UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary geologic report on the Milan mine, Milan, Coos County, New Hampshire

by

John H. Eric
U.S. Geological Survey

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<u>Location</u>.--An abandoned copper mine known as the Milan mine is located in the town of Milan, Coos County, New Hampshire. The mine is in the southeast ninth of the Percy quadrangle. From Berlin the mine is reached by state highway 110, which is followed 3.5 miles north of the Berlin-Milan town line; thence by Fogg siding Road, following this eastward 1.6 miles past Nay Pond and across the railroad tracks. The workings are several hundred yards east of the Grand Trunk (Canadian National) Railway. The relief is gentle and the country heavily forested.

<u>Present investigation</u>.--I made a preliminary examination and sketch map of the mine on October 22 and 23, 1943, with the assistance of my wife, Nancy Loomis Eric.

<u>History and ownership</u>.--According to Emmons [1/], the deposit was

1/ Emmons, W.H., Some ore deposits in Maine and the Milan mine, New Hampshire: U.S. Geol. Survey, Bull. 432, 1910.

discovered in the 1870's, and was worked for copper until 1886. The monthly production was 2,600 tons. At this time a little of the ore was smelted at the mine. From 1886 to 1895 the mine was closed.

From 1895 on, the property was operated by a number of companies. During this period, the deposit was worked primarily for pyrite to be used in the manufacture of sulfuric acid ; however, ore rich in copper was hand-picked and shipped to copper smelters; cinders from the burned pyrite were also smelted for copper, gold, and silver. According to Mr. James Scales of West Milan, New Hampshire, who operated the hoist, the mine was closed about 1911. It was acquired about 1938 by the present owners, Ventures, Limited, of 25 King Street West, Toronto, Ontario.

Workings.--At the present time, the workings are not accessible. Near the site of the old mill there is an open cut (Plate 1), about 170 feet long and 10 to 20 feet wide, now filled with water. South of the open cut are three water-filled shafts. The two southernmost shafts appear to have been shallow and exploratory, but the more northerly one may be connected with the underground workings of the mine. A fourth shaft, not observed in the field and not shown on the map, is said to exist some two or three hundred feet north of the north end of the open cut.[2/] The main shaft, the position of which is not

[2/] James Scales, oral communication.

known, is at the bottom of the open cut.[3/]

[3/] Emmons, W.H., op. cit. All of the following information concerning underground development is taken from this paper.

The main shaft, according to Emmons, is 265 feet long, and is inclined at angles ranging from 59° to 85° W. Levels are driven at 70, 88, 115, and 215 feet. According to the text (Emmons, p. 50) these depths are measured on the incline; according to the cross section (Emmons, fig. 22, p. 56) they are measured vertically. The 70 level appears to be the bottom of the open cut. The total length of the drifts is about 1,500 feet. Apparently the longest drift is on the 115 level; this level is at least 580 feet long, of which about 550 feet are north of the main shaft. There are stopes between the 115 and 70 levels. The 70 level may extend almost as far north as the 115. Apparently, there are no stopes below the 115 level.

<u>Metamorphic rocks</u>.--The formation in which the deposit occurs is known as the Ammonoosuc volcanics.[4/] In the vicinity of the mine, this

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4/ Chapman, R.W., Percy ring-dike complex: Amer. Jour. Sci., 5th series, vol. 30, pp. 401-431, 1935.
Billings, M.P., Regional metamorphism of the Littleton-Moosilauke area, New Hampshire: Geol. Soc. Amer., Bull., vol. 48, pp. 463-566, 1937.
Billings, M.P., Structure and metamorphism in the Mount Washington area, New Hampshire: Geol. Soc. Amer., Bull., vol. 52, pp. 863-936, 1941.

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formation consists of interbedded amphibolite, banded felsitic schist, and quartz-mica schist. A small amount of chlorite schist, possibly of intrusive origin, is also present. Some of the amphibolite and schist contains acicular crystals of actinolite up to one half inch long. There is a suggestion that the quartz-mica schist was the most favorable rock for ore deposition, for this rock is found near the open cut. The Ammonoosuc volcanics are probably of Ordovician age.

<u>Igneous rocks.</u>--Near the mine, there are large areas underlain by plutonic rocks. 5/ The contact of the Ammonoosuc volcanics and the

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5/ Shown on a manuscript geologic map of the southeast ninth of the Percy quadrangle, by Randolph W. Chapman, obtained from Prof. Marland P. Billings of Harvard University.

