

CORRELATION OF MAP UNITS

sd	SURFICIAL DEPOSITS	QUATERNARY
qt		
qf	VOLCANIC ROCKS	TERTIARY
cr		
art	PREVOLCANIC ROCKS	TERTIARY, CRETACEOUS, SILURIAN, AND ORDOVICIAN
pv		

DESCRIPTION OF MAP UNITS

Surficial deposits

sd Undifferentiated deposits (Quaternary)—Chalky, unconsolidated poorly sorted alluvial sand, gravel, and boulders along stream courses and alluvium, colluvium, and alluvial fans in valley bottoms. Unit includes poorly sorted bedrock-derived materials showing conspicuous earth-flow, block-flow, and block-slide features in landslide masses. Some probable glacial debris.

Volcanic rocks

qf **Quartz latite lava flows**—Local domes, plugs, and thick lava flows with some lenses of breccia and pyroclastics. Composed of light-gray, porphyritic quartz latite or rhyolite containing about 35 percent phenocrysts of plagioclase, sanidine, biotite, and quartz in a dense aphanitic crystallized vitro groundmass. Rocks average about 67 weight percent SiO₂, 15.5 percent Al₂O₃, 3.0-3.5 percent Na₂O, and 4.5 percent K₂O and are petrographically and chemically similar to underlying quartz latite ash-flow tuff (see qt). Largest mass on reentrant dome of Tankha Tankha caldera.

qt **Quartz latite tuff**—Widespread gray to buff, nonwelded to densely welded, crystalline quartz latite ash-flow tuff sheet covering most of volcanic field. Contains plagioclase, sanidine, biotite, and quartz phenocrysts (40-50 percent of rock) in generally devitrified matrix. Rock averages about 68 weight percent SiO₂, 15 percent Al₂O₃, 3.3 percent Na₂O, and 4 percent K₂O. Unit is as much as 300 m thick. Some thick flows or domes, in lower part of unit, exposed in valley eroded along western rim (east of reentrant Tankha Tankha caldera (source of subunit)). Erupted about 6.4 Ma.

cr **Upper rhyolite tuff**—Cordillerite-bearing rhyolite containing 71 weight percent SiO₂, 15 percent Al₂O₃, 3 percent Na₂O, and 4.5 percent K₂O. White, gray, and tan, nonwelded to densely welded ash-flow tuff and associated thick lava flows or near-surface agglutinate deposits. Tuff contains 20-30 percent phenocrysts consisting of plagioclase, sanidine, biotite, quartz, and cordierite in vitro to crystallized matrix. Unit is as much as 200 m thick. Erupted about 6.8 Ma from nearly circular caldera about 5 km in diameter, herein named Condent.

art **Lower rhyolite tuff**—Andesite-bearing, two-mica (biotite and muscovite), white to light-gray, rhyolitic ash-flow tuff. Contains about 72 weight percent SiO₂, 15 percent Al₂O₃, 3 percent Na₂O, and 5 percent K₂O. Tuff contains 20-30 percent phenocrysts including plagioclase, sanidine, quartz, biotite, and muscovite in a mostly devitrified matrix. Also contains numerous pumice fragments, some 20 cm in long dimension. Xenolithic rock fragments of varying size, but mostly less than a few centimeters, common throughout. Radiometric age of 8.4 Ma. Erupted from buried source believed to be within or east of Condent caldera.

Prevolcanic rocks

pv **Undifferentiated basement rocks** (Tertiary, Cretaceous, Silurian, and Ordovician)—Consists mostly of intensely folded and faulted lower Paleozoic (Ordovician and Silurian) marine clastic, locally weakly to moderately metamorphosed sedimentary rocks. Upper Cretaceous and middle Tertiary dacitic to rhyolitic porphyry intrusive masses also present.

EXPLANATION OF MAP SYMBOLS

Hydrothermally altered volcanic rocks

Contact

Fault—Dashed where approximately located. Bar and ball on downthrown side. Arrows indicate movement in cross sections.

Caldera structural margin—Ring-fault zones of Tankha Tankha and Condent calderas. Dashed where approximately located; dotted where concealed.

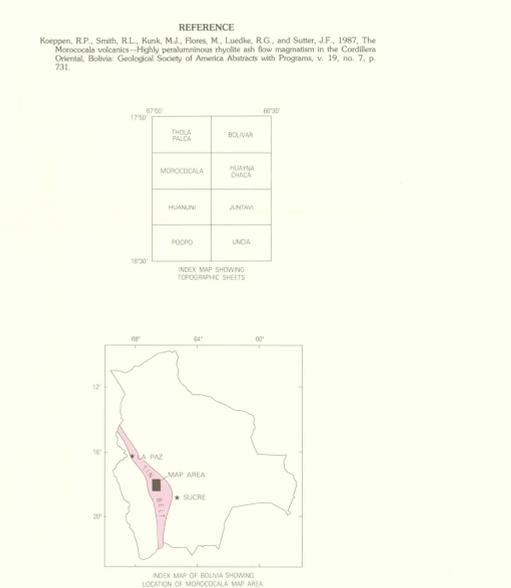
Lineaments—Trends of major fractures, probable faults, and possible dikes. Dashes indicate closely spaced minor fractures and joints. Locations from field mapping and interpretation of aerial photographs.

THE MOROCOCALE VOLCANIC FIELD

The Morococala volcanic field is located within the central and most productive part of the Bolivian tin belt in the eastern Andean cordillera. Two of the largest tin deposits of Bolivia, Huayna Chaca to the west and La Paz to the south, are at or near the margin of the field; other deposits of tin, silver, lead, zinc, and antimony are found in windows of older rocks within it. Similar deposits probably occur elsewhere in the older rocks beneath the volcanic rocks of the field, and other unexposed deposits, particularly tin, may occur within the volcanic rocks themselves. This map is part of a joint study by the Servicio Geológico de Bolivia and the U.S. Geological Survey to evaluate the potential for the existence of such unexposed deposits.

REFERENCE

Koeppen, R.P., Smith, R.L., Kunk, M.J., Flores, M., Laedke, R.G., and Sutter, J.F., 1987, The Morococala volcanics—Highly pernatent rhyolite ash flow magmatism in the Cordillera Oriental, Bolivia. *Geological Society of America Abstracts with Programs*, v. 19, no. 7, p. 731.



Base from the U.S. Geological Survey, 1:50,000; Prepared from Army Map Service (T), Corps of Engineers, U.S. Army, Bolivar (1968), Huayna Chaca (1966), Jordani (1966), Morococala (1966), Popo (1964), India Paz (1966), and Unca (1966). Black numbered lines indicate 1000-meter Universal Transverse Mercator grid zone 19, International spheroid.

SCALE 1:100,000
METERS
KILOMETERS
MILES
CONTOUR INTERVAL 20 METERS

Geology mapped in 1985. Manuscript approved for publication September 14, 1988.



RECONNAISSANCE GEOLOGIC MAP OF THE MOROCOCALE VOLCANIC FIELD, BOLIVIA

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