THE

GEOLOGY OF SAND CANYON

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SUMMARY

A body of complexly segregated igneous rock has been intruded into sediments at an early period in the earth's history. The segregations include a dioritic phase and a magnetite-ilmenite bearing ore phase in the area discussed.

During much later times the Miocene Mint Canyon formation was depositedon the west of the igneous body and in turn has been covered by old alluvium in places that has originated in the mountain block composed of the intrusion.

Two periods of stress are shown. One is post-Miocene and the other Pleistocene in age.

ECONOMIC CONSIDERATIONS

The bodies of ilmenite bearing ore should be carefully sampled and assayed to determine the percentage of titanium that can be obtained from the ore. The bodies promise sufficient tonnage and accessibility to be developed economically with a moderate titanium content that is not too variable.

INTRODUCTION

The area investigated lies in the western end of the San Gabriel Mountains in southern California, embracing the upper portion of Sand Canyon, a tributary of Soledad Canyon and the Santa Clara river. Parts of sections 4,5,6, 7,8,9, T3N,R14W; sections 1, T3N, R15W; section 36, T4N, R15W are included.in the area.

It is easily reached by travelling north from Los Angeles to Saugus, thence east on State Highway #6 to the Soledad Canyon road,about 8 miles. About 2 miles along this road is the Sand Canyon road which should be followed to the south to Bear Canyon, roughly the western end of the area, which lies as a rectangle 4 by 1 miles in size with the longer direction in an east-west direction.

The field work was done by mapping on the Sylmar and Little Tujunga Quadrangles of the U.S. Geological Survey, each of which has a scale of 1:24,000 and a contour interval of 25 feet. Location in mapping was done with a Brunton Compass.

The work was undertaken in connection with prospecting for ilmenite being done by E.I.du Pont de Nemours and Company. and the writer wishes to express his deepest thanks to Dr. J.L.Gillson and to Dr. George H.Anderson for permission to publish the paper and also for their invaluable assistance and direction.

Frequent references to Miller's paper[1] on the region has been made during the course of the work. The age of the formations and the regional data are taken from his paper, among other data, and future reference to the paper will be omitted.

PHYSICAL CONDITIONS

The region ranges in elevation from a little less than 2000 feet to about 5000 feet at its highest. The topography, as is usually the case in the San Gabriel Mountains, is extremely rugged. The divides that bound Sand Canyon on the north and south average about 1000 feet above the stream at the bottom. The dominant drainage is to the west through Sand Canyon to the western end of the area, where the canyon turns north and forms a wide, alluvium filled valley.

The hills are covered with a dense vegetation consisting of small shrubs, principally live oak, greasewood, mountain olive, buckthorn, yucca, and in places a few slippery elm and manzanita.

The exposures are varying, both in quantity and quality. On steep slopes, in the harder, less weathered rocks, there is very little soil and few bushes so that the

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1 Miller, W.J. : " The Geology of the Western San Gabriel Mountains". U.C. Publ in Math and Phys. Sci. V.1, no.1.

bed rock is exposed in large areas. Where the slopes are less precipitous and the vegetation is more profuse, the bedrock is covered with soil and the exposures are few. The sedimentary rocks in the western end of the area tend to badlands topography with resultant good exposures.

REGIONAL STRATIGRAPHY

The oldest rocks in the region are the Pre-Cambrian gneisses of sedimentary origin. These occupy the southern portion of the area and extend for some distance farther south. Intruding the gneiss is a differentiated body of anorthosite that has compositions varying from true anorthosite to diorite, to magnetite-ilmenite bearing ore bodies. These are also placed in the Pre-Cambrian period.

The oldest sedimentary rocks are those of the Mint Canyon formation of Miocene age. These are light-colored coarse, arkosic sandstones and conglomerates with a few interbedded lavas, all of sub-aerial origin. The youngest beds, except for Recent Alluvium, are a deposit of old Alluvium, Pleistocene in age, that are coarse, poorly sorted conglomerates, poorly cemented, and generally red in color.