Berlin gneiss lies about one mile south of the mine. The Berlin is intrusive into the Ammonoosuc. The contact of the Ammonoosuc and the Conway granite is exposed about 2.5 miles to the west. The Conway intrudes both the Ammonoosuc and the Berlin, and is younger than the metamorphism.

<u>Structure</u>.--Cleavage is well developed in the schist at the mine. Near the open cut the cleavage strikes N. 10°-30° E. and dips 45°-60° W. To the south and west, however, the strike of the cleavage ranges from N. 60° E. to N. 80° W., and the dip ranges from 35° N., through the vertical, to 70° S. The difference in attitude between the two areas is probably due to folding of the cleavage rather than faulting. Some faulting may, however, have taken place. The regional structure trends about N. 65° E.

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Minor folds in the cleavage were observed at the two southernmost shafts. Folds at the west shaft pitch 10° E; those at the east shaft pitch 15° W. Near the open cut, small folds pitch 5° N. Underground, Emmons[6/] noted "undulations along both the dip and the strike and

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[6/] Emmons, W.H., *op. cit.*, pp. 55-56.

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at some places there are turns of more than 45° along both dip and strike." The ore is parallel to the cleavage.

The deposit.--According to Emmons the deposit consists of two lenticular, overlapping bodies. On the 115 level, the south end of the north ore body is about 50 feet south of the north end of the south ore body. At the overlap the north body is 10 to 15 feet west of the south body. The relations of the two ore bodies on other levels and at the surface are not explained, and presumably, are unknown. Between the ends of the ore bodies on the 115 level is a tight "fissure," along which movement has taken place. According to Emmons, the fissure is not a fault, in the usual sense. The ore bodies are believed originally to have been a single body that was pulled apart along the fissure.

The deposit is described by Emmons[7/] as follows: "The south ore

7/ Emmons, W.H., op. cit., p. 56.

body outcropped on the present site of the mill...and...as developed is from 5 to 25 feet wide and like the north ore body it dips steeply westward. Near the surface, it is developed southward for 275 feet along the strike. At its northern termination, the end of the ore pitches southward at a low angle. On the 70-foot level, it is 45 feet from the shaft and dips toward it from 50° to 70°, becoming steeper in depth..." (Apparently "dips" in the preceding sentence means "pitches")."The north ore body is developed northward 550 feet along the strike and it is approximately 15 feet wide..." (This apparently refers to the 115 level).

A somewhat different description is given by Weed[8/], who says

8/ Weed, W.H., Copper deposits of the Appalachian States: U.S. Geol. Survey, Bull. 455, p. 18, 1911.

"The deposit consists of overlapping lenses 9 to 21 feet wide and averaging 8 feet thick and 600 feet long, with a dip of 21°." The angle of dip given here is probably a misprint.

Attitude of the ore bodies.--Concerning the attitude of the ore bodies the following quotations from Emmons are pertinent:

"The ore bodies are parallel to the schistosity" (p. 57).

"A tight fissure dipping westward at about the same angle as the two ore bodies joins the two ends and wraps around the ore at both terminations. The schistosity likewise wraps around the ends of these ore bodies and parallels the fissure which joins them" (p. 58).

"Since the broken end of the south ore body pitches toward the south, with the ore in the foot wall of the pitch, it should be expected that the broken end of the north ore body should also pitch to the south, with the ore in the hanging wall of the pitch" (p. 59).

But Emmons' fig. 4, p. 17, shows the fissure at the north ore body pitching 70° to the north on the 115 level. If so, the south end of the north ore body must also pitch 70° to the north at that level.

A possibility is that the south end of the north ore body becomes progressively steeper at depth, passing through the vertical and pitching to the south somewhere below the 115 level. In such a case, the south end of the north ore body would locally pitch to the north, but the long axes of the ore bodies might pitch to the south. Conversely, the north end of the south ore body might locally pitch to the south, but pass through the vertical and pitch to the north at lower levels, in which case the long axes of the ore bodies might pitch to the north.

The average angle of pitch of the north end of the south ore body and the south end of the north ore body are not known, but from Emmons' description the angle ranges considerably, becoming steeper at depth. If the angle of pitch of these terminations becomes, as Emmons states, 50° to 70°, which is roughly the angle of dip, the direction of pitch becomes the direction of dip, which, near the open cut, is approximately west. A distinct possibility, therefore, is that, in general, these two terminations of the ore bodies pitch down the dip to the west. Emmons does not mention the pitch of the two outer terminations--that is, the north end of the north ore body and the south end of the south ore body--but if these terminations are parallel to the two inner terminations, the long axes of the ore bodies may also pitch down the dip. Knowledge of the direction of pitch of both ore bodies would obviously be of immense importance in any program of exploration.

