighbouring cities, the city of Haibara on the north, Matsuyama on the west, and the village of Washidani on the south. The Hōno-gawa flows from south to north and drains the rice fields in this district. In this district, many outcrops of cinnabar deposits appear within an area of about four kilometers. Of these a vein in the village of Komagayeri was opened about fourty years ago and made to work during several months, but with no success. Later several persons tried to work the other outcrops, but until now no mine has succeeded.

Geology and Petrography.

The geological construction of central Japan is quite complex, the tectonic lines of this district run north-south and east-west through this mountainous region. Many depressions produced along these lines form the Nara, Kyoto and Osaka plains surrounded by many steep mountain ranges which are the remnants of old archean and paleozoic plateaus.

The mountain group in the southern part of the Nara plain is one of extreme geological interest because of its old geological formation. This formation consists chiefly of a series of imperfect schistose granitic rocks with their great complexity of differentiation. Among these the most prominent rock is fine grained hornblende gneiss, intruded by imperfect schistose coarse granular granite, imperfect schistose hornblende biotite granite, and porphyritic granite. In general the mountain mass of the Tōnomine region is composed of fine grained hornblende gneiss and a very few other rocks; while in the Uda and Ugashi region the prominent rocks are chiefly granitic. In the Uda and Ugashi region, however, we find a dark green colored schistose rock caught up in imperfect schistose hornblende biotite granite. This rock appears like the fine grained hornblende biotite gneiss of the Tōnomine region, but under the microscope it presents quite a different appearance, so that it may be considered a variety of the same gneiss metamorphosed by the action of later granitic rocks. Other granitic rocks of the order of hornblende biotite granite and coarse granular granite have intruded into this gneiss. This rock complex may be equivalent to the gneiss formation in other parts of Japan, and has been already described as a gneiss formation by Mr. Yamashita, and as old granite by Mr. Kanehara, the latter writer regarding the rock as belonging to the archean formation. The general strike of gneiss is nearly north-south, but the strike of the mountain range is east-west like the east-west techtonic lines. The crystalline schist system and paleozoic formation covered this complex in the southern part of the district. Through this rock complex the quartz mica andesite and mica andesite, which now remain in the forms of eroded domes or cones, breaks here and there in the tertiary era.

These andesite cones are exposed in the southern portion of the Nara plain as Muroo, Miminari and Nijō mountains, and also represent a volcanic chain in the same direction with the east-west techtonic line, but we can not find any cone in the district under consideration.

Fine grained hornblende gneiss.—The oldest of the rocks in the cinnabar districts of the province of Yamato is fine grained hornblende gneiss. It covers an area of Tōnomine environs and throughout its extent it appears to be uniform in texture and composition. Outcrops are few and are generally altered. It is fine grained granitoid in texture, and dark green, with fine spots of felspar grains. Microscopically, it consists of equal dimensions of ingredients. The constituent minerals are quartz, orthoclase and hornblende as essential ingredients with magnetite, and a little apatite and zircon as accessory. The hornblende shows more or less decomposition, the color changes to yellowish green, having weak polarization. The margin of the crystals have an irregular outline; and along the cleavage cracks light colored epidote grains have accumulated and sometimes chloritized. The orthoclase have undergone a little change to kaolin, but is comparatively fresh. It frequently shows undulatory polarization. The quartz is also comparatively fresh, and consists of small crushed fragments which appear as mosaic in crossed nicols. Magnetite, apatite and zircon appears in very small quantity, frequently as apatite crystals enclosed in quartz grains.

Schistose fine grained hornblende biotite granite.—This is a rock which the writer considers to be metamorphosed fine grained hornblende gneiss. It is exposed chiefly in the Uda and Ugashi region, and is intruded or caught up by the imperfect schistose coarse granular granite and also by imperfect schistose biotite granite. Its outward appearance is nearly the same as that of fine grained hornblende gneiss. It is dark green, microcrystalline in texture; but, under the microscope, the structure and minerals become apparent. All components are fresh. The biotite is yellow to dark brown, with strong pleochroism, and observed no inclusions. This character is quite the same as that of biotite in contact metamorphosed clay slate. Hornblende is found abundantly in small columnar crystals, colorless or light green in color, and of weak pleochroism. Orthoclase also appears in a fresh state in columnar shapes. Quartz fill up the interstices of other ingredients and frequently contains apatite needles as accessory.

