NOTES ON TELLURIUM-BEARING GOLD ORES.

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GENERAL.

These notes, commenced in 1909, were at first intended as a discussion of the paper of Lenher¹ in which was summarized much of the valuable work published by himself and assistants during the past twelve years. As unavoidable delay occurred in the preparation, and as they have grown beyond the original subject matter, it seems best to publish them as a distinct paper. A serious handicap in writing has been the inaccessibility of much of the important literature on the subject, but such references as are given have been verified.

One of the points emphasized by Lenher is the frequency of the association of gold and tellurium, but he says further: "It is not at all necessary that gold deposits should contain tellurium; in fact this association may be considered exceptional." On the other hand, my own experience in the examination of a considerable number of gold ores has confirmed the opinion, which has been expressed by Kemp in the résumé concluding his excellent bibliography and list of localities of telluride gold ores,² that "tellurium is a more widely distributed and more common associate of gold than has been generally appreciated." By grinding successive faces on a specimen of ore, examining them with a lens, and picking out minute particles of individual minerals for direct qualitative tests, or by selecting single grains from concentrated material, I have detected tellurium in a majority of such ores examined as have contained visible free gold.³

¹ "Some Observations on the Tellurides," *ECONOMIC GEOLOGY*, IV., 544.

² *Mineral Industry*, VI., 295-320, 1897.

³ Some of these occurrences have been briefly described and illustrated in *Mining and Scientific Press*, January 26 and June 8, 1907, CXIV., 117 and 731. It is perhaps only fair to add that most of the ore samples thus examined were from various points in the western United States. Out of eight samples

This system of testing segregated granules is generally preferable to that of dissolving and attempting to precipitate quantities of tellurium expressible in thousandths of a per cent., as it is possible in this way to detect it by the sulphuric acid test in particles of calaverite or tetradyomite weighing less than 0.005 milligram; in fact the limit is practically the visibility of the particle. In many cases it has been impossible to determine the nature of the tellurium compound, but in several instances bismuth was also found. The frequency of this association has already been pointed out by Pearce and by Kemp, and it seems too general to be fortuitous. That this is the case is indicated by the following list of occurrences in which gold and tellurium have been recognized as associated with bismuth.

OCCURRENCES OF BISMUTH AND TELLURIUM WITH GOLD.¹

- Highland, Montana, in lode with dolomite, and also in placer (Kemp).
- Cable Mine, Montana (calcite, S.); near Quigley, Montana (quartz, S.).
- Clear Creek, San Juan, Ouray, and Summit Counties, Colorado (in most cases with fluorite; Pearce and Kemp).
- Yavapai County, Arizona (Kemp).
- Goldfield, Nevada (with alunite and quartz; Ransome, S.).
- California; several instances in quartz fissure veins and "pocket seams" (quartz, or quartz with calcite; in one case quartz and fluorite; S.).
- Spurs of Mother Lode system, California (calcite, S.).
- Shasta County, California (Kemp).
- One occurrence in Black Hills, S. Dakota (calcite, quartz, and fluorite, S.).
- Southern Appalachian Belt, numerous instances in Maryland, Virginia, North Carolina and Georgia (see Kemp, and Dana's "System of Mineralogy").
- Seward's Island, Hancock County, Maine (calcite and quartz, Kemp).
- Yale District, British Columbia (Kemp).
- Jalisco, Mexico (Kemp).

tested from Japan and Korea not one showed any indication of tellurium, though several bore a remarkably close resemblance to typical Californian quartzose ores.

¹Most of the references to Kemp (*loc. cit.*) indicate localities quoted by him from a paper by R. A. Pearce, *Trans. Am. Inst. M. E.*, XVIII., 447; those marked "S." are occurrences which have been personally examined by the writer.

Minas Geraes district, Brazil (Henwood).
 Clogau and St. David's gold mines, North Wales (Forbes, *Phil. Mag.* (4), XXIV., 339; Huddart, *Trans. Inst. Min. & Met.*, XIV., 204).
 Southern Norway.
 Urals, several localities.
 Siebenbüрге of Transylvania, several localities.
 New South Wales, several localities (Mingaye).
 Copper ores of Arizona, Montana, and Australia.

CLASSIFICATION OF TELLURIUM-GOLD OCCURRENCES.

