and value of the ore mined. These figures, obtained from stoped areas above and below an unstoped block of ore, are averaged, and the resulting factors are applied to the unstoped block.

LUCKY TIGER MINE, SONORA, MEXICO

Mishler and Budrow [7] have described the methods of calculating ore reserves, and the following is abstracted from their paper.

The assays, figured to stoping width are plotted on longitudinal sections and plans drawn to a scale of 1 inch = 40 feet. Ore reserves are estimated as of January 1 and July 1 each year. Backs of old stopes are surveyed and plotted on the assay maps as of those dates. If the back has not been sampled, the average assays along the levels above and below are weighted inversely to their distance from the back, and the average thus obtained is taken as the assay value of the back. If all the assays surrounding a block represent stoping width, their arithmetical average is taken as the assay of the block. The tonnage is figured by multiplying the area of the block by the stoping width and dividing by a cubic-feet-per-ton factor of 11.5. When any of the assays around the block represent more than stoping width, the excess width must be considered in figuring the average assay and tonnage.

If blocks are developed on less than four sides, it is customary to figure that ore extends 30 feet from the drifts and raises, or below the lowest level.

The full assay value of each sample is employed. The modification of high assays is warranted when the estimates are based upon only a few samples, but when several thousand samples are available, abnormally high assays will be offset by abnormally low ones.

Over a period of 14 years the estimated ore reserves have averaged 34.0 ounces of silver per ton; the ore mined during the period averaged 37.1 ounces, an error of 3.1 ounces or 8.4 per cent.

JARBIDGE DISTRICT, NEVADA

According to Park,[8] raises are put up in ore, usually about 100 feet apart. The blocks between these raises are estimated from the average assay value and cubical contents. The tonnage figure for the ore is 18 cubic feet per ton in place and 23 cubic feet broken. The estimated tonnage in a block is generally within 10 per cent of the actual amount and is always low because of dilution in mining. The estimated grade runs about 17 per cent higher than the true grade, and this factor is taken into account when reports are prepared on newly blocked-out territory.

MOGOLLON DISTRICT, NEW MEXICO

According to Kidder,[9] stope maps on a scale of 1 inch equals 10 feet show the width and value of ore where each sample was cut as well as the tonnage and value of ore broken in the stope during each month. The average grade of ore is calculated from the foot-ounces of gold and foot-ounces of silver, allowing 13 cubic feet per ton of ore in place.

The sampling of the smaller blocks of ore generally checks closely with the tonnage and grade of ore produced, but the larger blocks are rarely sufficiently developed ahead of mining to permit more than rough estimates of their probable production. As stoping proceeds

[7] Mishler, R. T., and Budrow, L. R., work cited.
[8] Park, John, work cited.
[9] Kidder, S. J., work cited.

and the width and grade are more clearly established it has been found that the monthly estimates of ore broken, when finally checked against the ore drawn, agree closely as to tonnage and grade. The ore drawn, however, commonly exceeds the estimates of tonnage, while the grade of ore drawn will be correspondingly less.

CONSOLIDATED CORTEZ MINE, CORTEZ, NEV.

At Cortez, Nev., silver ore occurs principally in fissure veins and the ore bodies are irregular in dimensions and in grade. Hezzelwood [10] states that these conditions have been responsible for evolution of the following practice:

The usual methods of blocking out the ore by measuring and sampling in making estimates of ore reserves has been found unreliable at the Cortez mine. The tendency of the ore to narrow or widen and the grade to change without apparent reason makes such methods inaccurate. A ratio between the number of feet of development work and the number of tons mined has been worked out for the operations on the lower levels which were started in 1926. This ratio furnishes a basis for estimating probable ore, particularly when development work is confined to the three known zones. This method of estimating, although not accurate, is probably as safe as any method for this form of ore deposit.

COPPER MINES

HUMBOLDT MINE, MORENCI, ARIZ.

