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 copper and gold deposits of the Battle Mountain Mining District, Nevada, of the Helena, Bannack, and Cable Mining Districts, Montana, and in the Zeballos area, Vancouver Island, British Columbia. Gradational changes from Au-bearing skarn mineralization to another deposit type (Myers and Meinert, 1988), relatively small areas of gold enrichment within or peripheral to base- or ferrous-metal skarn mineralization, the presence of minerals that can be attributed to weak or distal development of skarn in deposit types not in a contact-metamorphic aureole, and continuous gold mineralization through multiple deposit types related to a single intrusion or series of events are common to Au-bearing skarn environments. In many gold-enriched skarn deposits of British Columbia, Ettlinger and Ray (1988) noted multiple types of gold mineralization within single deposits. For example, at the Discovery deposit at Banks Island, gold is present in skarn with massive pyrrhotite that replaces marble, as well as in brecciated quartz-pyrite veins that cross-cut skarn and marble. Ettlinger and Ray suggested that skarn and quartz-pyrite mineralization may be genetically linked. Similarly, high-grade gold mineralization (Parnell gold shoot) overprints earlier formed copper-gold skarn at Carr Fork in the Bingham district, Utah (Cameron and Garmoe, 1987).

Further studies are needed to address the problem of whether all of the gold, or some of the gold in a few deposits, represented a much later epithermal overprint on an earlier skarn system or was deposited as a continuum near the final stages of the skarn process along structures that permitted extensive development of retrograde assemblages.

In a number of mining districts that contain gold skarn deposits, ore deposits are zoned from a core area (sometimes, but not always, a porphyry copper or other stock) of Cu±Au and Ag mineralization, to an intermediate zone of Au-skarn or other types of gold mineralization, to an outermost area of dominantly Zn+Pb+Ag±Au mineralization. Blake and others (1984) demonstrated such a zonation about the middle Tertiary altered granodiorite stock of Copper Canyon in the Battle Mountain Mining District, Nevada, where the Tomboy-Minnie and Fortitude gold skarn deposits lie between an area of Cu+Au+Ag and Pb+Zn+Ag mineralization. El-Shatoury and Whelan (1970) described a zonal arrangement of ore deposits in the Gold Hill Mining District, Utah, from a central zone of W+Mo+Cu, through Cu, Cu+Au, Cu+Pb+As and Pb+Zn+Au mineralization. The Alvarado, Cane Spring, and Bonnemort skarn deposits all lie within the Cu+Au zone in the Gold Hill Mining District. In the Elkhorn Mining District,

