SPECIAL REPORT:

The first mine in copper district south of Lima which is characterized by extremely irregular and scattered ore bodies and deposit types

Mina Raúl, Peru's sea coast copper mine

By **Robert J.M. Wyllie**
Editor

Peru's suburban copper mine is practically on the beach a few miles south of Lima. Compania Minera Patavilca S.A.'s Mina Raúl was the first mine to be developed in Peru's coastal copper province.

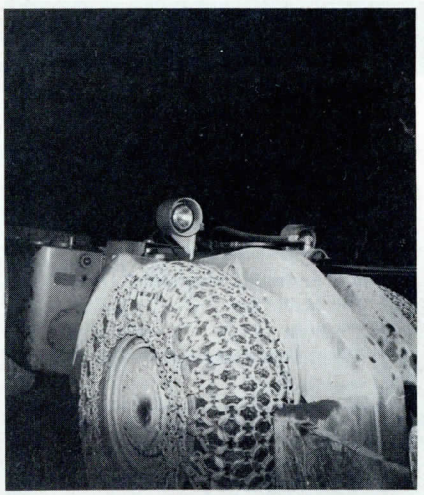
Peru's copper mines are, of course, famous. But talk of Peruvian copper mining and you immediately think of the huge porphyry mines high in the southern Andes. There is another Peruvian copper province, the coastal one. It is not as big, not as well known, and not as well developed. But there is good copper ore there and some small mines are in production.

The first and biggest of these is Mina Raúl producing 1,000 tons of ore daily averaging 1.8 percent copper. It is located about 50 miles south of the center of Lima, a lot less from that city's sprawling southern suburbs and barrios. The mine installations are 2 miles inland from the Pacific coast in the low foothills of the Andes.

Elevation is from 80 to 300 meters (about 250 to 1,000 feet) above sea level. This is a sharp contrast to the literally breathtaking elevations of most Peruvian mining areas. Access is ideal as the mine is only a mile or two from the paved Southern Panamerican Highway which follows the Pacific coast.

Small gold mines were worked in the desert coastal hills south of Lima in Spanish colonial times. This activity took place at Raúl although the mine did not carry that name then. In fact, after the small gold workings were abandoned the relics of the mine were known locally as the Mina Perdida, the Lost Mine.

In the 1950's interest was rearoused in the copper potential of the area and some drilling and prospecting was conducted around the old workings. Claims were registered under the name Mina Raúl in acknowledgement of a local inhabitant who provided information on the old workings.



TRACKLESS VEHICLES, such as this tire chain equipped Wagner scooptram are used for ore haulage in open stopes. **ABOVE**, blasting in the Raul open pit mine.

Various prospective miners, including the former Cerro de Pasco Corporation, looked at Raúl, but turned the prospect down as too low grade and uneconomic. Eventually Patavilca decided to take over and develop the property. Patavilca takes its name from the Patavilca river valley in the Ancash Department of northern Peru where it operated the "El Dorado" gold mine.

Patavilca put Raúl into production in 1961 at a rate of 100 metric tons of 4 percent Cu ore per day. Today the ore production is 10 times that level at a grade just under 2 percent.

Patavilca is 40 percent owned by the Hochschild group which also manages the Raúl mine.

Submarine Volcanics

The Raúl deposit is related to the Quilimana volcanic formation. These submarine volcanic sediments show a concordant sequence striking to the northwest with a dip of 35° to 40° to the southwest. They have a thickness of more than 2,100 meters (7,000 feet). Along with the six units of volcanic sediments in the mine there are two types of intrusive rocks.

The volcanic rocks are thought to belong to the Upper Cretaceous on the basis of fossils in limestones intercalated in the sequence. The volcanic sediments have been metamorphosed. However, all rocks remain in their original sequence and stratification. The commonest intrusive is a diorite or granodiorite porphyry. It is a massive, medium grained gray colored rock which shows definite contacts

with the intruded rocks. It occurs in two consecutive phases. The first is a gray-greenish colored dacite porphyry in the form of stocks and dikes. The second phase produces a dioritic porphyry of grayish color while in the form of dikes and sills.

The latest igneous activity in the area is represented by a series of dikes and stocks of diabase. The dikes trend northwest and northeast with widths from 5 to 16 meters.

There are two important premineral fault systems. One strikes northeast and dips at 75° to 90° to the southeast. The other strikes northwest and dips about 60° to northeast.

There are numerous post mineral faults, sometimes with over 50 meters (165 feet) vertical or horizontal displacement.

Ore Body Types

The ore bodies at Raúl occur in various forms.

Mantos (or sheet-like bodies) are replacements in beds of metamorphosed limestones, tuffs, or lavas. The mantos are far from continuous being constantly cut longitudinally and transversally by faults and intrusives. They dip at 35° to the southwest with the enclosing beds with very variable length.