PETROGRAPHY

The gneiss exposed in the region is, in composition, not very different from some of the igneous rocks exposed nearby. One of the prominent types is an augen gneiss that is represented by specimen S.C.#4. The banding is more apparent in the body of rock than in the hand specimen. The specimen is dark-colored, generally fine-grained except for porphyrablasts of orthoclase ranging up to one inch in length. Its composition is roughly feldspar,35%; amphibole,40%; biotite,4%; quartz,20%; and pyrite,1%. The biotite is associated with the amphibole in fine grained aggregates. The quartz, also fine-grained is scattered through the rock. The pyrite occurs as small euhedral crystals. Most of the other gneids has a similar composition and texture except for the phenocrysts or porphyro blasts.

One bed of impure talc was found in the body to support the theory of sedimentary origin for these rocks.

The igneous body has contributed to the gneissic rocks as is shown by specimen S.C. #9. This is a dark, fine-grained, crudely gneissic rock with crystals of apatite and magnetite-ilmenite up to 1/8 inch in diameter. Under the microscope, it is seen to have a composition of : andesine,30%; actinolite,43%; chlorite,5%; apatite,13%; magnetite-ilmenite,7%; hematite,2%. The feldspars are generally crushed to a fine matrix, through which is scattered the actinolite and its alteration, chlorite, in streaks. The hematite is found in cracks that penetrate the section. The magnetite-ilmenite is associated with the actinolite and apatite.

In a few places a gneiss is exposed that is made up mainly of plagioclase with a small percentage, usually less than 20%, of actinolite or chlorite in foliations through the rock. These laminae weather more easily than the feldspar and so appear as rough grooves across the face of the rock.

The igneous rocks in the area are of the dioritic phase of the anorthosite. The variation in composition and grain size is remarkable. The proportions of plagioclase to actinolite ranges from near a true anorthosite to an ore that is mostly actinolite and magnetite-ilmenite with very little plagioclase. There is no sharp demarcation between these rock types. Specimen S.C.#7 is a type that shows coarse grained aggregations of feldspar and amphibole. The feldspars may reach as much as ½ inch in size and have the characteristic , almost lavender color of the typical anorthosite of the region. The amphibole seems to be made up of many fine grains grouped together. Microscopic examination shows a composition of plagioclase andesine, 60%; actinolite, 25%; magnetite-ilmenite, 15%; apatite, 1%; sphene, 3%; biotite, 1%. The feldspar grains show a mortar structure, while the actinolite is arranged in bladed crystals around a center of fine grained aggregate of actinolite, feldspar and magnetite-ilmenite. These are, in turn, surrounded by reaction rims of some finegrained, undetermined light-colored mineral. The plagioclase is remarkable because it is untwinned through out the section. The texture of the actinolite would indicate that it had been formed from the reaction of hornblende and feldspar.

There is also a coarse grained phase that is more intimately mixed and occasionally contains almost enough magnetite-ilmenite to rank as an ore. Still another phase is similar in composition and without the segregation but is fine grained.

Fairly definite magnetite-ilmenite-rich bodies are scattered through out the igneous rocks. They are of irregular shape with apparently no great depth, although there is a tendency for some of them to assume an elongate shape like a dike. The majority of these are fine grained and show little feldspar. One specimen (S.C.# 10) is a heavy, dark, fine grained rock that appears in the hand specimen to be composed of amphibole and magnetite, with some of the magnetite altered to hematite. Under the microscope, the composition is magnetite,50%; actinolite,30%; tremolite,10%; apatite,10%; with a trace of feldspar and a little hematite. The grains are anhedral with the magnetite-ilmenite as the last to crystallize and therefore filling the interstices of the rock. A little magnetite-ilmenite is also found in the cleavage cracks of the actinolite and as fine dust through some of the actinolite. Another type of ore is shown by S.C.#11. It is a dark-colored, coarse, uneven grained rock with large crystals of feldspar and apatite and finer amphibole and magnetite-ilmenite. The thin-section shows it to have a composition of plagioclase (andesine),40%; actinolite,5%; chlorite,30%; magnetite-ilmenite,10%; apatite,10%;, boitite 0.5%; cacite,2%; kaolin, and sericite, 2.5%. The grains are fractured with actinolite and chlorite in the cracks and cleavages of the feldspar. The calcite is secondary in cracks and on the feldspar. The magnetite appears as a late crystallizing constituent. Other bodies are fine or coarse grained; in some of them, the feldspar amounts to as much as 50% of the total and is medium or coarse grained.

