A Scientific Search for a New Goldfield

By a Study of Ore Occurrence at Goldfield and of the Fault Systems of Nevada a New Alunite and Gold District Was Discovered

BY ROBERT T. HILL*

The discovery of the close association of alunite with the gold ores at Goldfield, which had not been recognized in Nevada prior to Ransome's investigation, throws great light upon the origin and nature of the ores, and in seeking other gold localities in that State the occurrence of alunite in association with gold would be a prime desideratum. This belief that we might find another alunite gold locality was inspired by the following extract from Ransome:†

"It is not believed that the Goldfield district is unique in the possession of this alunite type. Other examples are likely to be found among the great number of ore deposits associated with Tertiary volcanism, particularly when more investigators of mining districts realize the importance of close studies of rock alteration, such as have been so admirably carried out in this country by Mr. Lindgren and in Europe by the later Professor Stelzner, and when they accept neither kaolinite nor sericite on faith and external appearance."

Having endeavored to assimilate the type of ore occurrence and outcrops at Goldfield and to familiarize myself with the aspects, I resolved to take to the prospecting field and endeavor to find another locality in Nevada similar in its general features to Goldfield.

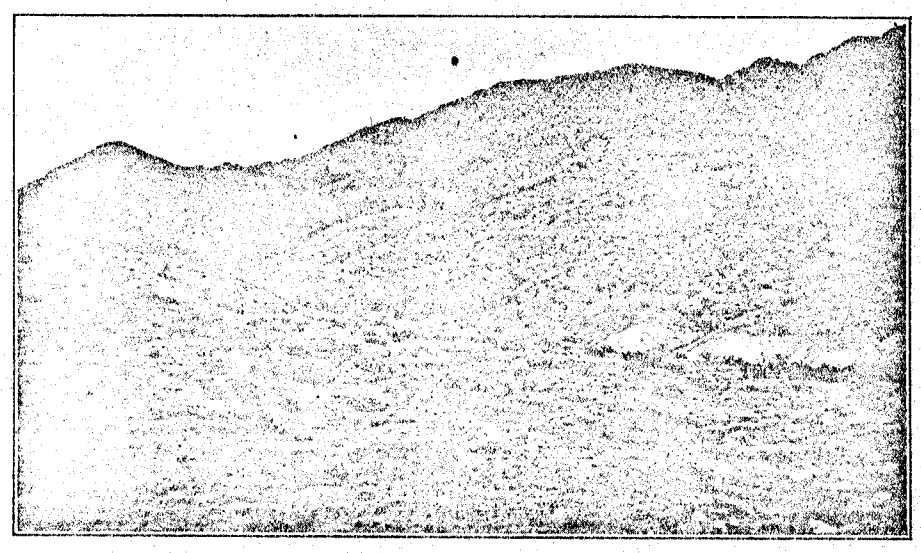
Difficulty of Distinguishing Alunite

Clearly the task before us was to find another area of igneous rocks approximating those of Goldfield, which had been similarly alunitized by fumarolic action and which carried at the surface prospect similar gold and associated minerals. Now alunite is a rare and not easily distinguishable mineral, and I am frank to say that, after a summer's research for it and the successful finding of it, I would pronounce no rock alunite, except by aid of both careful microscopic examination and chemical analysis.

In fact an eminent authority upon petrography, who has aided us in our researches, has stated that alunite is such a new thing in rock analysis that it emphasizes the necessity of confirming the results of microscopic determination by chemical tests, particularly where the quartz or alunite occurs in crypto-crystalline condition.

In the face of such conditions the finding of alunite would appear apparently a hopeless task; but such is not the case, for the broader principles of geology came to our assistance, and by their aid we were enabled by successive steps from condition to condition to find another locality of the alunite type.