The ore.--The sulfides consist of pyrite, chalcopyrite, and sphalerite, with much less galena and minor supergene bornite and chalcocite. The principal gangue mineral is quartz, with minor chlorite and mica. Pyrite and quartz are by far the most abundant minerals. They occur together, apparently in all proportions. Emmons states that "much of the ore is solid pyrite, which includes fragments of the banded schists oriented parallel to the walls." Dump fragments show that some of the ore consists of nearly pure massive chalcopyrite and massive sphalerite. In some of the fragments massive pyrite, chalcopyrite, and sphalerite are segregated into crude

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bands 0.5 to 2 inches thick. Cross sections of the vein itself apparently show a similar banding, though on a very much larger scale.[9]

[9] Emmons, W.H., *op. cit.*, fig. 21, p. 55.

From east to west, the section shown by Emmons is approximately as follows:

	Ft.
Massive pyrite	4
Pyritiferous schist (milling ore)	3
Oxidized seam	0.5
Pyritiferous schist (milling ore)	3
Massive quartz, pyrite, & galena	2.5
	13

Many of the pyrite crystals are euhedral. The cube is the common form, but octahedrons are also present. Some of the pyrite crystals suggest an apparent elongation, as though they had been stretched. Close inspection shows that this is not the case. In one dump fragment, a medium-grained granular rock composed of approximately equal proportions of quartz and pyrite, the apparent lineation is seen to be due to alternating pyrite and quartz. Except for a small amount of granulation, the pyrite is undeformed.

Metamorphism of the ore.--Emmons' persistently repeated statement that the ore is undoubtedly older than the metamorphism is open to some question. Several writers[10] disagree with him. Emmons states

[10] Lindgren, Waldemar, Mineral deposits, 4th ed., p. 750, New York 1933.

Newhouse, W.H., and Flaherty, G.F., The texture and origin of some banded or schistose sulphide ores: Econ. Geol., vol. 25, pp. 600-620, 1930.

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that the absence of "comb structure, crustification, or druses" in the ores is evidence that the ore deposit has been metamorphosed. The absence of such features can also mean that the deposit is one of replacement in metamorphic rocks. Emmons cites the absence of wall-rock alteration as evidence of the metamorphism of the ore; however, disseminated pyrite is common in the rocks near the vein; moreover, according to Newhouse and Flaherty[11], "cordierite occurs as a wall rock

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11/ Newhouse, W.H., and Flaherty, G.F., *op. cit.*, p. 610.

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alteration product." This mineral does not "show any notable deformation." According to Emmons, some of the ore has recrystallized; but such recyrstallization could take place regardless of whether or not the ore had been regionally metamorphosed. And whereas, as Emmons says, the movement causing the cleavage may have been controlled by the ore bodies, an equally plausible hypothesis is that the form of the ore bodies was controlled by the cleavage.

Assays.--Mine assays are apparently not available. Emmons gives the following analysis of shipping ore cobbed from the mine run:

Insol	15.40
S	39.84
Cu	2.25
Zn	7.26
Pb	1.57
Fe	32.85

The ore contained 1 or 2 ounces of silver, and $1.50 in gold (old price), to the ton. Mill heads averaged 26.5 percent sulfur and 1.35 percent copper. The ratio of milling ore to shipping ore is not known, but these figures suggest that the ore mined ran about 2 percent copper, perhaps slightly less. The percentage of zinc in the mill heads is not known. Hitchcock 12/ states that an analysis was made shortly

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12/ Hitchcock, C.H., Geology of New Hampshire, Concord, 1878.

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after the deposit was discovered: a "fair average" gave 5.3 percent copper. This figure almost certainly represents a highly selected specimen.

Conclusions.--The Milan mine may be a possible source of copper, zinc, and pyrite, but insufficient mine data are available to determine the pitch of the ore bodies and to answer the question whether the ore bodies were mined out in earlier operations. Emmons' data suggest that the north end of the south ore body and the south end of the north ore body may pitch, in general, nearly down the dip to the west or northwest. If the two ore bodies are elongate parallel to these terminations, additional ore may exist at greater depth down the dip.