These ore bodies are usually more resistant to erosion than the diorite and so have good outcrops. They also show a strong red color, due to the abundant iron, that makes them easy to see in the field.

Several dikes occur in the area close to the diorite-gneiss contact that appear to be lamprophyre dikes. In the places where no movement has taken place along the dike, they are dark, nearly black, with a bluish cast, very fine grained rocks. The minerals are not large enough to be recognized in the hand specimen. In specimen S.C. #5, a gneissic appearance is given by the layers of calcite and quartz between a dark micaceous or gouge-like mineral that is probably chlorite. The layers also show small tight folds. In section it is seen to be a fine crushed aggregate of feldspar and quartz, with small grains of chlorite in stringers across the section. Some corroded euhedral crystals of magnetite are present. Calcite is present in cracks and on the other minerals. Hematite as an alteration product is associated with the chlorite. The constituents of the section are: feldspar (andesine?) 25%; quartz, 20%; chlorite, 10%; magnetite, 10%; calcite, 30%; hematite, 4%; biotite, 1%:

Another phase of a similar dike is shown by S.C. #6. The hand specimen shows calcite in large grains and in seams in a dark blue-green mafic mineral. The section gives the following composition: calcite,50%; andesine,35%; chlorite,5%; apatite,1%; sphene (leucoxene),3%; kaolin,4%; hematite,1%. The feldspar is crushed in places and shows bent twinning striae in other places. Alarge amount of kaolin gives a dirty appearance to the whole section. The calcite is secondary as large grains and in cracks. The sphene is nearly all altered to leucoxene.

At stations 11 and 13, bodies of a fine grained diorite are seen. They have the appearance of dikes being 20 to 50 feet in width and several hundred feet long. Their composition is roughly 60% feldspar, 20% hornblende and 20% actinolite with a few grains of apatite. The possibility of a dike origin for these rocks is eliminated by a band of the dioritic country rock about three feet thick that cuts across the one at station 13.

Locally the Mint Canyon formation is made up of coarse, well sorted arkosic sandstone, the particles ranging from silt to 1/8 inch in size with a few pebbles less than ½ inch in size scattered through some of the beds; conglomerates with a size range up to 10 inches, the boulders well rounded, of dioritic or granitic composition and a few small fragments of andesite; and a few small lenses of mud stone. The cementation is variable through out the formation, some of the cleaner sandstones are fairly well cemented, with silica or ~~calcite~~ caliche, while the white sands with much

[illegible]

kaolin are hardly cemented at all. The soft beds form a badlands topography that gives good exposures.

The old Quaternary alluvium is composed of coarse, poorly sorted conglomerate, with many scour channels evident. The constituents are similar to the crystalline rocks in the mountains immediatley to the east, that is, diorite,gneiss, anorthosite, and ore. The particles range in size from silt to 1 foot in diameter with the largest percentage in the range from silt to ¼ inch in diameter. In general the beds are consolidated but only loosely cemented. A few beds are fairly hard due to iron oxide cement. The constituents are rather fresh, the large boulders show only rounded corners while the smaller particles are rounded.

GEOLOGIC STRUCTURE

The striking structural feature of the region is the large amount of minor faulting that has taken place. Every outcrop on the crystalline rocks, especially the gneiss, shows one or more small faults with a displacement of from only a fraction of an inch to some where in the tens of feet. These are high angle faults, mainly reverse, with a general trend of northeast-southwest. In the small area where some of the faults were mapped in detail, the general movement is indicated as having the northeast side move up and to the southwest. The largest fault in the detailed area is apparently the only one that disrupts the igneous-gneiss contact to a noticeable extent and does so only because of the flat nature of the contact.