The processes of reasoning which were pursued were as follows: Inasmuch as alunite is an alteration product of the feldspar of certain volcanic rocks, which had been penetrated by fumarolic vapors arising along fractures, and inasmuch as such occurrences of volcanic rocks and fractures usually occur at areas of fault intersections, the problem before us was first to find an area exhibiting the general controling conditions, i.e., altered igneous rocks, evidence of fumarolic action, and good faulting, and then, by the aid of the microscope, chemical analysis and the assay, to determine whether they were alunitized and mineralized.



BLACK ANDESITE PORPHYRY ALTERED ALONG A FAULT LINE

Prospecting Outfit

My principal equipment consisted of an observing eye, a belief that in nature there is a law for all things, a knowledge of what others had found out about these laws and country before me; and whatever kind of transportation the people of the country used. A gold pan, United States Geological Survey topographic maps, for such areas as are covered by them, and a traverse plane table were also carried.

Of course, one could have added all kinds of things to these essentials sufficient for a completely equipped caravan; Blowpipe outfit, petrographic microscope, everything one could think he might need. It has been my experience, however, that the best way to outfit is to assemble carefully everything one thinks he could need and then to hold an inquest over the pile and throw away everything one can possibly do without. As a result, a good prospecting outfit will reduce itself (aside from transportation) to a cow-boy blanket roll, a coffee pot, a frying pan, a bread pan, a stew pan, one extra canvas for rain or shade, a saddle, something to eat, and a compass.

The Rocks of Nevada

Another important point in the geology of Goldfield not touched upon in the foregoing descriptions, is that the Goldfield volcanic area is situated in a greatly faulted area and probably at a point along that fault where there have been great intersections. This fact of broad geology brings the prospector to face some general conditions which must be touched upon.

The broader physiography and geology of Nevada is the simplest thing in nature and the most poorly represented on maps of any part of our country. In general it consists of elongated mountain ranges and stretches of desert. The topography can all be classified into destructional mountain forms and débris-filled valleys. Very rarely there is an originally piled-up mountain in the form of an isolated basal-

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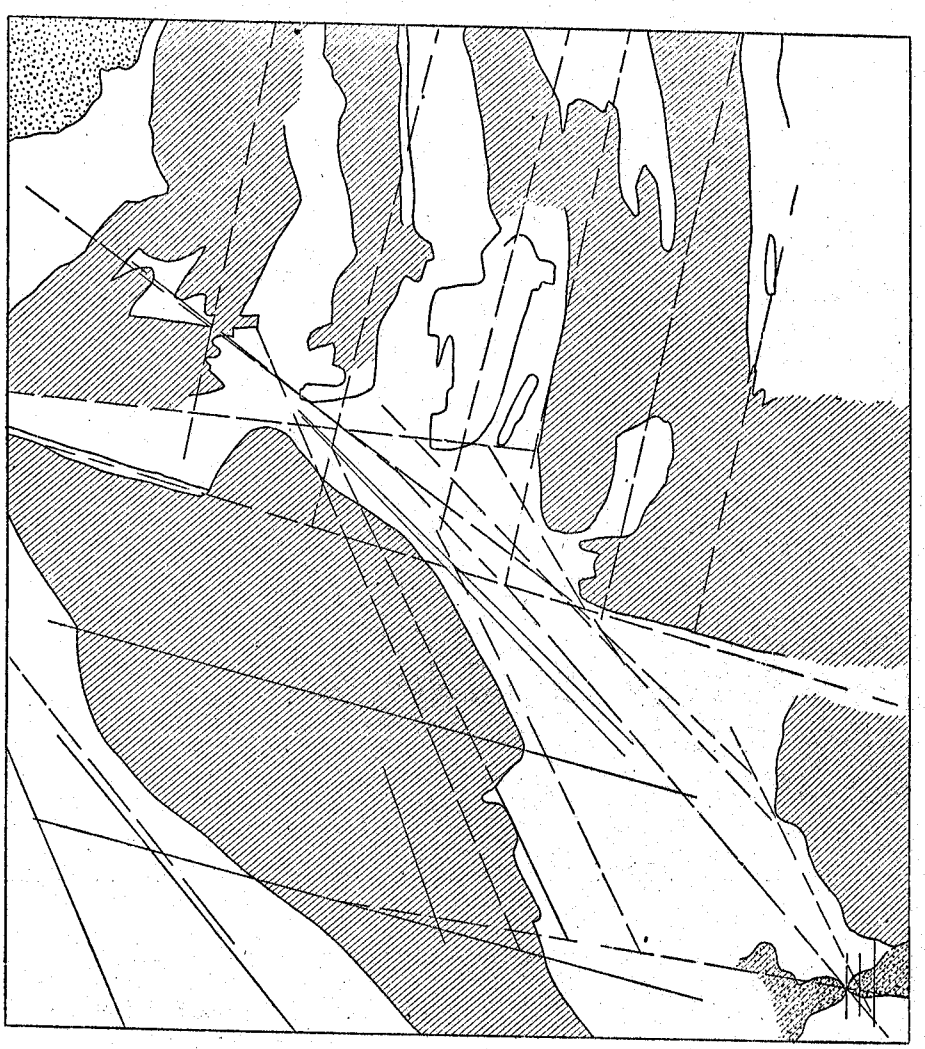
†"The Association of Alunite with Gold in the Goldfield District, Nevada." By F. L. Ransome. Economic Geology, Vol. II, No. 7, pp. 667-692; Oct.-Nov., 1907.