Hornblende biotite granite.—This is among the most dominant granitic rocks in the Uda and Ugashi region. It is a coarse, granular granitoid rock, dark gray in color. Its schistosity is imperfectly developed. Macroscopically, all the components are distinctly observed, and are found to be hornblende, biotite, orthoclase and quartz. Under the microscope, the hornblende is dark green in color, and aggregate with the biotite. It frequently changes to green chloritic matter, and contains a great amount of zircon and apatite crystals. Brown fibrous biotite is usually found with the hornblende, also altered to a chloritic substance or epidote. The orthoclase is not striped, is comparatively fresh, though frequently decomposed along the cleavage cracks; it also contains apatite and zircon. Plagioclase is more fresh than orthoclase and may be easily distinguish by its polysynthetic twin which represent the oligoclase nature. The quartz is clouded with an accumulation of liquid inclosures, arranged in bands along the fissures and cracks. As accessory, we have much apatite, zircon, magnetite and specularite.

Coarse granular granite.—This is white in color and consists almost entirely of quartz and felspar with a very subordinate amount of biotite. These ingredients distribute uniformly, the grains are very coarse, and the rock is very firm. The felspar is comparatively fresh and scarcely distinguishable from quartz. This rock crops out only in a limited area, in the Uda and Ugashi district, intruded into schistose fine grained hornblende biotite granite. This rock, however, may be supposed to be a much later generation of the granitic rocks. The thin sections show that the rock is uniform in composition; and the quartz and felspar appear in almost equal quantities. The quartz is crushed into small fragments and shows mosaic colors under polarized light. Abundant liquid inclosures include as bands or net works along numerous rehealed cracks. The felspar is generally orthoclase, with varying amounts of plagioclase. The orthoclase is fresh with a few inclosure of apatite, but frequently has become cloudy by kaolinization. The plagioclase, probably of oligoclase nature, is also fresh and can be distinguished by the polysynthetic twin from orthoclase. The dark brown biotite is entirely fresh and accumulated in a few spots; it is also fresh and free from its decomposition to chloritic matter. Apatite and zircon are found in the quartz and orthoclase.

Quartz mica andesite.—As before stated, quartz mica andesite and mica andesite intrude into the granitic rocks in the environs of this district. However, the rock exposed in the Uda and Ugashi region is quartz mica andesite, which is a part of the Muroo andesite dome. This rock is light grey in color with a rough surface including small phenocrysts of mica and felspar as porphyritic crystals. Microscopically, quartz, biotite and fresh felspar imbed into a light yellowish, glassy groundmass of fluctuation structure. The quartz is free from inclusion, though frequently having caught up some glassy groundmass; and it is in angular fragments, but sometimes presenting crystal outlines. The felspar also is clear and transparent; and is determined as the anorthite series. The biotite is mainly fresh, yellowish brown to dark brown in color, but sometimes presents slight decomposition.

Cinnabar Deposits.

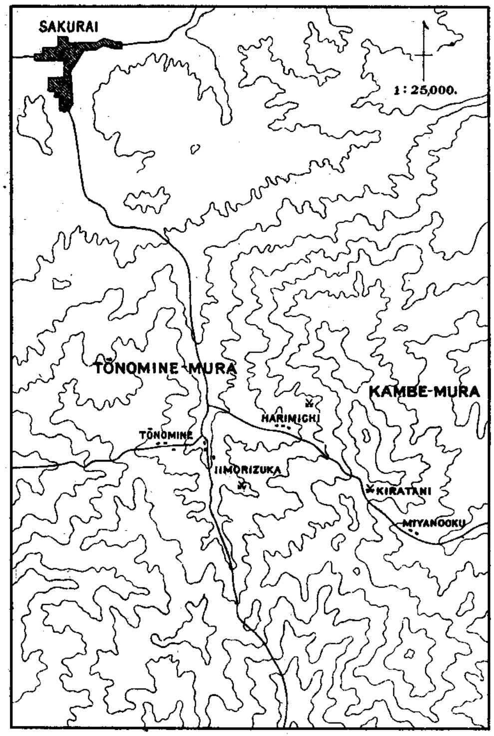
Tōnomine group.