A large fault has been drawn in the bottom of Sand Canyon. In this canyon just beyond the eastern end of the area, a large fault can be traced for some distance and it apparently extends westward down the canyon. The rock types across the canyon do not match, although the variance in the diorite could account for the difference, but the diorite inclusion at station 11 can be traced to the bottom of the canyon on the south side quite clearly, and is not seen on the north side although the canyon is less than 100 feet wide at this point.

Folding in the gneiss cannot be traced successfully due to the minor faults that break it into so many small separate bodies. There is no close folding as the general strike is northeast-southwest and the dips are mainly southerly. Along the part of the contact that runs through Wahoo canyon, the attitude of the foliation near the contact is nearly vertical with some apparent over-turning. There is a possibility that the contact in this region is a fault contact. In the eastern and central portions of the area, the contact is fairly flat as it swings up in the canyons and down on the ridges. A small roof pendant is found in the diorite on the ridge northeast of the main body of gneiss. In these regions the contact is seen to be definitely an intrusive contact. At station 5, a good section across the contact is made by the road cut. As the contact is approached from the diorite, a gneissoid character is seen to appear in the igneous rock and increases until definitely metamorphic rocks are seen. There is no sharp line of demarcation between the two rock types. This holds true also along the contact to the west. Specimens #7, #8, #9 were taken across what was thought to be the contact. Examination under the microscope shows them to be approximately of the same composition and the gneissic appearance increases from #7 to #9 and beyond. The dryness of the intruding magma is attested by the total lack of contact metamorphic phenomena in the gneiss.

The diorite is a border phase of the anorthosite. To the north of the area under discussion, the diorite can be traced directly into the anorthosite with a gradual change from one to the other. No attempt was made to differentiate the various facies of the diorite other than to map some of the more prominent ore bodies, as any attempt to do so would greatly increase the time necessary to cover the area. The ore bodies are seen to be magmatic segregations of the anorthosite. They are roughly ellipsoidal in form, sometimes irregular, and sometimes assuming a dike-like form. There is not a sharp contact bewteen the ore and the diorite; the zone of contact is measured sometimes in tens of feet. The textures and minerals are those of igneous rocks and especially the diorite in which the bodies are found. Invasion of the country rock by the ore has taken place only on a very small scale. In a few places the gneiss is stained brown or red by iron, but little magnetite-ilmenite can be found in it. Also pointing to a segregational origin of the ore is the lack of metasomatic replacement and metamorphism. In size the ore bodies range from those of about two feet in width to those that may be 400 feet wide and as much as 1000 feet long. The smaller ones are seen to outcrop on both sides of ridges with country rock below them so that it is probable that even the larger ones have definite lower limits that are not deeply buried. The bodies themselves have a general east-west trend and the zone in which they occur has a definite trend of a little north of west and south of east.

The lamprophyre dikes that outcrop on the south side of Sand Canyon dip in a southerly direction from 30 to 50 degrees and strike from nearly north at the eastern end to about North 60 West towards the western end. As these follow the foliation of the gneiss where they intrude it, it might be ventured that the change in dip and strike indicates a broad synclinical fold with a north west-south east axis. This would necessitate the assumption that the dike was fairly straight when intruded and that the gneiss was folded only after the placing of the dike. These dikes have a thickness that varies from about two feet to twenty-five.

The Mint Canyon formation that lies in the western end of the area has a general dip to the northwest of 30 to 70 degrees. Although the contact with the igneous rocks to the east is every where covered by Quaternary alluvium, it is fairly definite that the Mint Canyon and the diorite stand together in a fault contact. The Mint Canyon formation strikes sharply toward the contact which runs in a fairly straight line and occupies a topographic low between the igneous rocks and the sediments.

A number of small landslides are found in the soft incompetent sandstones of the formation.