‡Excellent description of the rich and general geology of southwestern Nevada will be found in Bulletin 308 of the U. S. Geological Survey, entitled "A Geological Reconnoissance in Southwestern Nevada and Eastern

tic cone. The formations and material can all be grouped into these three simple categories: The bed-rock complex, later igneous rocks and desert material. The mountains are composed of bed-rock complex and Tertiary eruptives; the desert formations are made of their débris.

The bed-rock complex is composed of three distinct unit groups of rocks: (1) Pre-Cambrian metamorphics and granites; (2) ancient marine sedimentary rocks of Paleozoic age, quartzites, limestones, shales, etc.; and (3) with some few patches of Mesozoic.

This group constitutes most of the mountain masses and, as a whole, it is



THIRTY-SIX HUNDRED SQUARE MILES OF NEVADA SHOWING REGIONAL FAULTING

wrinkled or folded in open anticlines and synclines, and most of these wrinkles were made before the modern eruptives and faulting appeared. As a whole, so far as gold occurrence is concerned, this group may be considered as a unit.

The Tertiary igneous rocks include granite (monzonites) "porphyries" (andesites) rhyolite, latite, "malpais" (basaltic lavas), and many other species of intrusives and effusives (igneous rock) of later geologic time, protruding into and through the basement complex.

It is a hopeless task for the prospector ever to learn to distinguish the various species of igneous rock; "granite," "porphyry" and "malpais" as used by him are pretty good field classifications, and about as far as he can go without plunging into error. The best way for him is to learn to tell them as a class and to cut out the other mountain rocks, belonging to the complex basement, from his field of research.

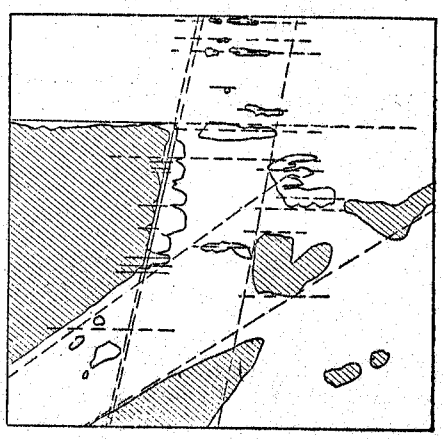
Fault Systems

Of all natural aspects, faults and fault systems are the most important and essential guides and features in mining and prospecting provided mineralization has been determined. Faults are the great channels through which the volcanic magmas and their mineralizing vapors reach the outer crust, and are the accompaniments of the same earth movements which produce folded mountain systems. There are fault systems as well as mountain systems. Sometimes even these fault systems antedate the folding.

