associated with magnetite (Eastwood, 1965). At the Merry Widow pit of the Benson Lake cluster of magnetite skarns, concentrates of chalcopyrite were reported to contain as much as 1 oz gold per ton of chalcopyrite.

Significant concentrations of gold have been reported, although specifics are unavailable, in many of the Paleozoic W skarns in the Soviet Union (table 4). Gold is an associated minor metal in approximately one-half of the W-skarn deposits in the Ural Mountains, U.S.S.R. (Rabchevsky, 1988). These skarns are reported to be associated with Devonian- to Permian-age granitoid bodies (Rabchevksy, 1988). In addition, selected samples of Mesozoic W skarns from Alaska are reported to contain as much as 30 ppm gold (R.J. Newberry, oral commun., 1987; Newberry and others, 1987). Tin skarns in China and Australia have reported significant Au or Au-enriched areas (see Stormont and Ge Jiou, table 4).

At a more detailed level, nontronite layers from some Au-bearing, calcic skarn deposits show significant concentrations of silver and copper and variable, but enhanced levels of other trace elements, such as tin (table 8). Spectral analyses of garnets from four Au-bearing skarn deposits in the Altai-Sayan study (Vakhrushev, 1972) show trace-element signatures distinct from those of garnets from Fe skarns: copper and zinc (tens to hundreds of parts per million), molybdenum, scandium, gallium, and tin (10 to 50 ppm each) are present in all the garnets from Au-skarn; some garnets carry several hundred parts per million arsenic, as much as 30 ppm lead, and similar concentrations of silver as well. In contrast, garnets from Fe skarns have titanium, chromium, vanadium, nickel, cobalt, and germanium as a characteristic trace-element suite and lack the elements associated with Au-skarn garnets or show inconsistent distributions of them.

The single report of platinum associated with gold skarn that we found is in northern Sumatra, where Bowles and others (1985) described a reference to 8 ppm Pt and 4 ppm Au in wollastonite-garnet skarn; however, they point out that some confusion exists over the precise locality of the occurrence.

Isotopic Signatures

Isotopic data are not available for a great number of Au-bearing skarns. However, the range in $\delta^{34}S$ values for sulfides is clustered tightly in one examined system: +2.7 to +4.7 permil for the Tomboy-Minnie deposit (Theodore and others, 1986). Such values suggest a magmatic source, and minimal contribution from heavy, crustal sulfur that was highly homogenized. An associated Cu skarn adjacent to the intrusion, the West orebody, shows more scattered values of $\delta^{34}S$, +1.1 to +5.1, in sulfides there, possibly reflecting disequilibria resulting from passage of retrograde fluids. Derivation of the associated altered granodiorite apparently was primarily from crustal components, to judge from initial neodymium isotopic compositions (Farmer and DePaolo, 1984).

Fluid Inclusions

Boiling, high-salinity fluids are associated with the early, prograde paragenetic stages of many Au-bearing skarn systems. The fluid-inclusion signature of skarn probably is most easily inferred from fluid inclusions trapped in quartz in the associated intrusive rocks if optical limitations preclude study of fluid inclusions in garnet or pyroxene. For example, possible involvement of high-salinity fluids some time during the generation of Au-bearing skarn may be implied by occurrence of halite-bearing fluid inclusions in quartz phenocrysts of a genetically associated granitoid. In some deposits (Tomboy-Minnie, Nevada), early fluids associated with diopside-quartz assemblages were dominantly $CaCl_2$-brines and were boiling at temperatures higher than 500 °C. Fluids then were progressively enriched in sodium and potassium over time, and during hydrosilicate stages, temperatures ranged from 320 to 500 °C at the time actinolite formed, and from 220 to 320 °C at the time chlorite became dominant in the assemblages (Theodore and others, 1986). Much of the gold is paragenetically late, deposited from NaCl-rich brines at temperatures less than 300 °C. However, genetic association of highly saline brines with skarn does not guarantee presence of a metal-bearing deposit somewhere in the environment of the skarn. Some Tertiary garnet-pyroxene skarn in the northern Battle Mountain Mining District shows fluid-inclusion signatures highly suggestive of many porphyry copper systems, yet the skarn is barren of any associated metal deposits (Theodore and Hammarstrom, 1989). At the Fortitude, Nevada, deposit, initial fluid-inclusion studies indicate that the Au-skarn was formed by fluids ranging from 300 to 450 °C and with salinities much less than 26 weight percent NaCl equivalent (Myers and Meinert, 1988). At Red Dome, Australia, copper-gold-silver ores apparently were deposited during a retrograde stage attendant with the circulation of relatively low-salinity (less than 10 weight percent NaCl equivalent), possibly meteoric-dominant fluids at temperatures in excess of 350–380 °C (Torrey and others, 1986; Ewers and Sun, 1988). In other skarn systems, gold also was deposited mostly during low-temperature stages: Alae-Sayan, U.S.S.R. (250–150 °C), Central Tadzhikistan, U.S.S.R. (350–250 °C), Sayakskig, U.S.S.R. (greater than 250–225 °C), and Kochulak, U.S.S.R. (270–240 °C; 190–170 °C) (table 4). Deposition of most gold close to the calc-silicate-marble interface, as reported in many Au-bearing skarns (Myers and Meinert, 1988), may reflect a combination of protracted solubility of gold in bisulfide complexes and build-up of HCO_3^- in the fringe environment of evolving skarn (Gumenyuk and Glyuk, 1983), thereby decreasing the