Mosier and Sherman [11] write briefly regarding estimating practice as follows:

For the estimation of ore reserves a full knowledge of the ore deposits must be obtained. Caving stopes have reasonably regular outlines, and selective mining is therefore not practicable by this method.

Some material of a grade that will not pay to reduce must be mined, and some good ore on the boundaries must be left because its inclusion would bring in too much waste. The side boundaries, which are vertical or nearly vertical, are drawn as compromise planes to inclose as much ore as possible without too much waste.

Except for preliminary estimates, the volume of material within the stope outlines constitutes the ore reserves which are bounded by (1) the undercutting level, (2) the shrinkage side outlines, and (3) the leached gossan or a stope above as the case may be. Within these boundaries the grade of ore in place is calculated by combining assays in a rational manner.

RAY MINES, RAY, ARIZ.

The following is quoted from Thomas: [12]

In churn drilling, samples were obtained by the use of a split divider. A careful record was kept of the type of material being drilled through, the color of the sludge and the character of its various mineral constituents, the weight of material cut for each 5 feet of drilling, the size of bit, and the length and size of the casing in the hole. From the weight of the sample and the size of the bit it was possible to determine whether there was caving in the hole and to thus arrive at some conclusion as to the accuracy of each 5-foot sample. The samples were assayed locally by the iodide method, and the remainder of the pulp was sent away for determination of the copper by the electrolytic method.

[10] Hezzelwood, George W., Mining Methods and Costs at the Consolidated Cortez Silver Mine, Cortez, Nev.: Inf. Circ. 6327, Bureau of Mines, 1930, p. 4.
[11] Mosier, McHenry, and Sherman, Gerald, work cited.
[12] Thomas, Robert W., work cited.

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TABLE 7.—*Summary of underground sampling practice*—Continued

