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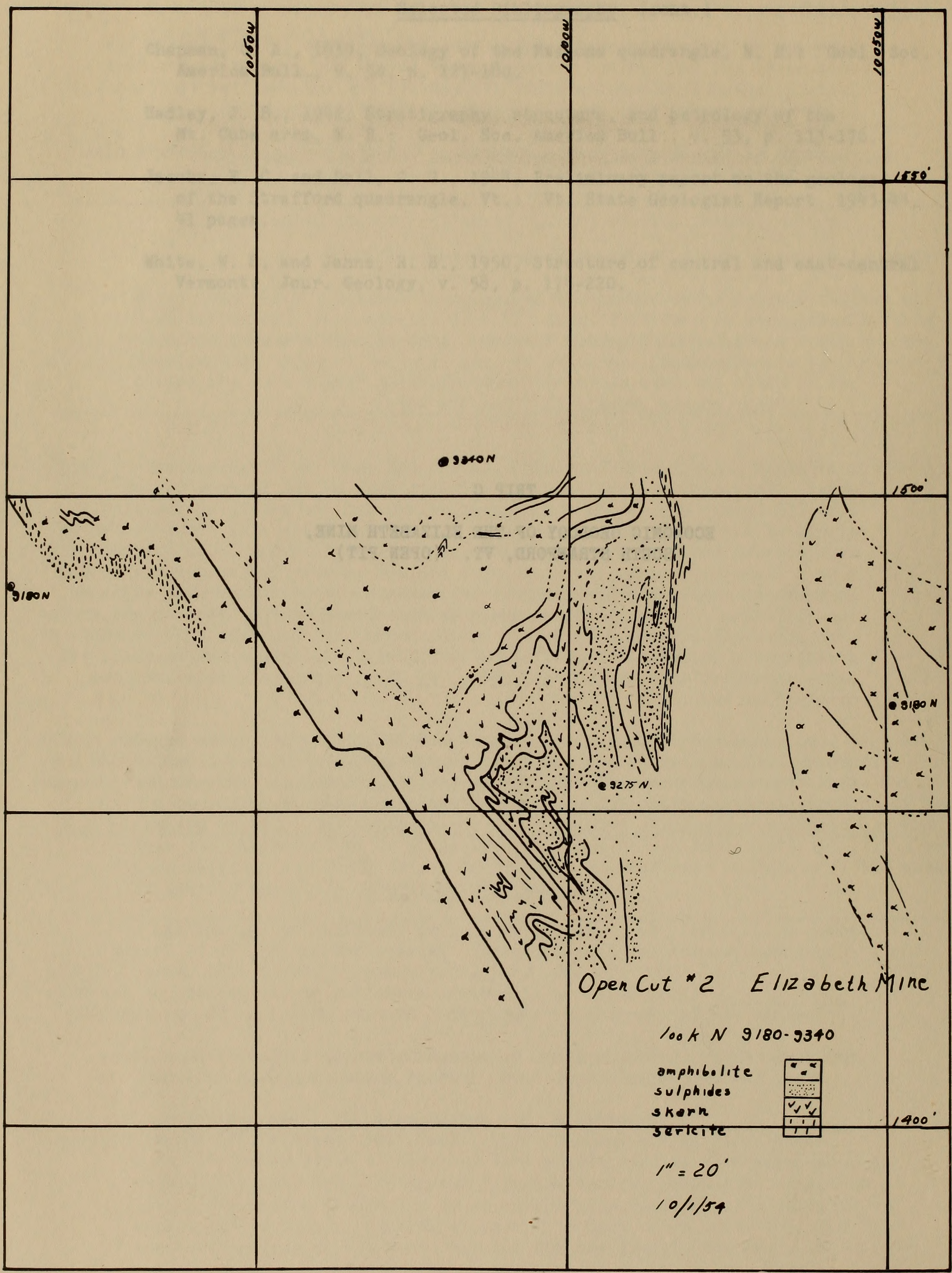
# Economic Geology of the Elizabeth Mine

McKinstry, H.E.

TRIP C

ECONOMIC GEOLOGY OF THE ELIZABETH MINE,
SOUTH STRAFFORD, VT. (OPEN PIT)


10150W
10100W
10050W
1550'
9340N
1500'
9180N
9180N
9275N
Open Cut #2 Elizabeth Mine
look N 9180-9340
amphibolite
sulphides
skarn
sericite
1400'
1" = 20'
10/1/54

TRIP C

# ECONOMIC GEOLOGY OF THE ELIZABETH MINE, SOUTH STRAFFORD, VT., (OPEN PIT) - SATURDAY, OCTOBER 9, 1954, 8:00 A.M.

Leader: H. E. McKinstry

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## Assembly Point

Tuck Drive in front of Silsby Hall, headed west.

## Route from Hanover

Turn right, down Tuck Drive a few hundred feet from Silsby Hall, and cross the Connecticut River bridge. Turn right on Route 10A immediately after you cross the bridge. Continue north on 10A, which joins with Route 5. Follow 5 to the junction of Route 132, approximately 6 miles from Hanover. A sign at the junction points to the copper mine. Turn left. Proceed to the outskirts of South Strafford on Route 132. Turn left as indicated by a sign. At the end of this short road, turn left again and proceed to the mine offices.

## General

The mine was discovered in 1793 but substantial production of copper did not start until 1830. From then on production was intermittent. In the present period of operation (1943 to date) three times as much copper has been produced as in all former operations.