The conditions under which these elements occur together admit of a division into several well-marked groups.

1. Gold tellurides proper (which may also contain silver and sometimes other elements).
- 1a. Products of partial alteration of these gold tellurides, yielding free gold on the surfaces or in cracks.

Both of these modes of occurrence are well illustrated in specimens from Kalgoorlie and Cripple Creek (see Rickard, *Trans. A. I. M. E.*, XXX., 708, and XXXIII., 567), and in some from California.

2. Tellurium minerals having free gold deposited on their surfaces, presumably precipitated by reaction with gold solutions. The surface of the original mineral may or may not show signs of oxidation.

This condition is observable in specimens of tellurides containing lead or bismuth (usually somewhat altered) from certain veins or spurs of the Mother Lode of California, and in scattered instances in Montana.

3. Free gold associated with tellurium minerals, apparently deposited either contemporaneously or alternately.

This condition has been noted in some specimens of crystallized gold intergrown with altaite from the "pocket belt" of Sonora (Tuolumne County, California), and in the coarse free gold with bismuth sulpho-telluride of the Cable Mine, Montana. To this class may also belong the deposits of Goldfield, Nevada, where free gold (some of it almost absolutely pure) is associated with a complex antimonial sulpho-salt of copper containing bismuth and tellurium, named goldfieldite by Ransome. An occurrence of wire gold at Carson Hill (Calaveras County, California), mentioned by Ransome in an earlier publication, and an instance from Western Australia (Kemp, *loc. cit.*, p. 319) afford other examples.

4. Free gold associated with tellurium minerals, generally not in contact, and bearing no evidence of either having influenced the deposition of the other.

As instances of this class may be cited several ore samples obtained from "true fissure" quartz-veins of California, ranging from Siskiyou southward to Tuolumne County; some specimens from Mother Lode mines may also be referred to it. In most cases a lens or microscope is necessary to recognize the scattered grains or scales of the tellurium minerals.

5. Ores containing small amounts (rarely exceeding two or three hundredths of a per cent.) of gold and tellurium associated with sulphides (especially of iron and copper), and which can only be recognized after concentration by analytical or metallurgical processes.

The copper ores of Australia, Arizona, and Montana represent this type, and some of the "Potsdam" ores of the Black Hills.

6. Free gold associated with tellurium oxide, tellurites or tellurates.

These may result from oxidation of tellurides in either of the other classes. The gold may be non-amalgamable and sometimes is finely divided; the surface is sometimes distinctly "rusty" or may be coated with an almost imperceptible film of foreign matter.

7. Occurrences of tellurium in detrital deposits with gold.

These are, as mentioned by Lenher, so rare as scarcely to deserve recognition in a scheme of classification; they are however not entirely unknown. One of the earliest recorded finds of tellurium in Montana is quoted by Kemp as having consisted of scales occurring in a placer. I once found a particle of a gray crystallized tellurium mineral in a small open cavity in a grain of placer gold from Butte Creek, Butte County, California, where it had been protected from wear by the gold.

Ores belonging to the third of the above classes are of particular interest and deserve investigation, as they may give a clue to the nature of the solutions whence they were derived, or to some of the conditions of precipitation of at least these particular ores. This might take place by the simultaneous precipitation or crystallization of free gold and a telluride from a single solution under some change of conditions, as by cooling, or by partial oxidation, or possibly by a complex precipitation in stages as suggested by some of Lenher's results. In the case of the Goldfield occurrences, including those of nearly pure gold with the sulpho-telluride "goldfieldite," Ransome has demon-

strated the probability of the simultaneous deposition of these two minerals being due to rising solutions of sulphides becoming oxidized when approaching the surface, as evidenced by the development of sulphates in the adjacent country rock.

In the case of the clusters of gold-altaite crystals, the two individual crystallized minerals are not only so placed as to make it certain that deposition took place either at the same time or alternately, but the crystals show in some cases well-marked parallel grouping. Both belong to the cubic system and pseudomorphism might be suggested, but they differ in habit, the altaite being mainly in symmetrically developed combinations of cube and octahedron, while the gold inclines to skeleton forms with bold octahedral outlines and unusually brilliant faces, quite unlike those shown by gold pseudomorphs. While some faces of the altaite are pitted, this does not appear to be due to its having been attacked by solutions while acting as a precipitant for the gold, as other subsidiary faces are brilliant, and some of the larger pits are distinct depressed octahedral faces.

