"greater than" in tables 2 and 3 were used in statistical calculations and graphs of data described below. This results in two tonnage values, one gold grade value, and two silver grade values being substituted by an unqualified numerical value. Values qualified as "less than" were not considered further in either statistical calculations or graphs of data. Iron skarn dominates the mineralized skarns worldwide, comprising approximately one-third of the deposits; however, gold contents for most of these skarns were reported in the literature as "trace," "minor," or "detectable." Only two deposits of iron skarn with grade and tonnage figures reported average gold grades exceeding 1 g/t (table 3), and 11 deposits reported grades lower than 1 g/t as deposit averages or in selected parts of a compositionally zoned skarn body. In a comprehensive data compilation for Alaskan skarns, Newberry (1986) classified 109 deposits as Fe-Au-skarns. He reported typical grades for these deposits of 40 percent Fe, 1 percent Cu, 0.1 oz Au per ton (3.4 g/t), 10 oz Ag per ton (343 g/t), and 50 ppm Co.

Several additional deposits have been described as gold skarns in one or more publications listed in the bibliography but were not included in the above tables for the following reasons: inadequate description of the deposit; inaccessibility to the publication; description(s) of the deposit showed the deposit to be inappropriately classified as a gold-bearing skarn according to the classification scheme we have adopted; or the gold grade was less than 1 g/t. These deposits include: Tennant Creek, Australia; Landusky-Zortman, Montana; Ertsberg, Indonesia; Andacollo, Chile; Equity (Sam Goosly), British Columbia; Salsigne, France; Pamlico, Nevada; Red Cloud, Nevada; Island Copper, British Columbia; and others. Ertsberg has an average gold grade below 1 g/t. Wedekind (1988) and Wedekind and others (1988) did not include garnet or pyroxene as part of the composite mineral assemblages of the deposits at Tennant Creek. Andacollo has been cited under other deposit types, and a detailed geologic description of the area is not available. Inappropriate or alternate classification of deposits and (or) lack of detailed geologic data have excluded the other deposits. Some deposits with grade and tonnage data reported were placed in table 4 because the tonnage and grade information conflicted with other known data and we were unable to resolve the conflict; an example of this situation is Mt. Biggenden, Australia. Although the Mt. Biggenden magnetite-bismuth-gold skarn is classified as an Au-skarn by Meinert (1988a) and assigned a size of 500,000 tons and a gold grade of 15 g/t, we have not included it with either our Au-skarn or byproduct Au-skarn subtypes primarily because of our uncertainty about the gold grade and tonnage of mined ore. For example, total gold production to 1969 from Mt. Biggenden is more than 7,000 oz, of which 5,751 oz was produced before 1901 (Clarke, 1969). The corresponding tonnage of ore mined is not reported. As of 1917, Dunstan (1917) calculated magnetite ore reserves as 500,000 tons, which apparently includes only "a few grains of gold per ton" (Clarke, 1969), because all of the "actinolite rock" that contained most of the gold and bismuth had been already mined out by that time. If 500,000 tons is a correct tonnage for the gold ore, then 14,500 oz of total gold production is required for an average grade of 1 g/t, and over 200,000 oz of production would be needed for a grade of 15 g/t. If the grade of 15 g/t is correct, 7,000 oz of gold could have been produced from about 16,000 tons of ore.

Pegasus Gold Corporation's Beal Gold deposit in the Siberia Mining District near Butte, Montana, described as a 9.2-million-tonne, low-grade (1.509 g/t Au), bulk minable precious-metal reserve (Hastings and Harrold, 1989), has some characteristics of skarn (N. Eric Fier, oral commun., 1989), but shows no extensive calcsilicate exoskarn gangue mineral assemblage at the present levels of exposure. Precious metals and sulfides (pyrrhotite, pyrite, chalcopyrite, trace arsenopyrite and molybdenite) are disseminated in metaconglomerate, quartzite, diopside hornfels, and potassium feldspar hornfels and also are present in veins with chlorite, quartz, adularia, and carbonate minerals. Gold is present as free gold and in association with Pb- and Bi-tellurides.

GEOLOGY

General Deposit Definition

Smirnov (1976) suggested that classification of skarns be based upon the composition of the original protolith of the skarn: calcareous, magnesian, or silicate. However, we follow the nongenetic definition of skarn proposed by Einaudi and others (1981): "replacement of carbonate [or other sedimentary or igneous rocks] by Ca-Fe-Mg-Mn silicates [resulting from] (1) metamorphic recrystallization of silica-carbonate rocks, (2) local exchange of components between unlike lithologies during high-grade regional or contact metamorphism, (3) local exchange at high temperatures of components between magmas and carbonate rocks, and (4) large-scale transfer of components over a broad temperature range between hydrothermal fluids ***and predominantly carbonate rocks." Most Au-bearing skarns owe their genesis to processes largely involving the fourth process. Thus we follow an overall classification of skarns based upon their sought-for metal content (see also Shimazaki, 1981, and Zharikov, 1970).