The effects of faulting persist in nature longer than the effects of folding, and these effects dominate the topography and geography of the country more permanently, although in a less readily discernible manner than any other structural feature. The mountains will wear away, but the fault fractures preserved in the eroding by the cliff line or adopted by the water courses will persistently impart their presence on all future geography, as the directions of the courses of great rivers or even the desert valleys.

Desert weathering and degradation of the type which I recently described in another article, has dulled the regularity of the fault scarps in some instances, but to one versed in physiography many examples are preserved in southern Nevada where they are astonishingly and overwhelmingly apparent. However faults may be found in social affairs, it is difficult for men to find them in nature. In fact, the talent of geological faultfinding or seeing is often lacking even in professional geologists; and their appreciation comes from long topographic and geologic experience. A knowledge of fault finding is one of the most important equipments to the prospector, for all great ore deposits not only occur in or adjacent to great fault systems, but frequently and usually at their intersection.

Now to the miner it is more important



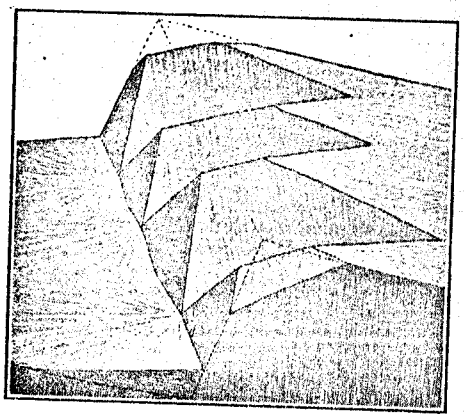
ONE SQUARE MILE OF THE REGION SHOWN IN THE LARGER MAP

that the fault systems should be unraveled than the folding, for sometimes, as in Nevada, especially at Goldfield, the mines are found in eroded valleys where the faults persist and the mountains do not; and again much of the mountain folding is more ancient than important fault systems.

Three great tectonic movements, each accompanied by intense faulting in a characteristic axial direction have left their impression on the topography of Nevada, and have made the channels for the ascending vapors of mineralization. Two of these types, the northwest-southeast and the north-south, are now well known to dominate the American Cordilleran continent. The third, the east-west, which has not as yet been interpreted or described, is also most important and its full significance will become clearer as research progresses. The three major fault systems mentioned are: (1) the Rocky mountain north-south system, (2) the Mexican or northwest system, and (3) the little understood east-west system.

The Mexican, or northwest system, cuts obliquely across the north-south and east-west systems, producing along the western border of Nevada nearly parallel to the California-Nevada State line, a series of northwest-southeast ranges and valley deserts of the Death Valley type.

The greater mineral occurrences of southwestern Nevada, as well as of Arizona and the Mexican plateau, practically occur at intersections along this northwest-southeast fracture system. In fact, if one will place a straight edge upon a proper map of North America and draw a line from Comstock, Nev., to Pachuca, Mexico, a distance of 2500 miles, he will find that many of the great modern mining camps



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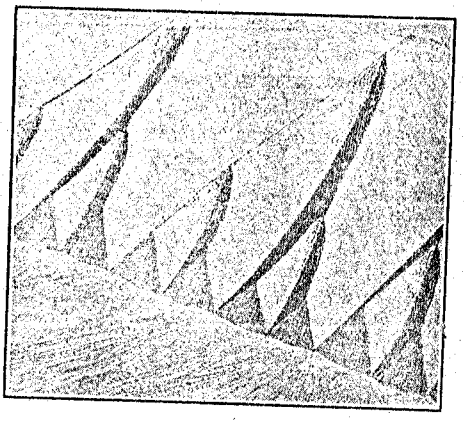

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of the Cordilleran region lie adjacent to this line, including Comstock, Tonopah, Goldfield, Searchlight, Globe, Clifton, Bisbee, Cananea, Ocampo, Guanajuato, El Oro and Pachuca.