Two facts, however, suggest that the elongation of the deposit, consisting of the two overlapping ore bodies, may be more nearly north-south, and roughly horizontal; and in this case, the deposit may virtually have been mined out. 1) Apparently no stoping was done on levels below the 115, and there is no record that any ore was developed on the 215. 2) Furthermore, in the vicinity of the mine minor folds in the cleavage pitch consistently 15° or less, and those nearest the ore bodies were observed to pitch 5° N. It is not unlikely that the axis of the ore shoot pitches approximately 5° N, parallel to these folds.

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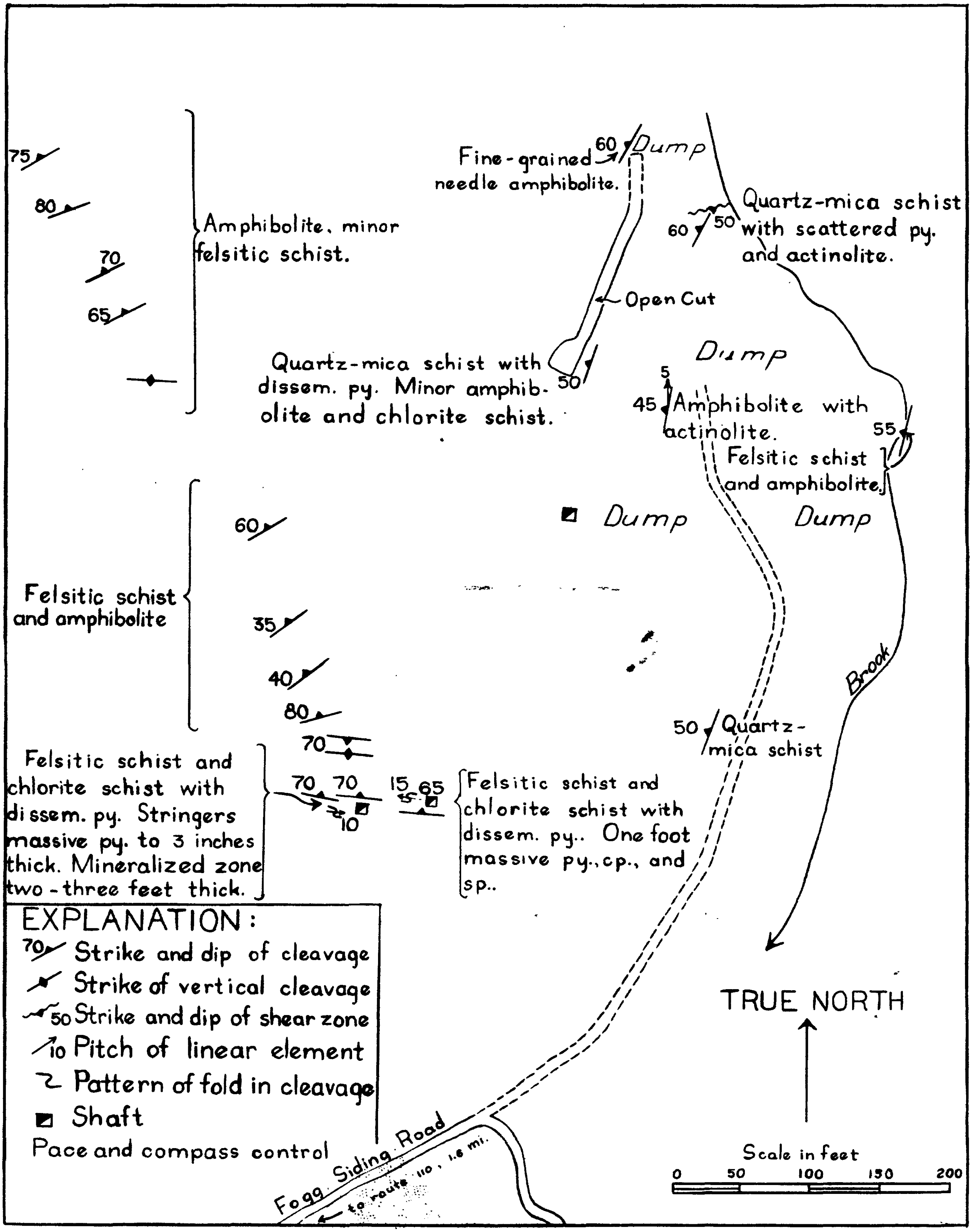
PRELIMINARY MAP
PLATE I



Geology by J. H. Eric

GEOLOGIC MAP OF MILAN MINE
MILAN, NEW HAMPSHIRE