The Tuolumne-Calaveras "pocket belt" from which these crystals were obtained, has yielded many noteworthy masses of free gold, some of great weight and others unusually well crystallized; in many instances these were associated with tellurides, but the conditions of occurrence have varied greatly. The largest masses found in places have come from the Bonanza and O'Hara mines, near the town of Sonora. It is regrettable that no adequate study has been made of these remarkable deposits, which merit investigation, and that only a few brief descriptions have been published.¹ This is due in part to the natural reluctance of owners and lessees to admit visitors at times when rich pockets are in process of extraction.

While the presence of tellurium in veins has in some districts been adduced without reason to indicate their persistence in depth, its association in others with deposits of a pocketly or irreg-

¹ California State Mining Bureau Reports, VIII., 652, X., 736, XII., 299; *Mining and Scientific Press*, June 6, 1908, XCVI., 782; U. S. G. S. Geologic Folio, XLI., 7 (Sonora Sheet).

ular character has led to the opposite view. That it is not incompatible with persistence in depth is evident from a consideration of its occurrence in the ores of the California Mother Lode, and of the great depth attained by some mines on that lode. One of the oldest and deepest mines on the American continent is the Morro Velho of Minas Geraes, Brazil, the existence of tellurium in which was mentioned by Henwood,¹ and which, though supposed to be exhausted at the beginning of the nineteenth century, has since been almost continuously worked by the St. John del Rey Co. for eighty years, yielding ore of a remarkably uniform gold content, averaging about half an ounce per ton. This shoot has been followed to a depth of over a mile, as measured on the dip. The famous Idaho-Eureka-Maryland ore-shoot of Grass Valley, California, extends over 5,000 feet in length, and contains tellurium in notable quantities.

While tellurium is present only in minute proportions in the copper ores of Montana, Arizona and Australia, it often far exceeds the gold in amount, as is evident from analysis of metallurgical products, especially of the slime or "anode mud" obtained in the electrolytic refining of the copper, from which part of the tellurium has been removed during the converting or blowing of the matte. Some of the tellurium may however have been originally combined with silver, which always occurs in these ores in much larger proportions than gold. In each of these districts bismuth also occurs in quantities comparable with those of the tellurium. This is shown in the following table:

COPPER AND GOLD ORES AND PRODUCTS CONTAINING TELLURIUM.

The following are items taken from analyses, mostly of large lots of material, and represent percentages of the constituents selected.

1. Average copper ore from Wallaroo Mine, South Australia. T. C. Cloud, *Trans. Inst. Min. & Met.*, XVI., 57.
2. Average of six "high-grade" ores containing free gold, Goldfield, Nevada. F. L. Ransome, U. S. G. S. Prof. Paper, No. 66, p. 169, analyses by Von Schulz and Low, Denver.
3. Matte from ore of Copper Queen Mine, Arizona. E. Keller, *Trans. A. I. M. E.*, 1899.

¹ *Trans. Geol. Soc. of Cornwall*, VI., 295.

4. Matte from ore of Butte, Montana. Private communication; see also Keller, *Trans. A. I. M. E.*, 1898.

5. Raw "anode mud" from electrolytic copper refinery of Great Cobar Syndicate at Lithgow, New South Wales. G. H. Blakemore, *Proc. Australasian Inst. M. E.*, 1910; abstract in *Mines and Minerals*, June, 1910, XXX., 651.

6. Raw "anode mud" from refining copper from ores of Butte, Montana. Private communication.

7. Typical "anode mud." L. Addicks, *Jour. Franklin Inst.*, 1905.

	Ag Per Cent.	Au Per Cent.	Te Per Cent.	Se Per Cent.	Bi Per Cent.
1. Ore, South Australia.....	0.0023	0.0002	0.001	—	0.0012
2. Ores with free gold, Gold- field, Nevada	0.26	1.34	2.13	?	1.12
3. Matte, Arizona	0.020	0.0035	0.0088	0.0113	0.0044
4. Matte, Montana	0.05	0.0003	$\left\{ \begin{array}{l} 0.001 \\ \text{to} \\ 0.01 \end{array} \right.$	$\left\{ \begin{array}{l} 0.001 \\ \text{to} \\ 0.01 \end{array} \right.$	$\left\{ \begin{array}{l} 0.03 \\ \text{to} \\ 0.05 \end{array} \right.$
5. Anode mud, New South Wales	15.725	1.450	0.654		0.707
6. Anode mud, Montana	25.	.05 to 1	2 to 3		2 to 3
7. Anode mud	40.	2.	5.		—

TENDENCY OF TELLURIUM TO SECONDARY CONCENTRATION WITH GOLD.

