quartz and calcite and may include relict skarn silicates (pyroxene, garnet, and epidote). Oxidized karst-collapse breccia developed in marble as a result of marble reacting with acidic ground water at Red Dome (Torrey and others, 1986). At this deposit, acidic ground water probably resulted from breakdown of sulfides in the surrounding pyritic halo of the Au-skarn.

Effect of Metamorphism

Gold-bearing skarn systems could undergo regional metamorphism to yield gneiss-hosted Au deposits with a resultant loss of most contact-metasomatic features. The Tumco deposit, California, which has been metamorphosed to amphibolite grade and is provisionally included by us with Au-bearing skarn (Smith and Graubard, 1987; Tosdal and Smith, 1987), may be an example of such a process. However, some relatively extensive tin-tungsten-base-metal skarns in Alaska show readily recognizable prograde and retrograde contact-metasomatic assemblages through a superposed greenschist dynamothermal event (Newberry and others, 1986). In these Sn skarns, strain is confined largely to 1-m-wide zones at the margins of skarn where calc-silicate porphyroclastic mylonite is present. Skarn away from the contact shows some kinked chalcopyrite-bornite exsolution lamellae, but no cleavage or foliation. The Falun deposit in Sweden is hosted by Proterozoic granite, amphibolite, and quartz porphyry (Grip, 1978). Greenstone-hosted Au-Ag-W-As deposits in the Southern Cross greenstone belt of western Australia may represent Archean analogues of Phanerozoic gold skarn deposits (Mueller, 1988).

Geochemical Signatures

Geochemical signatures for Au-bearing skarn include anomalous gold primarily in an environment of retrograde-altered, sulfidized skarn. The associated pyrite in some Au-skarn deposits is reported to contain 0.1 to 250 ppm Au (Vakhrushev, 1972). At Bau, Malaysia, anomalous antimony (in stibnite) and arsenic (in scorodite) are present with gold in wollastonite-bearing skarn assemblages and in colloform-banded quartz and jasperoid, all distal to quartz- and calcite-flooded, calc-silicate gold ore (Wolfenden, 1965; W.C. Bagby, oral commun., 1987). In other Au-bearing skarn systems, quartz-calcite veins contain anomalous gold. In addition, gold mineralization and highly anomalous concentrations of gold in some skarn systems (Akshiryak Range, U.S.S.R.) are found mostly in fine-grained, gray to light-gray, highly silicified sequences of rock in carbonate beyond the outer limit of established skarn (Dolzhenko, 1974). Many Au-bearing skarns in British Columbia contain elevated abundances of arsenic, bismuth, and tellurium (Ray and others, 1987b; Ettlinger and Ray, 1989). The bismuth minerals reported from some Au-skarns include native bismuth, bismuthinite, wittichenite, hedleyite, maldonite, and Bi-bearing galena (Meinert, 1988b). Theodore and others (1989) report major-element and trace-element data for garnet skarns associated with gold mineralization at Copper Basin, Nevada, including low-grade, oxidized ore from the Surprise Mine (29 ppb Au, 6 ppm Ag, <10 ppm Bi, 57 ppm As, 4 ppm Sb, 3 ppm Co, 25 ppm Cu). Finally, surface expression of some Au-skarn systems (Red Dome, Australia; Surprise, Nevada) includes relatively abundant, fracture-controlled secondary copper minerals (Torrey and others, 1986; Schimdt and others, 1988).

The Au/Ag ratio in rock apparently increases laterally outward (away from the center of the associated intrusion) in some productive copper-bearing calcic skarn systems toward ore (Fortitude, Nevada) that is approximately 0.6 km from the exposed, genetically associated intrusion. The Fortitude Au-skarn is close to a relatively sharp boundary between marble and sulfidized calc-silicates (Blake and others, 1984; Theodore and others, 1986; Wotruba and others, 1987a, b; Myers and Meinert, 1988). In other Au-skarn systems that are predominantly zoned vertically close to the related intrusive rocks (Red Dome, Australia), much of the gold ore is near the original intrusion-wallrock contact and interior to massive magnetite developed at the calc-silicate-marble interface (Torrey and others, 1986). Surrounding rocks in many systems typically show high local thresholds for many associated base and ferrous metals and, for some deposits, arsenic, bismuth, selenium, and tellurium values in particular may be relatively high both within and peripheral to the Au-bearing skarn (Ray and others, 1987b).

Zonation of gold in Au- and Pb-Zn-bearing skarn (Ban Ban, Australia; Thanksgiving, Philippines; Tomboy-Minnie, Nevada) seems to show inconsistent patterns. At Ban Ban, gold in unreported trace abundances may coincide with known distribution of silver, which varies directly with lead and zinc concentrations that are, in turn, constrained tightly to the central part of associated garnet skarn (Ashley, 1980). At Thanksgiving, irregularly distributed sphalerite-pyrite pods that replace andradite skarn show higher gold contents than pyrite-magnetite replacement pods (Callow, 1967). At Tomboy-Minnie, local metal zoning of the gold orebodies shows high concentrations of gold (more than 0.05 troy oz/ton or more than 1.7 g/t); these high concentrations of gold show increased abundances of zinc and silver (more than 500 ppm and more than 0.1 troy oz/ton, or more than 3.4 g/t respectively) on the granodiorite side of the gold orebody. Such metal-zoning relations constitute a local reversal of the district-wide zoning from Cu+Au+Ag, through Au+Ag, to finally Pb+Zn+Ag (Theodore and others, 1986).

Zonation of gold in some Fe-skarn systems that contain byproduct gold (Benson Lake, British Columbia) seems to be related directly to the abundance of sulfide