District or mine and State	Character of ore	Sampling method	Indicated accuracy of sampling
GOLD AND SILVER—continued			
Mogollon district, New Mexico.	Gold and silver with sulphides in quartz and calcite gangue.	Moil samples; grab samples from muck piles, chutes and cars and at mill.	Mine car samples 3 to 4 per cent high. Grab samples at chutes very unreliable on high-grade ore. Grab samples at mill sometimes 10 per cent high.
Telluride district, Colorado	Gold ore with quartz and complex sulphides	Diamond drilling for exploration. Channel sampling.	Erratic high assays must be reduced in channel sampling.
Cortez, Nevada	Silver-bearing quartz and sulphides in fissures, bedding planes and dikes. Some oxidized ores.	Pick samples; chute samples for stoping control	Pick samples not accurate for estimating grade of ore.
Zaruma district, Ecuador	Gold with sulphides in quartz-calcite veins	Channel samples	Tonnage recovered larger and grade lower than estimates due to dilution.
Lucky Tiger, Sonora, Mexico	Silver, gold, and sulphides in veins in rhyolite. Average grade about 36 ounces silver per ton.	Channel samples. Grab samples in stopes. Grab samples from chutes for controlling grade in mining.	In check sampling by channels average discrepancy was 5.3 per cent. Estimates over 14 years based on channel samples, 8.4 per per cent low.
COPPER ORES			
Humboldt, Ariz	Chalcocite disseminated in porphyry	Channel sampling. Diamond drilling	In diamond drilling core recovery 50 per cent. Core alone not representative.
Ray, Ariz	Chalcocite disseminated in quartz-sericite schist	Long holes for exploration, grab samples for stope control. Channel samples for record.	
Miami, Ariz	Chalcocite disseminated in porphyry	Churn drilling, channel samples, test holes, grab samples. Bulk samples to check accuracy of other samples.	Churn-drill samples accurate. Channel samples 13 per cent high. Test holes most accurate small samples.
Cananea, Sonora, Mexico	Sulphide replacement in porphyry	Pick samples in waste development and walls of stopes. Channel samples in doubtful ground, grab samples from cars at station.	Car samples check closely enough for production control.
Campbell, Bisbee, Ariz	Sulphide replacement in limestone	Pick samples, drill cuttings or grabs from muck piles or cars in all development. Channel samples.	Channel samples to check uncertain ground, where accuracy is required.
Pilares, Mexico	Chalcopyrite in brecciated intrusives	Grab samples and drill cuttings in development and for stope control.	Samples check mill heads closely.
United Verde, Arizona	1. Uniform massive sulphide bodies; 2. erratic sulphides in schist and porphyry.	Pick and channel samples of all faces	1. Samples 2 per cent high. 2. 8 to 20 per cent error. Average error all classes of ore in 1928 was 5 per cent.
Engels, California	Copper sulphides in shear zones in diorite	Pick and grab samples from stopes and development faces, drill cuttings and car grab samples.	Car samples high.
Eighty-Five mines, New Mexico.	Sulphides in siliceous vein; uniform ore	Grab samples from all development faces and from cars; channel samples in development and marginal ore.	Mine samples 10 to 15 per cent higher than smelter samples.
Burra-Burra, Ducktown, Tenn.	Massive sulphides replacing schists; hard ore	Grab samples biweekly; diamond drilling and long-hole drilling.	Ore estimates based on grab samples accurate enough for practical purposes.
Mary, Ducktown, Tenn	do	Pick samples, grab samples from cars, muck pile grab samples once a week.	Pick samples as accurate as channel samples.
Magma, Superior, Ariz	Oxidized and sulphide copper ores in altered diabase or porphyry and ores with quartz.	Channel samples	
Michigan copper district	Native copper in amygdaloid and conglomerate beds.	No underground sampling. Control by visual inspection.	Has been found impossible to sample these ores accurately underground.
Old Dominion, Globe, Ariz	Mainly sulphide ores in limestone and quartzite	Pick samples. Marginal material checked by channel or drill samples.	
Butte district, Montana	Sulphide ores in veins in granite. Quartz or crushed granite gangue.	Pick samples	Where ore is uniform in veins of good mining width error about 0.5 per cent. In spotty ores and small widths error is high.
LEAD ORES			
Southeast Missouri district	Galena disseminated in limestone	Diamond-drill samples and test-hole drilling	Quite accurate.
Coeur d'Alene district, Idaho:			
Hecla and Star	Lead-silver ore in shear zone in quartzite	Channel samples	
Morning	Lead, zinc, and silver ore in quartzite	Channel samples (in drifts only)	
Tintic Standard, Utah	Lead-silver ore in limestone; 3 types of ore	Groove samples cut with pick from all faces for stope control and reserve estimates. Grab samples from chutes and from cars on surface.	
ZINC ORES			
Tri-State district	Zinc and lead sulphides in flint and cherty limestone beds.	Churn drill and test-hole samples	Results are usually lower than actual grade.
COMPLEX ORES			
Park-Utah, Utah	1. Siliceous silver ore. 2. Lead-zinc-silver ore in altered limestone, uniform mineralization.	Grab samples from cars	
Black Rock, Montana	Sphalerite and galena in altered granite with quartz and pyrite.	Pick samples in development headings and stopes.	
Page, Idaho	Zinc-lead-silver sulphide ore in quartzite	Channel samples of all ore faces in development	
Ground Hog, New Mexico	Galena, chalcopyrite, sphalerite with quartz and pyrite.	Channel samples in all drifts and crosscuts. Grab samples from cars.	
Pecos, N. Mex	Zinc, lead, copper, silver and gold ore in shear zone in schist.	Channel samples of all ore faces	
IRON ORES			
Lake Superior district	Hematite and limonite ore bodies of different types.	Channel samples; churn and diamond-drill samples; grab samples	High degree of accuracy obtainable if sufficient care is used.
Fierro, N. Mex	Magnetite replacing limestone beds	Grab samples from cars. Channel samples where face contains more than one class of ore.	