When a secondary concentration of gold is apparent, resulting in the deposition of masses or flakes of relatively coarse free gold in stringers or incrustations of either quartz, fluorite or carbonates, it is in my experience not unusual to find some tellurium mineral also present (not necessarily itself containing gold) even if tellurium is not recognizable in other parts of the deposit. Tetradyomite (or some similar bismuth mineral) and altaite have been found several times in such situations.

Thus the Cable Mine of Montana, the Jumper (which includes the Golden Rule from which some of Genth's type material was obtained) and other mines on the Mother Lode of California, and numerous small pocket mines in Tuolumne and Calaveras counties, California, contain coarse free gold in stringers of calcite or dolomite with bismuth telluride. At the Homestake Mine, South Dakota, a single occurrence has been noted of large flakes of gold with calcite and a bismuth-tellurium mineral in the lining of a vugg, while I believe tellurium has never been found in any other part of the deposit.

In a series of samples from the Cable Mine, the low-grade gold ore was found to contain pyrite and pyrrhotite without visible gold or telluride, associated with dolomite containing a little iron. Richer specimens contained coarse free gold in calcite with small grains and crystals of bismuth sulpho-telluride, some enclosed in the gold and others attached to its surface, the calcite containing very little magnesia and including some quartz. This occurrence of tellurium is not mentioned in the list of minerals from this locality in W. Emmons' report on the district,¹ but had been previously noted by Bohn,² and by Pierce.³

ASSOCIATION OF EXCEPTIONALLY PURE NATIVE GOLD WITH
TELLURIDES.

In many instances where native gold has been found of exceptional purity, it has been associated with tellurides. This is the case at Goldfield, Nev., where some of the original free gold, found in the complex mineral goldfieldite, is over 996 fine, though a larger proportion of silver is met in other parts of the deposits. Only a portion of this gold is amalgamable, a considerable part, although evidently in the metallic state, being apparently coated in such a way as to resist the action of mercury and also of cyanide solutions. No definite film of foreign material can, however, be detected with the microscope, and the surface of some of the irregular gold particles is as brilliant as that of Californian or Australian "free-milling" gold. On the other hand, some of it has a distinctly dull, sometimes brownish, surface.⁴ At Cripple Creek almost absolutely pure gold was found, and in some specimens of Colorado calaverite the silver is present only in minute proportions. At some of the West Australian mines gold of like purity occurred, bullion from the Great Boulder hav-

¹ U. S. G. S. Bulletin 315.

² *Mining Mag.* (N. Y.), 1906, XIII., 373.

³ *Proc. Colo. Sci. Soc.*, III.

⁴ Attempts to determine the nature of this coating have not met with success. After treatment of concentrated gold particles with hydrochloric acid, I have detected iron, tellurium, bismuth, antimony and sulphur in the solution, but in minute amounts which may have been obtained from particles of other minerals adhering to the gold grains.

ing been reported as 999 fine. Much of the gold from these two districts was however of a more or less spongy character, and dull or earthy in appearance. The gold of Mt. Morgan, South Australia, was about 997 fine and non-amalgamable, being also derived from the oxidation of tellurides in ore of the same character as the underlying cupriferous sulphides now being mined there. It has been suggested that the fine, non-amalgamable, gold of Mercur, Utah, associated with realgar and cinnabar, is also derived from an original telluride. At the Passagem mine (Ouro Preto), Minas Geraes, Brazil, gold is obtained 940 to 960 fine by simple concentration, or by cyaniding, from an ore containing bismuth and tellurium.¹ The purest Californian *vein* gold recorded is that of the San Giuseppe mine, near Sonora, one shipment of which to the San Francisco Mint was 998 fine, and several over 990.² I am informed that some of this bullion was decidedly brittle, and it is said to have contained bismuth and tellurium. At the Golden Gate mine, in the immediate vicinity of the San Giuseppe and probably genetically connected with it, the gold occurring in a pyritic quartz vein was almost free from silver and for the most part was non-amalgamable, while tellurium could occasionally be detected. In assaying this ore and concentrates from it I have frequently obtained gold buttons over 990 fine.³ The purest *placer* gold on record, such as that from Ekaterinenburg in the Urals, the Fine Gold hydraulic mine of Vallecito, Calaveras County, and a few other localities in California and Oregon, has not, I believe, exceeded