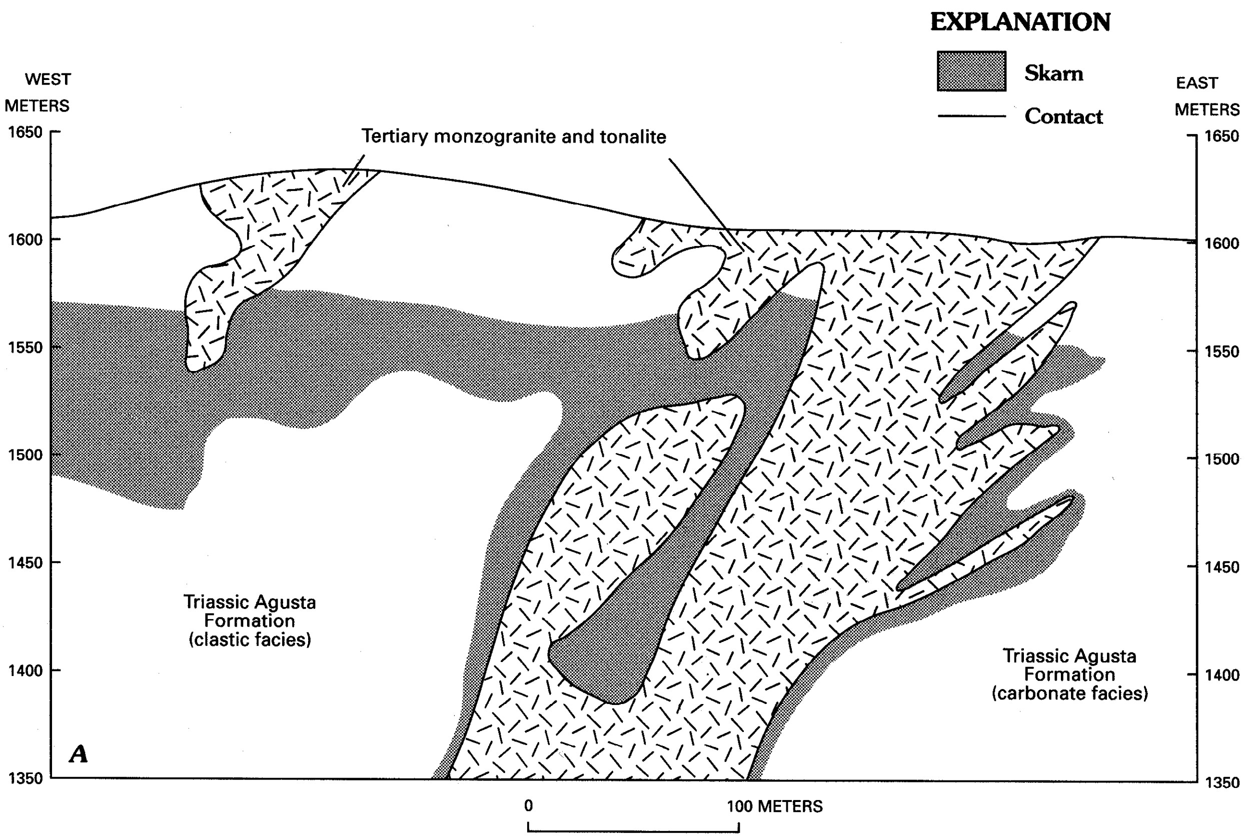

Figure 4. Schematic cross sections of Au-skarn deposits in north-central Nevada. *A*, McCoy Mine, modified from Lane (1987). *B*, Fortitude Mine, modified from Myers (1988). *C*, Surprise Mine, modified from Schmidt and others (1988).

Montana (Klepper and others, 1957), the distribution of deposits around the eastern edge of the stock of the Black Butte area suggests that the Klondyke and Dolcoath gold skarn deposits, and possibly the Golden Curry deposit to the west, represent a gold-rich zone interior to a zone of Pb+Ag mineralization.

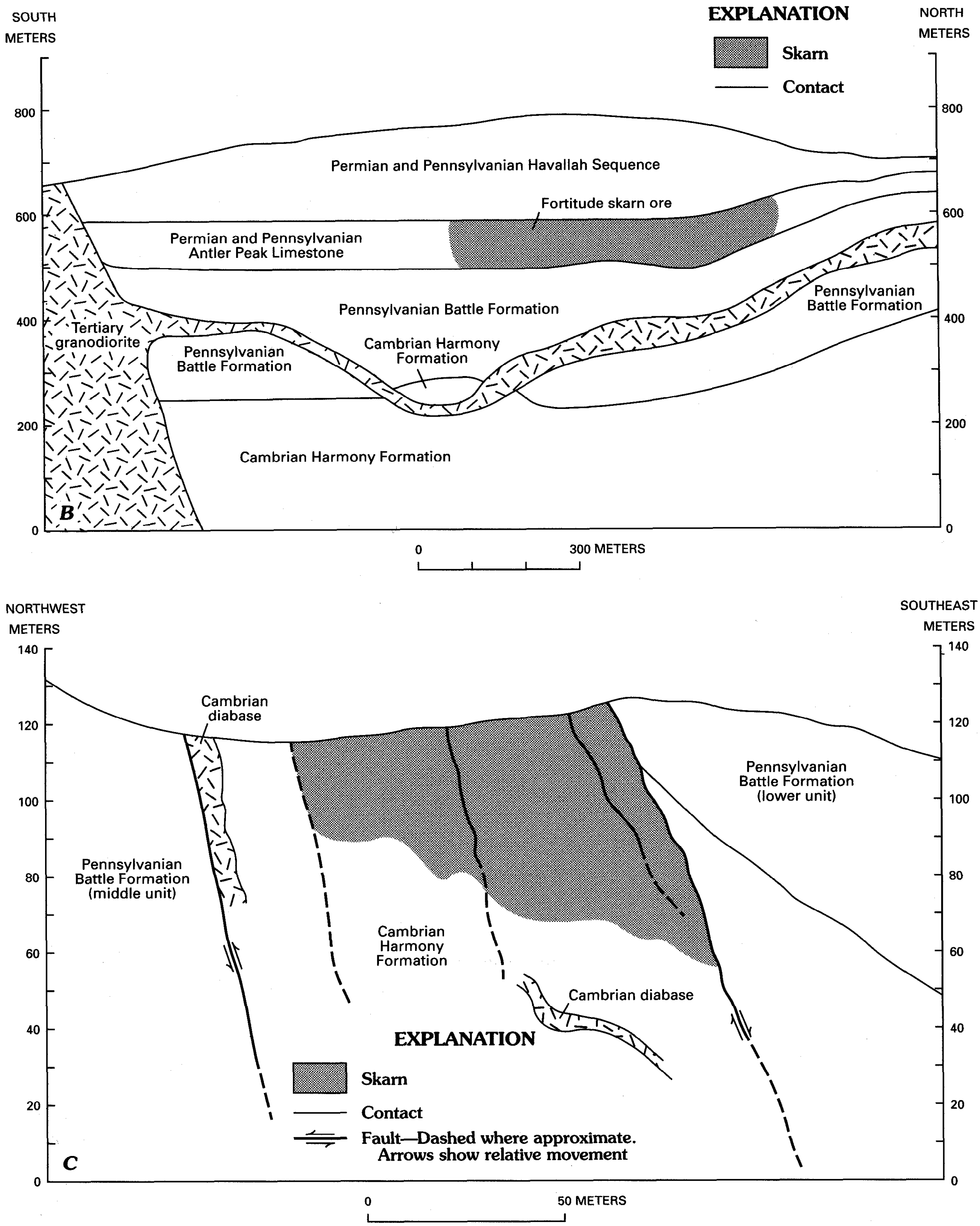

Figure 4. Continued.