Relation of Faults to Ore Deposits

The occurrence of the great mineral localities discovered along this zone is a broad generalization which needs refinement, for it is not alleged that the zone is continuously mineralized. It is known that the ore occurs only widely in spots along this zone in southwestern Nevada and elsewhere.

It is this crossing of the north-south Rocky mountain fault trend by the northwest Mexican fault trend that causes some of the greatest and least explained topographic phenomena of the Mexican region, like the sudden transitions in Arizona and New Mexico from the Colorado plateau and Rocky mountain region to the physical characters of the Mexican plateau; in the great bends of the Colorado, the southern scarp line of the Colorado plateau and the remarkable geological crux at El Paso, Texas, and other points which I have lately described.[2]

The effect of these three great interesting fault systems upon the hard consolidated strata of the folded basement complex in Nevada is a series of elongated mountain blocks (ranges) separated by intervening valleys and deserts, which were developed originally by drainage along fault lines. In a general way the great fault lines are indicated in the topography on good maps, like the Amargosa and Las Vegas quadrangles of the United States Geological Survey, but are utterly lost on bad maps, like the average commercial map of Nevada. There is no good map of the State. Concerning the "Geological Reconnaissance Map of Nevada, South of the 10th Parallel," by J. H. Spurr, the author, in accordance with a good principle that a bad map is better than no map, frankly confesses that: "Anyone examining it closely will find it nearly all inaccurate."

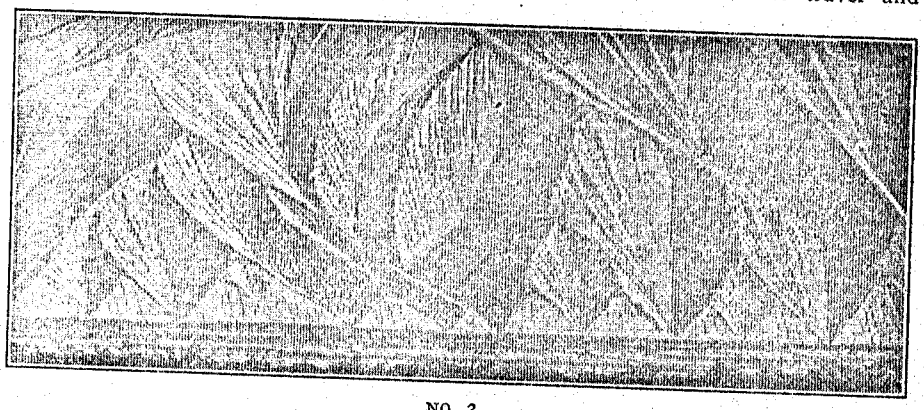
Unfortunately for the miner, as well as for knowledge in general, the occurrence, sequence and relations of the great fault systems of Nevada have not been clearly mapped and defined. Most of the geologic literature of Nevada, with one or two notable exceptions, seems to be controversal in regard to the fault systems, and the controversy seems to have ended without conclusions. G. K. Gilbert, the dean and master of American physiography, 30 years ago announced his theory that the desert ranges of Nevada were chiefly faulted blocks. Spurr, the young and intrepid, later controverted this theory and concluded that the mountains were mostly residual erosion forms. I am not the umpire in this controversy; but my opinion, based upon my own observations, is that Gilbert's position is in general more nearly correct, and that Nevada is check-boarded with great faults which, when understood, will be found to be the chief key to most of its geographic, geologic and mineralogic features.

Spurr has said that: "The chief faults belong to a north and south and an east and west system."[3] I believe that if he would continue his work farther that he would now say that: "The chief faults of all the faults run in a west of north to south of east direction, and that the north and south and east and west systems are subordinate to them."