Vetas (or veins) are filled fractures which generally cut across the strike of the mantos and are subvertical with lengths of 100 to 300 meters (330 to 1,000 feet). The vein bodies have a higher grade than the mantos and can be 6 to 20 percent Cu. The vein systems correspond to the above mentioned premineral faults. In the first set of veins the mineralization is characterized by coarse grained chalcopyrite accompanied by pyrite, actinolite, calcite, galena, and sphalerite. The second vein set's mineralization is characterized by fine grained chalcopyrite, pyrite, pyrrhotite, quartz, and occasional galena and sphalerite.

Irregular bodies or breccia pipe mantos occur in the beds of pyroclastic origin with the mineralization both in the fragments and the matrix. Mineralization is concentrated in favorable zones which are highly irregular. It is in the form of fine threads and veinlets which are joined and linked together and disseminations containing fragments of the volcanic host rock—the true breccia ore. These bodies are similar in grade and volume to the manto bodies.

Disseminated ores occur as veinlets, small aggregations, and bands in beds of lava and tuff. They are the lowest grade bodies.

Stockwork ore consisting of interlaced veins is restricted to a small area.

Throughout the deposit the sole ore mineral is chalcopyrite. The main gangue minerals are pyrite, pyrrhotite, magnetite, calcite, quartz, actinolite, etc.

Enough has been said about the nature of the ore bodies at Raúl to make it clear that they are highly irregular and hard to locate. There is plenty of ore but the problem is finding it. As the local engineers point out, it is a giant plum pudding and they are looking for the plums.

Open Pit/Underground

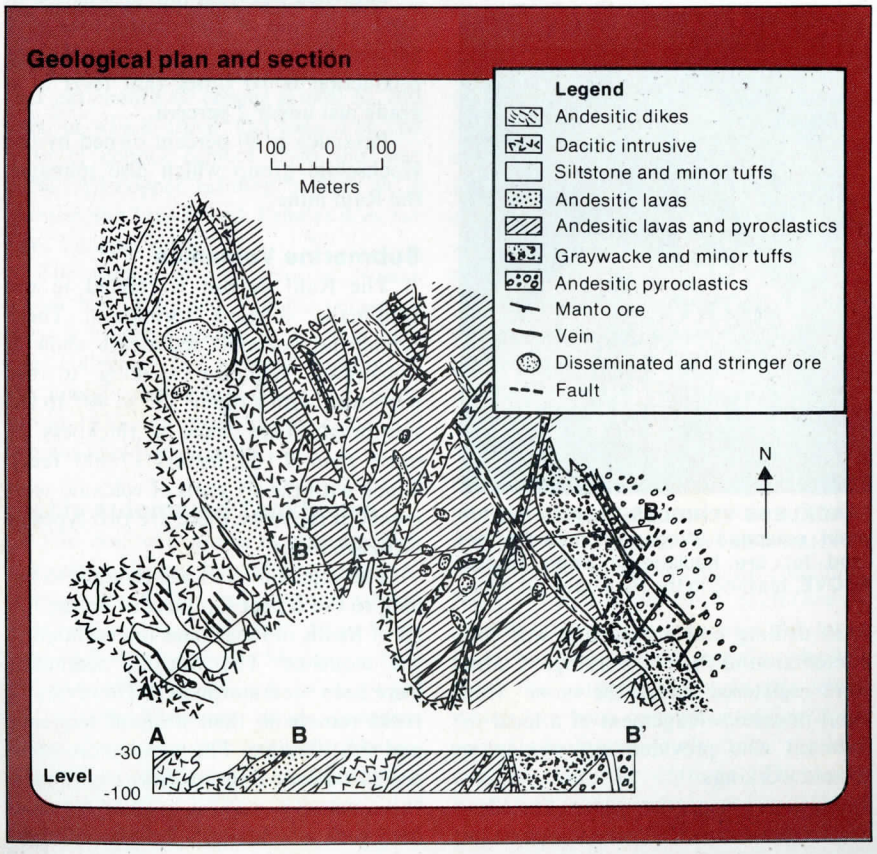
There is an open pit and an underground mine at Raúl. Each accounts for half of the total production.