As before stated, the cinnabar deposits of the Tōnomine group are found in fine grained hornblende gneiss, and have been worked in three mines, but none of them are important deposits for working mercury.

a. Iimoridzuka mine.

We find this mine in a thick forest in Omichi, in the village of Iimoridzuka about one kilometer south of the Tōnomine shrine. A small stream flows from the high peak, and forms a small vale. At the upper part of this vale, we find a small outcrop of cinnabar deposit. The fine

MAP OF THE TŌNOMINE CINNABAR-DISTRICT.



grained hornblende biotite gneiss, imperfectly decomposed into clay, developed about seven meters, probably by the metasomatic action of thermal ore solutions. Though this small grains of cinnabar are sparsely distributed but are not rich enough to make a workable deposit. The clay is intercalated by some original barren rock, and few narrow veins also are associated with a few marcasite crystals and cinnabar grains (fig. 2, Pl. III.); but chalcedony, which is a most characteristic associate is never present here. The order of succession of deposit in the calcite veins is marcasite first and next calcite filling up the crevices in a crystallized zonal structure (fig. 2, Pl. I.). Thus we can imagine that the ore solution was introduced into the rock partly through fissures forming calcite veins, and partly through the rock mass altered into clay, that is as impregnation veins.

b. Harimichi mine.

The Harimichi mine is situated in Montani of the village Harimichi about one kilometer from the eastern part of the Tōnomine shrine. The cinnabar deposit here also occurs in the fine grained hornblende biotite gneiss, in a narrow vein of from twenty to one hundred centimeters, traversing vertically in rock, and striking north-south. The ore of this vein consists chiefly of an aggregation of marcasite crystals, intermixed with small quantities of cinnabar. The gangue mineral is always chalcedonic quartz which fills both walls of the vein. The rock has not changed so extensively as in the Iimoridzuka mine, and only a small extension has undergone decomposition in both walls. Marcasite, a typical mineral of deposition near the surface, occurs in large quantities with well defined crystals. The crystals are tabular to oP and always have the crystal faces $oP . \infty P . P\breve{\infty}$.

Granular cinnabar fills up the interstices of the marcasite aggregate. These two minerals are so intimately associated that it renders successive deposition a matter of doubt. This vein is a true fissure vein in the rock, giving metasomatic action along the walls. This mine was worked for a short time, but abandoned on account of the small quantity of ore.