¹ Bensusan and Kendall, Bull. 73, Inst. Min. & Met., Oct., 1910.

² F. A. Leach, "California Mines and Minerals," p. 170.

³ In comparing reports of the fineness of gold bullion shipments it must be remembered that bars resulting from the chlorination process are practically free from silver, no matter what the proportion in the original ore. On the other hand, in bars obtained by the cyanide process there is a larger proportion of silver to gold than in the *free* gold of the ore; in bars resulting from amalgamation the proportion of silver is also higher, and that of gold lower, than in the *free* gold of the ore; both cyanide and amalgamation bars however contain less silver in proportion to the gold than an assay of the average ore would indicate—some silver being usually present in the ore in combination with sulphur, etc., and only partially extractable by these processes, while the silver alloyed in the native gold may be wholly recovered.

990 fine. That of Vallecito is certainly in part derived from tellurium-bearing lodes.

NOTES ON ANALYSES OF SOME TELLURIUM MINERALS.

The actual composition of the complex mineral goldfieldite, to which the formula $5\text{Cu}''\text{S.R}_2\text{S}_8$ was tentatively assigned by Palmer¹ is somewhat uncertain. In view of its close association

GOLDFIELDITE.

	Found Per Cent.	Atoms.	Atomic Ratio Found.		Atomic Ratios Calculated from Formulas.		
			Unmodified Analysis.	Corrected Analysis. ²	Enargite type, $3\text{Cu}_2\text{S.R}_2\text{S}_8$	Palmer's formula, $5\text{CuS.R}_2\text{S}_8$	Alternate formula, $5\text{Cu}_2\text{S.R}_2\text{S}_8$
Copper	33.49	527. 527	30	30	30	30	30
Silver	0.18	1.6					
Sulphur	21.54	671. } 804	45.7	43.5	40	48	45
Tellurium . . .	17.	133. }					
Antimony . . .	19.26	160. } 202	11.5	10	10	12	12
Arsenic	0.68	9. }					
Bismuth	6.91	33. }					
Gold (free?) . .	0.51						
Gangue	2.0						
Total	101.57						

FAMATINITE OR ENARGITE OF GOLDFIELD.

	Found Per Cent.	Atoms.	Atomic Ratio Found.	Atomic Ratio Calculated for Enargite Formula, $3\text{Cu}_2\text{S.R}_2\text{S}_8$.
Copper	48.0	754 754	30	30
Arsenic	11.0	146.5 } 248	9.9	10
Antimony	12.2	101.5 }		
Sulphur	28.8	900 900	35.8 ³	40

¹ U. S. G. S., Prof. Paper No. 66, p. 116.

² Corrected as suggested by Ransome by subtracting the constituents of Bi_2S_3 , but in this case subtracting only sufficient to bring the residual $\text{As} + \text{Sb} + \text{Bi}$ to the proportion required for the enargite formula. This leaves an *excess* of S over the requirements of the enargite formula, corresponding to nearly 2 per cent. S in the original analysis.