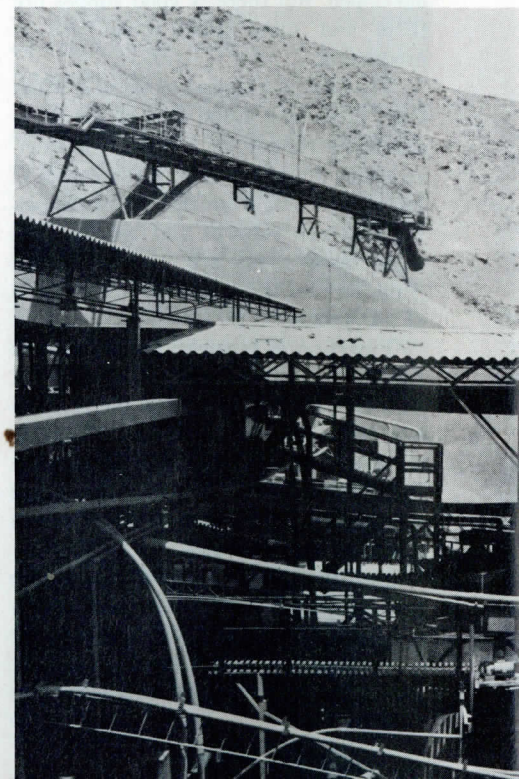
The body which is mined in the open pit is a disseminated type of ore in a manto formation. It is 400 meters (1,300 feet) wide, 150 meters (500 feet) long, and goes to a depth of 70 meters (230 feet).

The open pit is mined in 10-meter (33-foot) high benches. Ore and waste is all drilled and blasted. The mine uses two Toyo TYCD track drills to make 3-inch-diameter blastholes. The 10-meter holes are on a 2 by 2.2-meter (6.6 by 7.3-foot) grid in waste and oxidized ore zones, this is tightened up to 1.5 by 1.5 meters (5 feet) in sulphide ore. Ammonium nitrate blasting agent of Peruvian manufacture is shot with dynamite primers.

All loading, grading, and hauling is handled by the pit fleet of two Caterpillar D8 tractors, two Caterpillar 966D crawler loaders, and six Kockum's 20-ton trucks.

The pit walls are quite steep, 55° usually except in the southeast corner where a 45° slope is maintained. Although the slope is 40° it is possible to make the pit walls steeper because there is no ground water and also, because the pit will only





be in production for a relatively short time, these are not long-term walls. The main ramp into the pit is quite steep, too, at 12 to 15 percent.

The Peruvian coast is an extremely arid desert so ground water or rain water cause no problems in the open pit or the underground mine. Instead the problem is to find water for the mill. This is pumped from two deep boreholes.

In the underground mine, which is adjacent to the open pit and accessed by short declines, many stoping systems have been used in the irregular bodies.

Shrinkage has been used in the irregular disseminated bodies and breccia ore.

In the big, thick mantos (average 2 meters—6.6 feet) blasthole open stopes with longhole drilling are used.

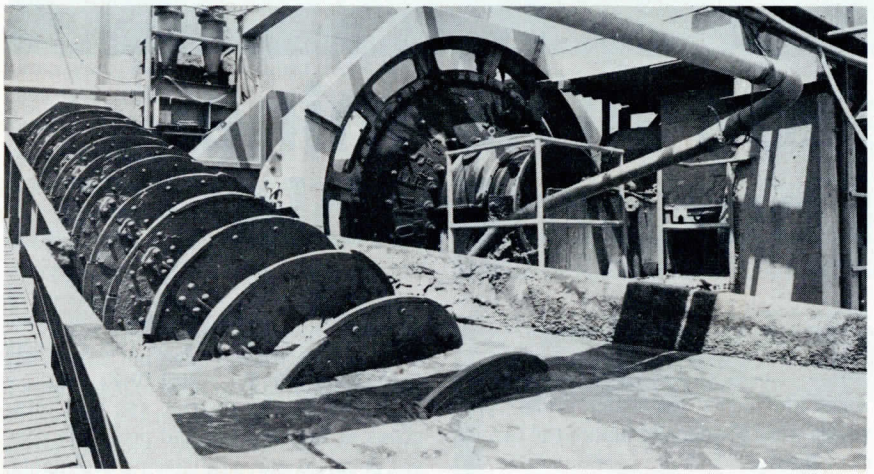
For the subvertical vein bodies cut and fill is the most useful method.