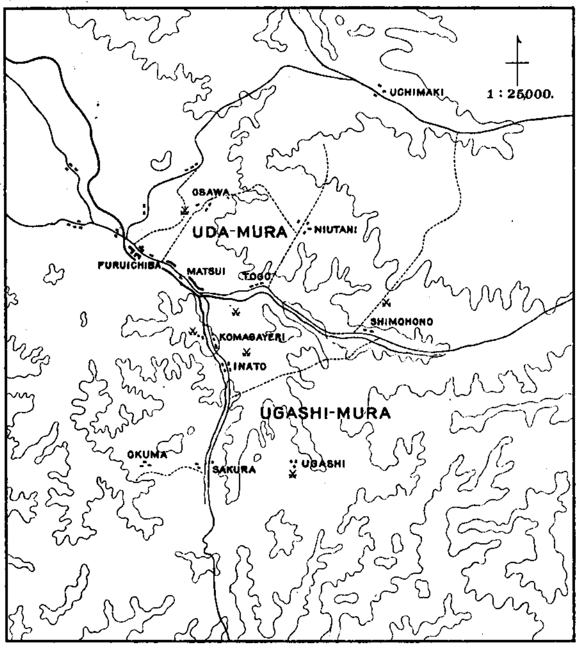
c. *Kiratani mine.*

At the summit of the mountain pass from Harimichi to Kami-Miyano-oku also we have a large clay vein in the fine grained hornblende biotite gneiss. The thickness of the clay seam is about six meters, standing vertically with a north-south strike. In the selvage and the middle portion of the clay seam, we have a narrow marcasite stringer of one to two centimeters in width associated with a small quantity of cinnabar and stibnite, but frequently we lose the vein on account of the small quantity of ore. Iron pyrite, crystallized in cubical forms which are probably of secondary origin, is sparsely disseminated through the clay mass. This clay vein appears to be a decomposition product of the rock by influences acting from thermal solution containing but little ore. This mine is worked only for clay, not for metallic minerals.

Uda and Ugashi group.

This cinnabar district is confined to a limited area of granitic rocks extending in a southern direction from the village of Furuichiba. The district is further complicated by the intrusion of granitic rocks. The bodies of ore usually occur in hornblende biotite granite and crop out in the villages of Komagayeri, Inado, Ugashi, Shimo-Hōno and Ōzawa. Nearly fourty years ago, the prefectural offices of Sakai and Kyoto were

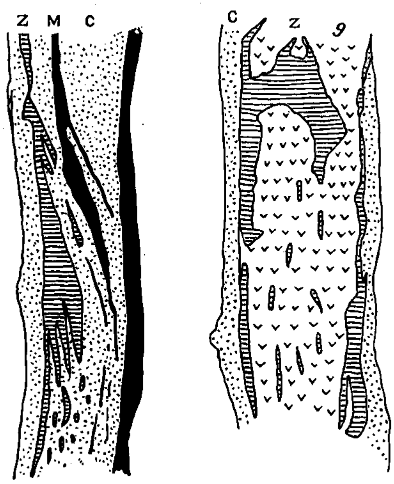
MAP OF THE UGASHI AND UDA CINNABAR-DISTRICT.



the first to mine cinnabar in the Komagayeri district at the outcrops in a rice farm by a river side; but it was soon abandoned on account of water and the poor quality of the ore. There after many prospectors were attracted to the region by the outcrops, and the mines of Inado and Ōzawa were opened; but they also were soon given up.

This region offers types of various structural developments in the deposits. The metasomatic process has been effected on a large scale by the ascending ore solution. The felspar has changed to clay and formed a certain amount of sericite. The colored minerals are all bleached. Under the microscope the rock appears of the same structure as fresh rock; but the felspar has completely kaolinized. The colored minerals have bleached and frequently changed to colorless grains of epidote which sometimes contain yellowish epidote in the central portion. The quartz remains in a fresh state, but almost always crushed, presents mosaic polarization color under the microscope. The apatite needles break into small fragments.

Through this altered rock, the cinnabar either is disseminated in the form of grains or occurs in stockwork of minute stringers. The stringers are always short and irregular, often divergent. In which case the boundary of the vein is commonly sharp, and the successive phases of mineralization are as follows: chalcedony first was deposited on the walls, marcasite and cinnabar came next, and afterward calcite filled up (fig. 1. Pl. II.). The silica has frequently crystallized as drusy quartz, and also contains very small rhombohedral crystals of cinnabar imbedded in it, though unfortunately we have not the measured crystals. The marcasite, as in the Tōno-mine group, has crystallized to tabular crystals, which are disseminated through the vein or have come to the walls as a crystal aggregate. When the cinnabar is impregnated through the rock mass, it is always sparsely disseminate as grains or replaced the quartz of the original rock (fig. 2, Pl. II.). In this case, secondary silica also has impregnated into the altered rock and formed fine grains. Near the veins we have frequently a crushed, breccia-like zone (fig. 1, Pl. III.), and also a compact zone like microgranite. The latter appears under the microscope as a breccia of crushed grains of quartz and infiltrated by chalcedonic silica, which is considered as a shear zone of vein-forming fissures.