³ The *deficiency* in sulphur here indicated corresponds to about 3.3 per cent. in the composition of the mineral proper as tabulated, but to only 1.5 per cent. in the material analyzed, which included much gangue.

with a mineral undoubtedly belonging to the enargite-famatinite type it seems highly probable that goldfieldite itself may be a telluriferous variety or species of similar structure, since a careful examination of the published data shows that the analysis of goldfieldite agrees quite as well with the enargite type formula as does that of the Nevada famatinite analyzed by Schaller and quoted by Ransome, as is seen from the figures tabulated below. The excess or deficiency of certain constituents is not surprising in view of the small amounts of materials available for analysis and of the complications introduced by the presence of certain constituents in the determination of others. The formula sug-

AVERAGE OF SIX ANALYSES OF ORE FROM THE 220-FOOT LEVEL OF THE HAYES-MONNETTE WORKINGS, MOHAWK CLAIM OF GOLDFIELD CONSOLIDATED CO.,
BY VON SCHULZ AND LOW, DENVER.¹

	Per Cent.	Atomic Ratio.		Approximate Atomic Ratio.
Tellurium	2.13	16.7	} 184.4	19
Sulphur	5.38	167.7		
Gold (free ?)	1.34	6.8		
Arsenic	0.14	1.86	} 9.74	I
Antimony	0.30	2.5		
Bismuth	1.12	5.38		
Copper	2.38	37.4	} 39.8	4
Silver	0.26	2.4		
Iron	5.72	102.	102.	} II
Manganese	0.13	2.3	} 5.9	
Nickel-Cobalt	0.065	1.1		
Zinc	0.16	2.5		
Alumina	5.665 =	Al III.		II +
Soda	0.13 =	Na	4.2	} 9.7
Potash	0.26 =	K	5.5	

Some of the sulphur is combined with part of the alkalis and a proportional amount of the alumina, as alunite; a large part of the iron is in the form of pyrite, and much of the bismuth as bismuthinite. The other elements are probably combined as complex sulphy-salts, goldfieldite, famatinite or enargite. The copper is, however, distinctly in excess of the ratio demanded by compounds of this class. Silica and some other constituents are omitted as non-essential to the present purpose.

¹ Ransome, *loc. cit.*, p. 169.

gested by Palmer—indicating a *cupric* thio-antimonite—seems improbable, considering the number of known natural sulpho-salts, in all of which cuprous copper alone has hitherto been recognized. It is remarkable that much of the richer ore of Goldfield shows a still higher proportion of copper to antimony, etc., if the analyses quoted by Ransome are typical. Taking the mean of six analyses which agree pretty closely, it may be seen that the ratio Cu: (As + Sb + Bi) is about 4:1 instead of about 3:1 as found by analysis in the minerals and as indicated by the enargite formula. This suggests the presence of some other copper mineral, such as chalcocite or bornite. Recent reports indicate that copper minerals are more prevalent at deeper levels.

While the Nevada mineral classed as famatinite by Ransome differs materially from ordinary enargite, and contains more antimony than arsenic by *weight*, attention is called to the fact that the *atomic* percentage of arsenic is considerably greater than that of antimony (As:Sb = 1.45:1).

Selenium occurs in appreciable quantities with tellurium in the Goldfield ores, its presence being evident from the deposition of the element from sulphuric acid that has been used in parting, on the large scale, the bullion obtained from southern Nevada mines. It is also present in traces in West Australia gold ores, as well as in the copper ores previously discussed, and (also with tellurium) at the Waihi gold mine in New Zealand. It has also been found in the Republic district of Washington, where the gold is extremely finely divided and not susceptible to amalgamation or direct cyaniding.¹ Selenium also exists in considerable quantities in certain silver-gold mines of Sumatra, but I believe that tellurium has not been reported from these deposits. In all these cases it seems probable that the selenium may be associated with silver. I have also detected selenium in pyritic concentrates from the Rawhide Mine, on the California Mother Lode, together with tellurium and nickel—the concentrates carrying fully 2 per cent. of the last named metal, which suggests the presence of melonite though this could not be isolated.

¹ Chatard and Whitehead, *Trans. A. I. M. E.*, XXX., 419.

It may be recalled here that a later analysis by Hillebrand¹ of melonite, from the same deposit as Genth's type material, shows a close agreement with the formula NiTe_2 ; while Genth's original analysis indicated the composition Ni_2Te_3 . Tibbals² finds that the precipitate formed in solutions of nickel acetate is hydrated Ni_2Te_3 . The anhydrous compound formed at high temperatures is NiTe .

In examining some samples of ore from one of the mines of the Melones group, I obtained about 50 milligrams of apparently homogeneous particles of a lead-gray mineral. Analysis showed that its composition approximated closely to the improbable formula PbAgTe_4 ,³ though the amount available was of course too small for exact determination.

