North Korea, that magnesian Au-bearing skarn may show dolomite followed by marble bearing kotoite [$Mg_3(BO_3)_2$] and ludwigite [$(Mg,Fe^{2+})_2Fe^{3+}BO_5$]; a narrow fluoborite [$Mg_3(BO_3)(F,OH)_3$]-bearing reaction zone marking the contact between skarn and marble; a marked concentration of native gold, bismuth, chalcopyrite, pyrrhotite, and cubanite just inside the reaction zone; diopside; clinohumite; and, finally, diopside partly replaced by phlogopite—all zones developed across 25–35 cm. At the Surprise, Nevada, gold skarn, limonite, fine-grained quartz, copper oxide(s), and calcite occur interstitial to massive garnet; garnet is crosscut and replaced by veins of limonite and chlorite (Schmidt and others, 1988). In this deposit, gold is present as electrum in limonite (fig. 8) associated with quartz, calcite, and secondary copper minerals. The only sulfides remaining in extensively oxidized high-grade ore currently (1989) exposed at the Surprise Mine are pyrite remnants in limonite and tiny blebs of various sulfides encapsulated in late, euhedral quartz crystals. The Buffalo Valley, Nevada, gold skarn shows widespread development of nontronite throughout much of the exposed ore.

Structural Setting

Gold-bearing skarn may occur in the immediate vicinity of, or relatively distal from, weakly mineralized intrusive rocks, commonly where wallrocks are extensively brecciated or faulted (fig. 4). On a local scale, gold-enriched dikes and small plutons astride hinge regions of broad anticlinal arches seem to have been an important structural control (Madrid, 1987). The Bau Mining District, Malaysia, lies along the axis of a major anticline flanked by synclinal basins (Wolfenden, 1965).

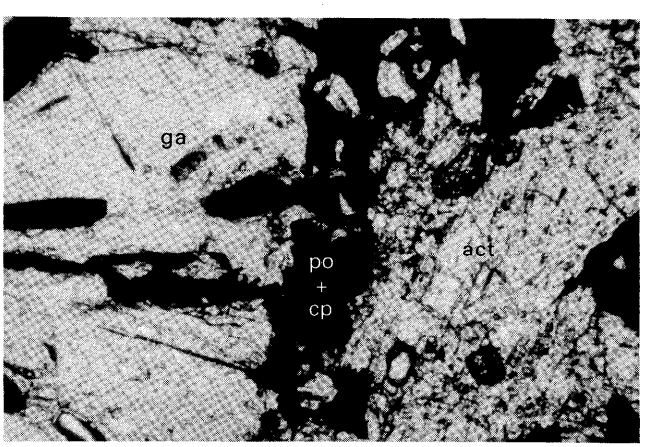

Figure 12. Photomicrograph showing massive garnet (ga), partly replaced by pyrrhotite (po) and chalcopyrite (cp) and separated from a pod of actinolite (act) grains by pyrrhotite; Fortitude Mine, Nevada.

Dimensions of Ore in Typical Deposits

Overall dimensions of ore in Au-bearing skarn are highly variable; dimensions possibly increase with distance from the genetically associated intrusive rock and as grade decreases. Geologic configuration of such deposits is largely a function of respective geometries of mineralizing magma and premineralization structures, favorable replacement sequences, and impermeable barriers to fluid flow, if present. However, eventual configuration of economic dimensions of deposits results from cut-off grades that are influenced highly by factors such as pre-mining topography (R.G. Russell, written commun., 1989).

Dimensions of Alteration or Distinctive Haloes

Alteration haloes that surround Au-bearing skarn are highly variable in size, from very restricted to as much as several kilometers from inferred loci of mineralizing systems. In some systems, the overall size of the alteration zone has been enhanced by the presence of premineralization structures that channeled fluid flow. Nonetheless, in a largely carbonate terrane, the Au-bearing skarns are almost always found within the outer limit of conversion of carbonate sequences to marble.

Effect of Weathering

The economic limits of some deposits are entirely within the oxide zone. In fact, gold grade is commonly higher in the oxide zone than in the equivalent sulfide zone. The oxide zone in some deposits includes coarsely crystalline vivianite along fractures in areas showing limited overall amounts of iron oxide development and limited amounts of subjacent iron sulfide(s) (R.G. Benson, written commun., 1988). At the McCoy, Nevada, Au-skarn, samples from the 5,080-ft bench show some extremely small, micrometer-sized crystals of greenockite (CdS) concentrated at interfaces between chalcopyrite and chalcocite. In this deposit, some chalcocite also appears to be associated paragenetically with a silver-selenide mineral, possibly $Ag_2(S, Se)$. Nontronite layers are commonly interbedded with some garnet skarn and locally concentrated along fractures in some deposits. At Browns Creek, Australia, gold-bearing nontronite was the major target of mining activity inasmuch as it typically contained greater than 10 g/t gold (Creelman and others, 1988). The term "nontronite" is used as a field term for iron-rich, yellow-green montmorillonite that swells upon treatment with ethylene glycol; a Mössbauer spectrometic study of one such clay from skarn in the Harmony Formation near the Surprise Mine shows that nearly all of the iron present in the sample is ferric iron. Thus, nontronite is the main component of the clay layer there. Clay layers include