Z = cinnabar. g = gneiss.
M = marcasite. c = chalcedony.

No other accessory secondary mineral can be found here, except a small amount of native mercury which is probably a product of oxidation, derived from the sulphide disseminate in the rock.

Resume.

As a rule the cinnabar deposits have been formed near the surface by ascending waters and in genetic connection with igneous rock. The mineral association of the deposits is cinnabar, stibnite and marcasite, with a number of other gangue minerals, such as quartz, chalcedony and calcite. Most of the cinnabar deposits are found in tertiary formations.

The cinnabar deposits under consideration are of the common type of the deposit. The deposits are found in granitic gneiss of archean formation. In the tertiary era, the gneiss formation was intruded by quartz mica andesite and mica andesite which remain as cones in the northern part of the district. Though these cones have no direct contact with the cinnabar deposits, they may be supposed to have genetic relations to the emission of the ore-forming solution. Closely after the andesite eruption, the ore-bearing solution ascended through the fissures of the gneiss and caused the metasomatic alteration and the deposition of the ores. The ore-bearing solutions and gasses moved in the paths prescribed by fissuring and brecciation, and rock alteration was effected to great extent in the country rock. Felspar converted to kaolin and sericite, and ferruginous minerals were bleached.

The deposition of ore minerals appears in two different forms: true vein and impregnation. In the case of vein, the ore minerals fill little crevices and fissures in the altered rock; and their boundary to the country rock is comparatively sharp. In mineral succession, the silica came first and crystallized as drusy quartz or chalcedony, deposited upon the vein walls; this was followed by cinnabar and marcasite, after which calcite also was deposited. While the impregnation of the ore to the country rock is quite different, the cinnabar disseminated as grains decomposed rock and marcasite deposited only along the fissures. Under the microscope, the cinnabar replaces the quartz, or fills up interstices of the rock ingredients.

Concerning the genesis of the ore, the writer concludes that this cinnabar deposit was made in the rock through the fissures soon after the intrusion of andesite, giving extensive metasomatism to the granitic rocks.

Thanks are due Mr. T. Suwa, a teacher of the Ugashi common school, for assisting my field work.

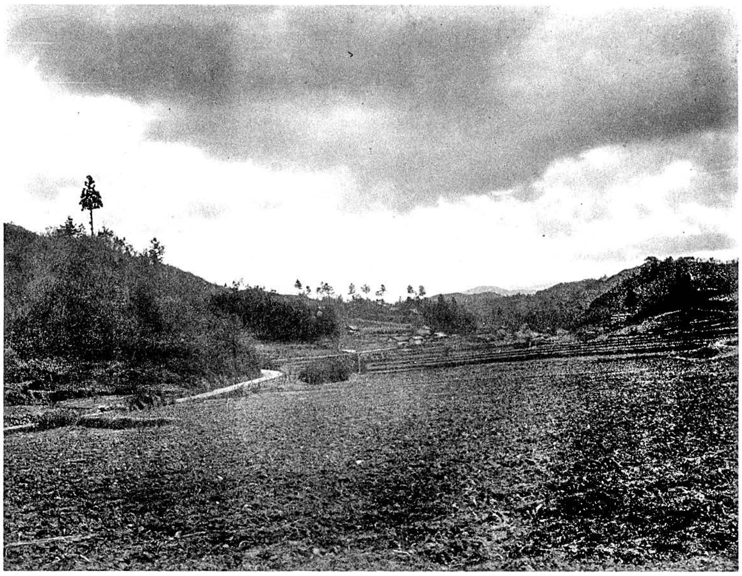


Fig. 1. Inado cinnabar district looking south from Komagayeri village in the Uda and Ugashi region.

Fig. 2. Crustification of calcite upon marcasite. × 50.