¹ U. S. G. S. Bull. 167, p. 61.

² "A Study in Tellurides," *Jour. Am. Ch. Soc.*, 1909, XXXI., 909.

³ A consideration of this and a number of analyses yielding tellurium in excess of the proportions demanded by what are usually considered rational formulas, seems to bear out the suggestion made by Lenher that some of the natural tellurides differ from ordinary chemical compounds, and may partake more of the nature of alloys. One argument used by him to support this view appears, however, to be fallacious. It is intimated that natural gold tellurides, in their action toward gold solutions, are "unlike true chemical compounds of gold and tellurium, since we know of no true chemical compound that can precipitate one of its constituents in such a manner as takes place between the natural tellurides and gold solutions." Admitting that these tellurides may be abnormal in some respects, and that similar cases of precipitation, which may be illustrated by the equation

are exceptional or infrequent, is there any logical reason why true chemical compounds should not react thus? Is not the condition requisite for a reaction of this type merely the existence of two compounds of one element with two radicals which can themselves combine directly to yield a stable product?—a condition which is by no means common.

The artificial tellurides, for instance Au_2Te , made by heating the two elements in suitable proportions, react with gold salts like the natural minerals mentioned by Lenher, presumably following the equation:—

Is there any essential difference between such a reaction and that between the two compounds of sulphur with oxygen and with hydrogen, which takes place on mixing the moist gases:

In testing for tellurium in minerals by the familiar sulphuric acid method there is a possible source of error, which I believe is not mentioned in the literature on the subject. Some time ago a sample presented for examination was passed on to an assistant who soon reported that it gave a strong reaction for tellurium, which seemed improbable from its general appearance. Further tests proved it to consist largely of manganese peroxide, although a fine purple color developed when it was heated with strong sulphuric acid and then allowed to stand a few minutes. The tellurium test requires that the particles be moistened with the strongest sulphuric acid and cautiously heated nearly to the point at which white fumes rise, the colored compound forming only between rather narrow limits of temperature. Several other specimens containing manganese peroxide were found to yield a similar color when similarly treated and then cooled and exposed a short time to a moist atmosphere; the color could generally be brought out by breathing on the sample while cooling. It is probably due to the formation of permanganic acid.

While this test is an excellent one for clean particles of unoxidized tellurium minerals, it often fails in the presence of large amounts of sulphides such as pyrite, and is useless in the case of oxidized compounds unless previously reduced. G. T. Holloway¹ has described a method of isolating tellurium from ores for testing purposes, by concentrating it with the gold and silver in a lead button obtained by the ordinary fire assay, it being pos-

In metallurgy we have several instances of the practically complete reduction of a metal by the mutual decomposition of two of its compounds—for instance when either of the sulphides of copper is heated with either of its oxides in suitable proportions, the metal is separated. Similarly galena, added to a fused silicate of lead or to molten litharge, reduces the metal, in the latter case quantitatively, though each of the compounds reacting is itself quite stable at the temperature of this reaction.

As a somewhat analogous instance may be mentioned the simultaneous separation of oxygen from two of its compounds, when a peroxide reacts with silver oxide, or permanganates on peroxides or other oxidizing agents, such as the tellurate mentioned by Lenher.

¹*Trans. Inst. Min. & Met.*, XVII., 175.

sible to treat as much as 50 or 60 grams of ore in this way. The lead button is then dissolved in nitric acid, diluted, and the tellurium precipitated by means of lead foil, the deposit thus obtained being then dried and tested by concentrated sulphuric acid.

SUMMARY.

The points to which special attention is called are:

1. The frequency of the occurrence of tellurium in gold ores generally.
2. The frequency of the triple association of bismuth with tellurium and gold.
3. The fact that tellurium cannot be taken generally as an indication either of irregularity or of persistence in depth of gold deposits, as it occurs both in the extremely irregular deposits found in pocket seams, and in some of the deepest and most continuous shoots which have been worked for gold.
4. The tendency of tellurium to segregation together with gold in veins where a secondary enrichment has taken place.
5. The fact that exceptionally pure native gold, in almost every recorded instance of its occurrence, has been associated with some tellurium mineral, or derived from a telluride.