Tonopah, Goldfield and Rhyolite are all along a great northwest-southeast fault. At Rhyolite this intersects with a still more northwesterly fault extending toward Searchlight and bleaching out the west side of Spring mountain range, and these faults cut through Railroad pass. Where the east-west faults and north-south faults intersect with the northwest faults, hot springs still frequently exist, and ancient alunitizing fumarolic localities should be looked for. The east side of Spring mountain range and the west side of El Dorado ranges are also bounded by faults parallel to the Rhyolite-Searchlight fault.

Applying the Principles Discovered

It is not necessary to weary the reader with the details of how we proceeded to apply these principles in prospecting trips in Nevada. It is sufficient to say that after many miles of desert travel and pleasant camp experiences, we canceled out as impractical large areas and explored others which seemed probable. The result of our investigations, however, was finally successful, and an area was found combining all the essentials, features of rock material, faulting, rock alteration, alunitization, surface mineralization and other peculiarities of Goldfield.



NO. 3

THREE MODELS BY PROF. W. M. DAVIS, OF HARVARD, SHOWING PROGRESSIVE FAULTING AND EROSION, THE LAST DRAWN FROM SPANISH WAHSATCH RANGE

The finding of our locality, however, was a simple task in comparison with the continuation of our prospecting the claims to be staked, the monuments to be recorded and the location work to be done. A good topographic map also had to be made. Fault lines and their intersections had to be unraveled and careful microscopic and chemical studies made of the

[2]Science, May 3, 1907, pp. 710-712.

[3]"Origin and Structure of the Basin Ranges," p. 241.

rock material. Finally, sites had to be selected for prospect shafts. Today workmen are steadily sinking toward the expected ores of the unweathered zone. The details of this locality which may be called a scientific prospect will be described in a later article.

Gold Dredging in California

SPECIAL CORRESPONDENCE

The dredging industry of California is fast increasing in importance and in output. The new machines recently built are far more powerful and of greater capacity than those first in use, and what is of still greater importance are more cheaply operated and better gold savers. The use of double banks of gold-saving tables on the larger machines gives much more amalgamating surface that was possible by the old plan. The adoption of hydraulic nozzles throwing water under pressure on the hard ground in certain localities, breaking it down into the buckets, relieves the dredges of much work, and increases their capacity for digging in a given time. The rotary screens are also excellent, especially where the gravel is hard to wash. It was this feature which brought about the litigation recently alluded to in THE ENGINEERING AND MINING JOURNAL, and the courts have decided that the combination involving the rotary screen or grizzly as one of its elements can be used only by permission of the inventor.

Twelve new dredges have been set in operation in this State since the beginning of the year and about a dozen more are being built or are planned for. There are now 69 gold-mining dredges in operation in California. Of these 37 are in Butte county; two in Calaveras county; one each in the counties of Merced, Stanislaus, Shasta, Placer and Siskiyou; 10 in Sacramento, and 15 in Yuba county. The principal fields continue to be at Oroville, Butte county, Marysville, Yuba county and Folsom, Sacramento county, where there are large tracts of available dredging ground at points where the Feather, Yuba and American rivers cease to be torrential streams and widen out as they debouch from the mountains or foothills into the valley sections. It is at points like these, in cases where the streams flow through placer fields, that the best dredging ground is found.

At such points, though the gold is fine, it is pretty evenly distributed through the gravel and the average per cubic yard is subject to little change. At other places in the State small areas of ground available for dredging have been found in isolated spots, generally but a few hundred acres in extent. At such places one or two dredges can be profitably installed. Along the Klamath river in Trinity and Siskiyou counties several dredges are being built, but not more than one at any particular place, the area where dredging may be carried on being usually small.