The country rock is biotite schist of the Gile Mountain formation. Structure, is outlined by beds of hornblende-plagioclase rock ("amphibolite"), probably metamorphosed volcanic tuff. The orebodies are in the east limb of a structural syncline that plunges northerly an average of about 12 degrees. The fold is overturned, its axial plane dipping steeply eastward. The simplest interpretation is that there are two "amphibolite" formations in this fold, the rock between them being biotite schist and "skarn"--carbonate rock metamorphosed to tremolite-phlogopite schist. This and the adjoining biotite schist are replaced by sulphides. Adjoining the ore, biotite schist is altered to sericite schist and bleached. "Amphibolite" is altered to biotite and in extreme cases to sericite.

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STOP 1 No. 2 Open Cut.

Looking northward into the open cut, the wall on your left is the "westwall amphibolite", which is folded, forming also the overwall of the orebody. To your right, the wall is mostly "hangingwall amphibolite". Here you will find: Ore: Pyrrhotite and chalcopyrite, locally with much tourmaline and metacrysts of plagioclase. "Amphibolite": containing large garnets; also long radiating hornblende blades now altered to biotite in a matrix of sericite.

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STOP 2 No. 1 Open Cut (not operating), 2000 ft. north of No. 2 Open Cut.

Looking north you can see a small synclinal fold of "amphibolite". The openings beneath it were parts of the orebody now mined out. From here the ore has been mined almost continuously on the northerly plunge for 6000 feet to a depth 975 feet below the open cut. The north end of the oreshoot is beyond the Pompanoosuc River. (You passed a raise beside the road along the stream as you came to the mine from Hanover.)

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STOP 3 Mill.

The combined mine and open cut ore from the Elizabeth mine is reduced from a maximum size of 25" x 40" to a finished product minus either a 3/4" square or a 1/2" x 2 1/2" rectangular screen openings by using an intergrated combination of two Blake type and one gyratory type crushers plus the required grizzlies, vibrating screen and inter-connecting conveyors.

To prepare the ore for further treatment it is ground wet in a #96 Marcy grate type ball mill, using 3" steel grinding balls and operating in closed circuit with a 78" Wemco spiral classifier. During the grinding, solutions of milk of lime and cyanide are added to the mill stream as a start in the separation of the copper and iron containing minerals from the gangue minerals.

In the Elizabeth ore, the mineral of most importance is chalcopyrite and of lesser importance is the pyrrhotite which at this time is valuable only because it contains sulphur used in other industrial plants. The most objectionable minerals from the mill man's point of view are muscovite, phlogopite and sericite or as they are called in the mill, mica and talc.

The average assays of the mill heads, (ore), concentrates produced and the tailings for the past three months are as follows:

| | Oz. Ag. | % Cu. | % Insol | % Zn. | % Fe. |
|---|---|---|---|---|---|
| Mill Head | 0.17 | 1.67 | | 0.59 | 21.8 |
| Cu. Concentrate | 2.57 | 24.21 | 9.27 | 1.19 | 31.2 |
| Mill Tailing | 0.017 | 0.166 | | 0.49 | 20.8 |

| | % Fe. | % S. | % Insol | % Cu. | % Zn. |
|---|---|---|---|---|---|
| Fe. Concentrate | 53.82 | 36.16 | 5.84 | 0.59 | 0.89 |

It will be noted from the above assays that the iron content of the ore is high. Nearly all the iron in the ore is contained in the pyrrhotite and the rejection of this mineral along with the mica and talc from the copper flotation circuit is the main problem in the milling of the Elizabeth ore.

The beginning of the pyrrhotite rejection starts in the grinding circuit and the use of additional lime to maintain a pH of 9.0 to 9.3 is used in the cleaning operations of the copper rougher concentrates. Using an excessive amount of either lime or cyanide effects the flotation of the chalcopyrite and usually results in a higher copper tailing and hence a lower recovery of the chalcopyrite.

STOP 3 (cont.)

To increase the flotation of the copper, a promoter in the form of a zanthate solution is added to the mill stream and this reagent plus the use of a pine oil - alcohol mixture produces a froth that gives us the desired condition for the flotation of the chalcopyrite. The excessive use of any of the foregoing reagents will cause the pyrrhotite to float and result in the production of low grade copper concentrates.

The so-called mica and talc minerals are easily floated with the same reagents used in the copper flotation. Partial rejection of these two minerals is accomplished in the cleaner operations by the use of suitable reagents known for their depressant effects on the flotation of the two minerals. However, the addition of a small amount of the reagent used will cause a costly rejection of the chalcopyrite.

Of all the minerals in the Elizabeth ore the most interesting one is the pyrrhotite, which causes complications in the flotation plant. It is known that some of the ore containing pyrrhotite oxidizes very rapidly and likewise probably reacts with other chemicals used in the flotation of the chalcopyrite.

Proof of this is seen from time to time in flotation of the pyrrhotite. The flotation of this mineral is accomplished by using sulphuric acid to bring the pH down to 6.2 - 6.6. At this point the addition of suitable promoters, collectors and frothing reagents will cause the pyrrhotite to float and produce very good metallurgical results. At times the pyrrhotite will not float in an acidified pulp and the pulp must be made alkaline. At times it is practically impossible to float the pyrrhotite under any conditions.

Some days the pyrrhotite concentrate produced will have a tendency to oxidize very rapidly and even start burning by spontaneous combustion after being stored less than 48 hours. All the pyrrhotite concentrates will oxidize and eventually catch fire but in some cases it takes up to ten days storage before this takes place. It has been noted that some of the pyrrhotite ores are magnetic and others are not. It has not been determined whether the foregoing characteristics of the pyrrhotite are responsible for the erratic results obtained from the concentration of the ore by flotation.

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## Selected Bibliography

McKinstry, H. E. and Mikkola, A. K., 1954, The Elizabeth Copper Mine, Vermont: Econ. Geology, v. 49, p. 1-30.