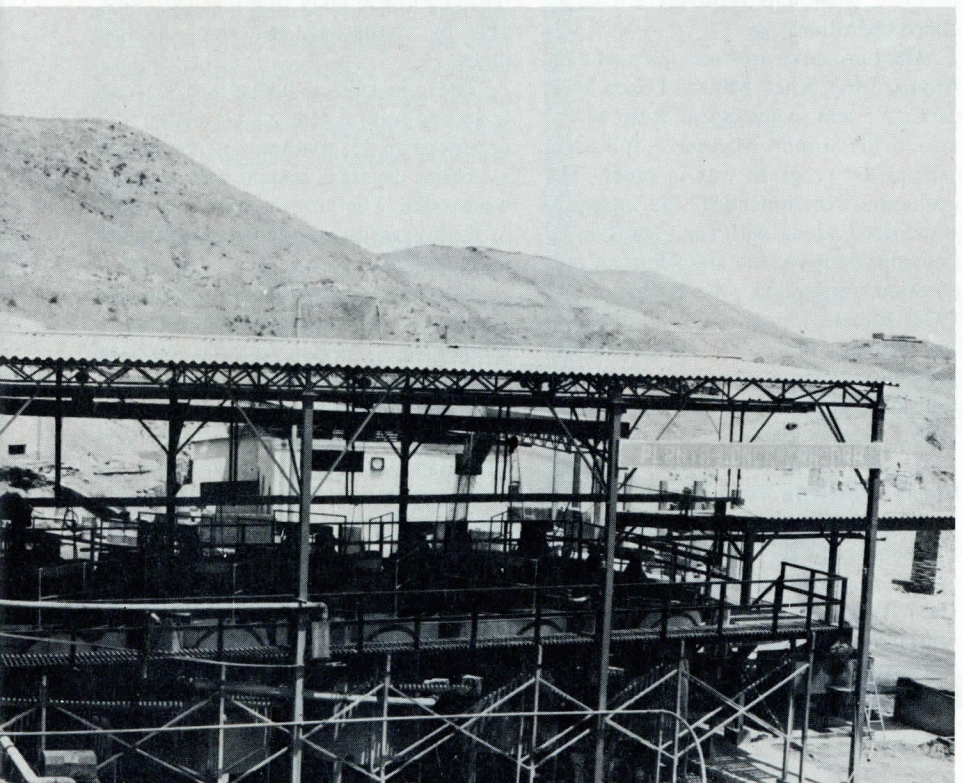
Wagner Scooptrams are used to load ore in the stopes and the ore is hauled up the decline to surface and the mill in 20-ton Kockum trucks.

Although Mina Raúl is small, it is unique in that it is believed to be the only mine in Peru using an all-hydraulic drill jumbo. All the main development drilling for the underground mine and ramps is done by a Tamrock Minimatic twin-boom hydraulic jumbo. The Minimatic is not operated by the mine but by the development contractor, Trans-sub SA, which is entrusted with all this work by Raúl by Patavilca.

The underground mine was started using conventional, small mine tracked methods but has been converted to trackless mechanized operation.

The mine is not deep, the bottom level is minus-100 meters (330 feet), and with large cross section ramp access ventilation is good and mostly natural.





PRIMARY Comesa ball mill in closed circuit with a 5 by 32-foot spiral classifier (above). Note mineral laden froth from recirculating reagents. Below, open air construction on flotation section is possible because of the lack of rain in the Peruvian coastal desert.

Flotation Mill

The 500 daily tons from the underground mine joins the 500 tons from the open pit in the mill bin after dropping through an 18-inch grizzly. The two ore types can also be crushed separately in campaigns and two crushed ore stockpiles are provided. The primary crusher is a Kue Ken 36 by 24-inch jaw unit with 18-inch maximum to 3-inch discharge. The crusher delivers to a ⅜-inch double deck screen which passes undersize to two fines stockpiles while oversize is crushed in a 4.25-foot Symons Standard delivering to a ⅜-inch screen whose oversize is in turn crushed in a 3½-foot Symons Shorthead to produce minus-⅜-inch fine ore for the mill.

The open pit and underground ore can be treated separately in the grinding and flotation sections. The open pit ore section is simplest. Ore is ground in a 9 by 8-foot Comesa (Peru) ball mill in closed circuit with a spiral classifier and hydrocyclone to produce an 80 percent minus-100-mesh pulp.

In the underground ore grinding circuit a primary 8 by 10-foot Denver ball mill operating in open circuit passes its discharge to a classifier working in closed circuit with a 6 by 6-foot Grieve ball mill. The classifier overflow is cycloned and the fine fraction goes to flotation while the coarse fraction is ground in another 6 by 5-foot ball mill.

The two flotation circuits are identical with 12 each SW 240 vertical cells arranged in four stages of primary, rougher, cleaner, and scavenger. Reagents used are Aerofloat 242, 2T-6 xanthate, Frother 65, and lime. Scavenger concentrate is reground in a 4 by 4-foot Denver ball mill.

Concentrate is thickened and filtered on a six-disc Denver filter. Concentrate grade is 25 to 26 percent Cu.

Tailing is pumped out to the tailing pond where it soon dries out. There is no water run off problem as it virtually all evaporates in the desert climate.

The concentrate is trucked to the port of Callao (Lima) for shippnig.

Raúl is not the only copper mine to be developed in the Peruvian coastal belt, although it was the first. Cia. Minera de Condestable, with Japanese financing and management, also developed the nearby, and smaller, Condestable mine.

The primary problem facing any mine in this district is the extreme irregularity and scattered nature of the ore bodies and payshoots. To find ore and build reserves you need a lot of drilling, a lot of drifting, a lot of "nose," and a lot of luck. So far Raúl seems to be doing fine all around. ■