The most profitable dredging appears to be carried on near to, but away from the rivers themselves and but little is being done in the river beds proper. Those set at work directly in the river beds in most of the counties of the State are liable to be enjoined unless they are "landlocked," that is, throw a rock wall around the pits where operations are carried on, so that the material disturbed in the digging may be confined and not allowed to pass into the running stream. Where this latter occurs, there is liability of damage to the lands adjacent to the streams, and litigation is apt to ensue. The dredge-men perfectly understand this feature and are usually careful to avoid any chance of harming other interests and involving themselves in lawsuits. Moreover, when dredges are operated in the main rivers there is liability of wreck and damage to the machines in case of floods. This was demonstrated at Oroville last year, for the spring floods in the Feather river destroyed several dredges altogether, and damaged several others so that costly repairs had to be made. Operations are now almost entirely confined to places at some distance from the river bed, though some machines are running close to the banks so as to mine certain tracts of land there. Some of the large new dredges are now mining in soft ground at a cost of less than 2c. per cubic yard for operating expenses.

This month the dredge which has been building at Hamburg Bar, on the Klamath river, Siskiyou county, has been launched. The machinery was built by the Byron Jackson Iron Works in San Francisco, and is of the suction type. The principal owners in the company are J. A. Brent and Thomas Bair, of Arcata, Humboldt county.

At Marigold, in Yuba county, a pit is being dug for launching the hull and installing the machinery of the largest dredge in the Marysville field. The big Scott river dredge in Siskiyou county has been started up. The building of this dredge was a difficult undertaking as the heavy machinery had to be hauled over mountain roads a long distance from the railroad station, and even the heavy timbers had also to be transported by team. The Gold Bar Dredging Company, of Chico, Butte county, is building a "dry land" dredge to be used in that county.

The Mokelumne Dredging Company, in Calaveras county, has reconstructed its dredge this year and installed electric machinery. This is a Philadelphia company. The shortness of water this fall has affected the dredging industry in California to some extent, mainly in the way of reduced power available. The search for available dredging ground is still continued, and much prospecting and drilling is going on in different portions of the State.

Gold Production in Australasia

During the third quarter of the present year gold production in Australia and New Zealand has improved. The returns for the first half of the year showed a decrease of 2.6 per cent. in the total output, as compared with 1907; but for nine months, now covered by official returns, the loss is only 1.9 per cent. The table herewith sums up the official returns for the nine months ended Sept. 30, in nearly complete form. It has been necessary only to estimate the comparatively small production of South Australia and Tasmania. The South Australian figures include the Northern Territory:

GOLD PRODUCTION OF AUSTRALASIA, NINE MONTHS.

	1907.	1908.
Western Australia	1,247,153	1,235,967
Victoria	502,084	483,426
Queensland	341,873	338,053
New South Wales	182,473	170,296
South Australia	11,250	10,025
Tasmania	48,100	39,900
Total Commonwealth	2,332,933	2,277,067
New Zealand	359,600	363,533
Total, oz.	2,692,533	2,640,600
Total value	$55,675,327	$54,581,202

The total decrease shown this year was 51,933 oz., or 1.9 per cent. Only New Zealand shows a gain.

Western Australia showed an increase of 9450 oz. during the third quarter; this, however, was not enough to offset the loss during the first half of the year. The decrease would have been less, but for a stoppage in the Kalgoorlie mines in July, resulting from short supply of fuel, owing to a strike. The main cause of lower production, however, is the lower grade of ore in some of the chief mines. This State supplied this year 46.8 per cent. of the total Australasian production.

In Victoria, the second State in production, the decrease was due chiefly to the closing down of several of the deep lead mines, and to a reduction in the output of the Ballarat district. The old district of Bendigo maintains its position as a large producer. In Queensland the decline was almost entirely in the gold obtained from the copper smelters. Mount Morgan kept up its record, but several other districts decreased.

New South Wales had the largest proportional decrease, resulting from the temporary closing down of several large mines. Like Western Australia, however, this State increased its production in the third quarter. Tasmania and South Australia are comparatively small producers; the latter is quite likely to show an increase in the fourth quarter from the inclusion of belated returns from the Northern Territory.

In New Zealand the increased production was from the Waihi and the lesser