

It may be seen that a slight difference from average values will materially affect the result.

The time record taken from the chart of a single shift—day shift, January 31, 1913—is as follows:

Drill reciprocating	36.5%
Changing steel	14.4
Moving drill on post	17.5
	69.4%
Mucking out out for post	10.7%
Time lost going to face	4.1
Getting drill steel and water	2.2
Cleaning and charging holes	2.8
Blasting	2.9
Blowing smoke	7.8
	30.5%

Number of holes per shift, 6.
Feet drilled per shift, 40.5 (medium hard amygdaloid).
Cutting speed, 4.205 ft. per min.
The air pressure was about 96 lb. absolute, the consumption of air around 110 cu. ft.,—for the C110 drill 85 cu. ft.

From this time study it appears that the first three factors, amounting to 69.4 per cent., are inherent in the operation of the particular drill and cannot well be reduced. The other factors, amounting to 30.5 per cent., may be reduced for the benefit of the former,—that is, for more actual drilling time. This may be accomplished by a change in the method of drilling holes or by employing additional labor to perform part of the 30.5 per cent. time-loss, always with the condition that the cost of the additional labour is repaid by the increased footage obtained. In our case it is not.

GLACIATION OF ORE DEPOSITS*

By W. H. Emmons.

In comparatively late geologic time a considerable portion of North America was capped by a continental ice sheet, which removed by erosion the loose debris and the surface rock over great areas. Glaciation was most extensive in northern latitudes, but the continental glacier extended southward as far as Ohio and Missouri rivers, and smaller glaciers accumulated in the more lofty mountain ranges of the American Cordillera. Many of the ore deposits that lay in the paths of the glaciers were planed off, and the ores in their upper zones were scattered in the rocky material which was left when the ice had melted. Erratic fragments of such deposits have been carried far from their sources and have been the cause of much fruitless prospecting.

The outcrop of an ore body may be removed gradually by erosion by water, but weathering generally precedes erosion. The solutions may leach the valuable minerals from the outcrop and may precipitate them at a lower level, where they will be preserved. But weathering does not attend erosion by ice, and chemical action of low temperatures is slight; consequently the metals present in the portions of the deposits that are removed are likely to be scattered. The extent to which the ore deposits in a glaciated region were weathered or otherwise altered by surface agencies before the glacial period began can not be estimated. The amount of rock removed by the continental ice sheet is known to be considerable, however, for the drift which it deposited is in many places more than 200 feet thick. It is probable that glacial erosion was in places equally great or greater. Whatever the amount of ice erosion, it appears to have been sufficient to remove the highly altered zones in most parts of northern North America.

As stated already, the processes of solution and enrichment are retarded in regions of low temperature. The areas in which ice erosion has been most vigorous are those in which the lower temperatures prevail today, and there is reason to suppose that the deposits in these areas were not so deeply altered before the glacial epoch as were similar deposits at lower latitudes. In Canada and in Alaska there are few large deposits of sulphide ores which are clearly of secondary origin. If the deposit at the Bonanza mine in the Chitina copper region, Alaska, is primary no large rich secondary sulphide deposits in Alaska are known to me. The sulphide ores now exploited in Canada, except possibly the deposits at Cobalt, in the silver-bearing region of Ontario (which some have consid-

ered of secondary origin), and certain well-authenticated examples in British Columbia, are generally believed to be primary. I know of no important secondary deposits in New England. Small deposits of chalcocite ores were exploited in the Ely district, Vermont. In a copper deposit at Milan, N.H., where the sulphides outcrop at the very surface, no considerable amount of oxidation has taken place below 30 feet, and in general oxidation is trivial at even shallower depths. Only a little chalcocite enrichment has taken place, the secondary ore consisting of primary yellow sulphides coated with thin films of chalcocite, adding to its value probably not more than 1 per cent.*

In Norway and Sweden, according to Vogt, the surface has been polished clean by the Quaternary ice sheet, and secondary alteration is insignificant.

Glaciers do not erode their beds equally at all places. In their higher portions, where the ice is accumulating, pressures are greater, the ice is more rigid, and erosion is more vigorous. Near the margins, where the ice is melting, deposition exceeds erosion and the deposit of drift protects the surface from wear. These differences are very conspicuous in some mountainous sections of the West where the glaciers covered only portions of the country and the processes are more clearly shown. In some of the ranges of Montana, Colorado, and Utah, where ore deposits are numerous and varied, the evidences of mountain glaciation are conspicuously preserved. At some places the mountain glaciers seem to have removed very little of the altered ore, for the secondary sulphide zones and even the oxidized ores are intact, and some of these appear to be too extensive to have formed since the Quaternary glacial epoch. The Amethyst lode at Creede, Colo., has an extensive secondary zone, and one end of this lode was over-ridden by the ice in late geologic time. In general, erosion by mountain glaciers has been localized, the maximum wear taking place near the heads of the glaciers.

Erosion by the continental glaciers is also somewhat erratic, for great differences in the effect of the action of ice may be seen in a comparatively small area. In the Mesabi range of Minnesota the hard, fresh country rock is polished clean in places, whereas a few rods away and at but slightly lower elevations thick bodies of cellular, almost powdery iron-oxide ore remain intact. These facts suggest that other important secondary zones may be encountered when the area over-ridden by the continental ice sheet is more thoroughly developed.

*Extract from Bull. No. 529, U. S. G. S., "The Enrichment of Sulphide Ores."

*Vogt, J. H. L., "Problems in the Geology of Ore Deposits," by Posepny, Franz. The Genesis of Ore Deposits, 1902, p. 675.