Assuming an average dip of 45 degrees and a total breadth of out crop of 3000 feet at right angles to an average strike of the beds, a thickness of a little more than 2000 feet was calculated for the formation. In view of the extensive area covered by the formation immediately to the west, this estimate is probably less than the actual thickness of the formation.

The old Quaternary alluvium lies on the Mint Canyon formation with a strong angular unconformity between them. The alluvium has not been greatly folded as it has generally gentle easterly dips. The steep westerly dip in the western part of the exposure is probably due to a small fault whose exact position could not be found. A thickness of about 3000 feet is found here.

GEOLOGIC HISTORY

The history of the region opens in the Pre-Cambrian with the deposition of a thick series of sediments, mainly sandstones and other clastics with a few limestone beds.

Some time later, still in the same period, a body of anorthosite was intruded into this series of sediments, with probable regional metamorphism of the sediments. In the intrusion of the igneous material, magnetite-ilmenite and the actinolite rich bodies were segregated from the rest of the magma to form the diorite and ore facies of the batholith. A late action of the magma was the intrusion of lamprophyre dikes into the gneiss and the already solidified portions of the magma. A long period without further deposition or intrusion followed during which time erosion and gentle folding took place. In Miocene time, the Mint Canyon formation was deposited over a wide flood plain by a stream of considerable length and transporting power as is shown by the sorting, rounding, and size of the particles deposited.

After another shorter interval of folding and erosion, and after the San Gabriels had achieved approximately their present condition, coarse gravels were deposited on their flanks made up of detrital material from the mountains. A period of faulting elevated the new sediments to the point where deposition was replaced by erosion and the beds were folded gently. The faulting in the crystalline rocks to the east was probably contemporaneous with this as a part of the rejuvenation of the San Gabriels. Steep canyon walls in the mountains indicate a late uplift that increased the gradient of the streams.

PLATE I

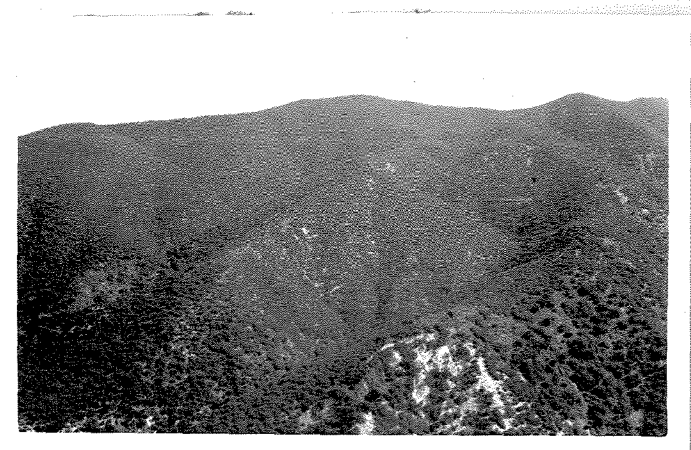

Fig.1. View looking north near head of Sand Canyon

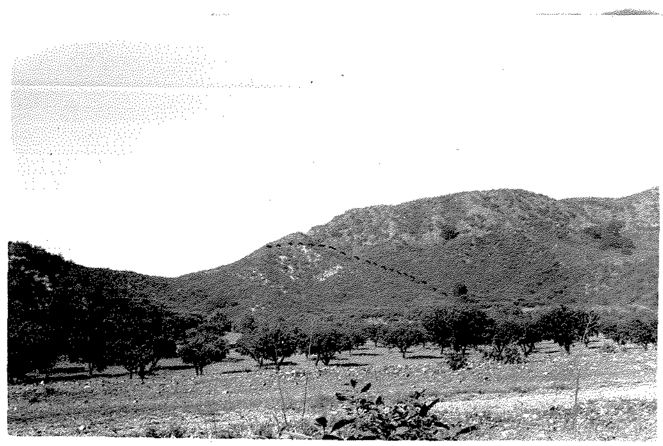

Fig.2 View of Mint Canyon and old Alluvium. Looking east inlower Sand Canyon.

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