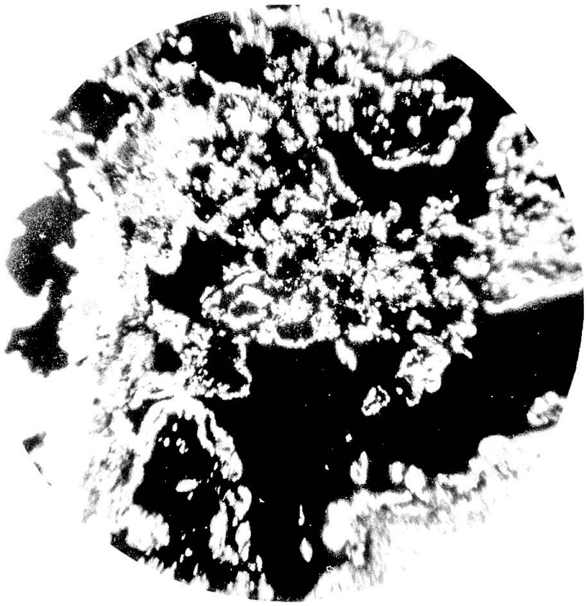


Fig. 1. Intergrowth of chalcedonic quartz with cinnabar.
× 50.

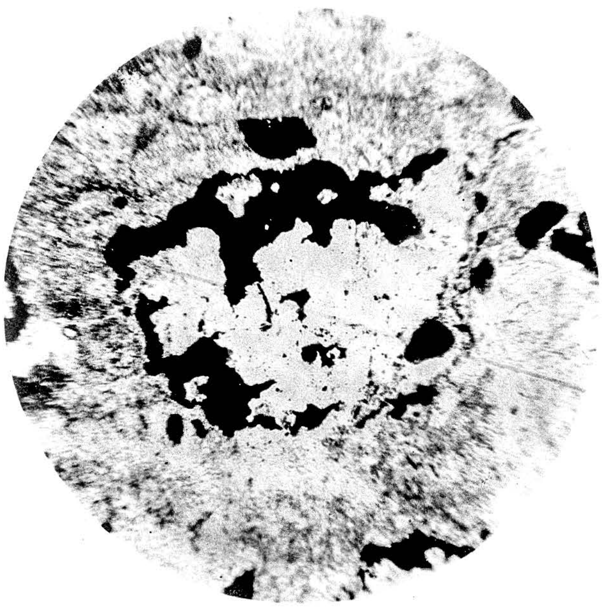


Fig. 2. Cinnabar, formed by replacement in quartz.
× 50.

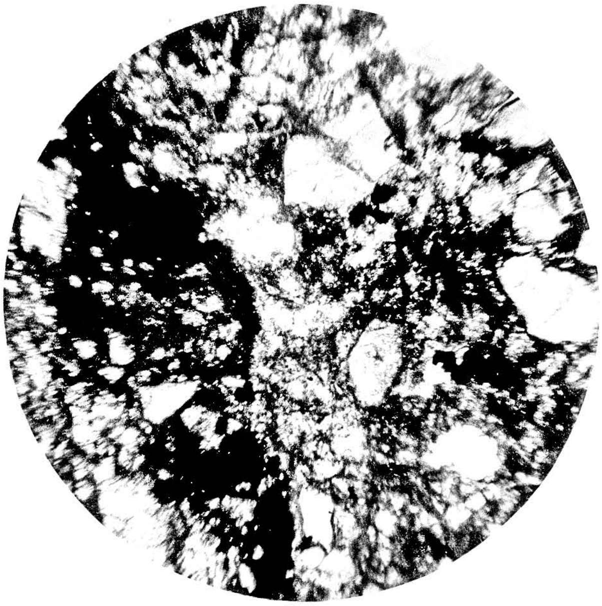


Fig. 1. Section showing silicified shear zone with cinnabar grains.
× 50.

Fig. 2. Intergrowth of calcite with marcasite.
× 50.