As recognized by Meinert (1988a), many deposits referred to as Au-skarns in the literature have been classified, or could be classified, under skarn deposit models such as Cu- and Fe-skarns by their dominant base- or ferrous-metal contents. For these deposits, gold production may be considered a byproduct of base- or ferrous-metal mining. Furthermore, Au-bearing skarn deposits commonly may be gradational into skarn that contains no gold but does contain significant other metal(s), including the Ag-rich skarns as defined by Ray and others (1986a), sediment-hosted disseminated Au-Ag deposits (also known as carbonate-hosted and Carlin-type), porphyry Cu or Cu-Mo deposits, or polymetallic replacement deposits (exemplified by the McCoy megasystem in Nevada), as well as other deposit types related to felsic to intermediate plutonic emplacement or volcanic activity. The Cove deposit, McCoy Mining District, Nevada, has been classified recently as a distal disseminated Ag-Au deposit according to a scheme proposed by Dennis P. Cox (written commun., 1989). Polymetallic veins are one of the other deposit types that may be present on the fringes of Au-bearing skarn deposits. Therefore, we have chosen to use the term "Au-bearing" skarn as most aptly describing such skarn deposits and related mineralization commonly distal to the immediate contact zone. Other commodities produced by Au-bearing skarns include silver, copper, zinc, iron, lead, arsenic, bismuth, tungsten, and tin as principal or byproduct commodities and cobalt, cadmium, and sulfur as byproducts.

In addition, we have provisionally restricted our working model of this deposit type to those Au-bearing skarns that have more than 1 g/t gold. This figure is based largely on cutoff grades that were reported as low as 1 g/t for many Au-bearing skarn operations in production in 1988 that required milling of their ore to a very fine grain size for efficient gold recovery. Some Au-skarn operations, such as McCoy, Nevada, that utilize heap-leach extraction procedures for their ores, have cutoff grades as low as 0.3 g/t for oxidized ore (Bruce A. Kuyper, oral commun., 1987), but the average deposit grade is greater than 1 g/t. Deposits with average gold grades below 1 g/t and without other economic mineralization are rarely reported in a quantitative manner in the literature and thus result in an artificially truncated data set. In an attempt to limit the influence of this reporting problem when comparing Au-bearing subsets, we have limited all our data to those with gold concentrations greater than 1 g/t or reasonably inferred by cited reporters to be greater than 1 g/t.

Gold-bearing skarns are generally calcic exoskarns with gold associated with intense retrograde hydrosilicate alteration, although Au-bearing magnesian skarns are known and in some areas are dominant. Some economically significant Au-bearing skarns (Hedley, British Columbia, and Suian, South Korea), however, are partly in endoskarn (Barr, 1980; see also Lee, 1951; Lee, 1981). Reported pyrrhotite, chalcopyrite, and "augite" enclosed in quartz monzonite at the Golden Curry deposit, Montana, may be endoskarn (Knopf, 1913; Pardee and Schrader, 1933). Significant concentrations of gold-bearing endoskarn also are present at the Nambija, Ecuador, Au-skarn deposit (table 4). In some districts, our data set includes deposits that are significantly distant from igneous contacts at current levels of erosion but still exhibit high-temperature, prograde mineral assemblages composed of garnet and (or) pyroxene. Gold-bearing skarns show diverse geometric relations to genetically associated intrusive rocks and nearby premetallization structures (fig. 4).

As presently constituted (tables 2, 3), our compilation includes some deposits that were previously considered as Cu, Fe, or Zn-Pb skarns in the classification schemes of Einaudi and others (1981) and Meinert (1988a). In some cases when establishing deposit size or grade, we have included other styles of genetically related, generally late-stage mineralization adjacent or continuous to known skarn mineralization under the size estimate and description of the Au-bearing skarn deposit when demarcation between the mineralization styles would be arbitrary.

Associated Deposits

Deposit types most commonly associated with Au-bearing skarn include Cu, Fe, Zn-Pb, and porphyry Cu skarn-related deposits. Other deposit types include porphyry Cu-Mo or Cu-Au deposits, porphyry Cu deposits, carbonate-hosted Au-Ag (see Sillitoe, 1983), polymetallic replacement and polymetallic veins, distal disseminated Ag-Au deposits (Dennis P. Cox, written commun., 1989), W skarns, Sn skarns and greisens, Au placers, and other deposits related to felsic and intermediate intrusions (Cox and Singer, 1986), including stockwork molybdenum systems such as at Red Dome, Australia, and Buckingham, Nevada. The Carissa and the Surprise Cu-Au-Ag skarn deposits are on the northern fringes of the Late Cretaceous (86 Ma) Buckingham, Nevada, stockwork molybdenum system, and they appear to be related genetically to emplacement of potassic-altered monzogranite porphyry (Schmidt and others, 1988; Theodore and others, 1989). Other examples of deposits associated with Au-skarn include skarn mineralization at Katanga, Peru, which becomes porphyry Cu-Mo mineralization at depth, and the deposit at Bau, Indonesia, that includes a large component of sediment-hosted gold mineralization as well as that hosted by skarn. Other areas that probably document transition from a skarn environment into mostly sediment-hosted systems are silver and gold mineralization at the McCoy-Cove mineralized system in north-central Nevada, gold mineralization in the general area of the Broadway, Montana, Au-skarn deposit (Sahinen, 1939), and mostly gold at the Kavak-tau area in Kirghiziya, U.S.S.R. (Dolzhenko, 1974). Near the Broadway deposit and other nearby Au-skarn-related occurrences, Au-bearing jasperoid mantles epidote-rich endoskarn that formed at the contact of Cretaceous quartz monzonite and Cambrian limestone (Sahinen, 1939). At Kavaktau, most of the gold mineralization is apparently associated with "secondary silicates," probably jasperoids in North American terminology, that are present in marble and silicate-carbonate rock beyond the outer limit of well-developed skarn assemblages. Placer gold deposits are found associated with