How Swedish metallurgists developed

For many years attempts have been made to concentrate scheelite by flotation in the presence of fluorspar, calcite, and apatite which have very similar flotation properties. Until recently, however, it was considered impossible to separate it

At Yxsjöberg in central Sweden (Figure No. 1), AB Statsgruvor mines a low-grade scheelite ore for production of scheelite, chalcopyrite, and fluorspar concentrates. Formerly the scheelite was recovered by gravity concentration. But because of unfavorable prerequisites for this beneficiation method, the operations have given unsatisfactory results until recently. Comprehensive experimental work, however, has resulted in a new selective scheelite flotation process, which is drastically improving the mine economies.

According to laboratory and pilot plant tests the new process yields concentrate which exceeds 65 percent WO_3 in grade and 75 percent in recovery from a feed assaying less than 0.4 percent WO_3. The process came on stream in late 1977.

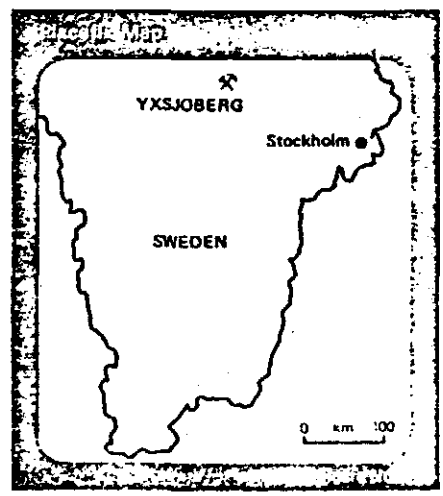
This article describes research and development work which resulted in improvements to the original gravity concentration and finally led to the novel process for selective flotation of scheelite in the presence of fluorspar and calcite. Results from full-scale operation will be presented in a later article.

Statsgruvor is a wholly-owned subsidiary of LKAB, the large, state-owned iron ore mining group. Stoping at the Yxsjöberg underground scheelite mine is mainly cut-and-fill. The run-of-mine ore averages 0.3 to 0.4 percent WO_3. The scheelite in the ore is partly fine-grained and is associated with several times larger quantities of calcite and fluorspar.

Skarn Ore

The Yxsjöberg field belongs to the upper, sodium-rich part of the Svecofennian leptite region, which in the area consists of moderately metamorphic sediments and volcanic rocks of intermediate to acidic composition. After folding and uprising, the complex has been tectonized and amply cut by metabasitic dykes. These strike roughly east-west and are in parallel with the folding. Younger granites, traditionally believed to represent the parent magma of the ore-forming solutions, crop out some 4 miles to the east of the mine.

Mineralization occurred along a limestone horizon in the series, preserved in places but mainly transformed into three somewhat distorted bodies of amphibole and pyroxene skarn. The scheelite is associated with pyrrhotite and chalcopyrite as well as garnets, other skarn materials and abundant amounts of fluorspar.



The pyroxene skarn is characterized by xenomorphic hedenbergite normally coarser than 200 microns and seems to be unevenly impregnated with fairly coarse-grained scheelite. The amphibole skarn on the other hand is on average more fine-grained than the pyroxene skarn. It consists mainly of common hornblende with small scheelite grains fairly evenly distributed in the matrix. Some grain counts exemplifying the scheelite grain size distribution in these ore types are given in Figure No. 2. To a minor extent mineralization also occurred in garnet skarn and in pegmatite veinlets. The fluorspar and calcite proportions vary considerably in all ore types.

On average the run-of-mine ore assays 0.38 percent WO_3, 0.25 percent Cu, 2.2 percent S, 0.02 percent P, and 7.5 percent CaF_2, which corresponds to the following mineral composition:

- 0.5 percent scheelite
- 0.7 percent chalcopyrite
- 5.5 percent pyrrhotite
- 0.1 percent apatite
- 7.5 percent fluorspar
- 5.1 percent calcite
- 5.2 percent quartz
- 10 percent biotite
- 15 percent feldspar
- 50 percent skarn minerals

Reopen Mine

In 1963 low tungsten prices forced the former owner, AB Yxsjö Gruvor, to cease operations. In 1969 AB Statsgruvor acquired the mine and after construction of new facilities production recommenced in 1972. Basically the same flowsheet was adopted for beneficiation as in the old plant.[1]

The ore was crushed in three stages to minus-20-millimeters, each time bypassing the fines, and then ground by rod mills in two stages to minus-0.5-millimeter (Figure No. 3). A rougher scheelite concentrate, mainly consisting of pyrrhotite, skarn minerals, and garnet, was obtained on three-deck shaking tables and further upgraded in two stages on single-deck diagonal tables. Most of the pyrrhotite was discarded by wet magnetic separation and then the scheelite product was dried, roasted, and cleaned from residual impurities by dry low and high intensity magnetic separation.

Rejects from the roughing tables were reground in a ball mill operated in closed circuit with a hydrocyclone. After reducing the pyrrhotite content by magnetic separation, chalcopyrite was floated by conventional methods. The copper rougher concentrate was reground and cleaned in four stages.