

Dolomite: magnetite-serpentine skarn with minor bornite and relics of dolomite; garnet skarn with minor diopside and epidote which is locally absent or only a few feet thick; quartz diorite generally without endoskarn. Locally bleached pyritic siltstone with pyrite-chalcopyrite veinlets separates the magnetite-serpentine skarn from the quartz diorite (Fig. 22). Approximately 140 tons of high grade Cu ore with values in Au and anomalous As, Co and Ni were taken from the old workings (Kindle, 1964). No ore has been defined elsewhere in the Valerie area.

The difference in skarn mineral assemblages in different parts of the Valerie area can be explained by the different compositions of the host rocks. In particular, the association pyrite-pyrrhotite-chalcopyrite in dolomitic limestone compared with magnetite-bornite in dolomite can be explained by the presence of carbon in the dolomitic limestone. The conversion of carbon to carbon dioxide causes reduction of the ore-forming fluid leading to precipitation of more reduced species where carbon is present (Yui, 1966).

### 5.3.2 Cu Fe (Au Ag) deposits

The Cu Fe (Au Ag) deposits are magnetite skarns that may or may not contain recoverable quantities of Au and Ag. The Arctic Chief deposit, which had the highest Au and Ag grade in the copper belt, has a skarn zoning sequence similar to that at Little Chief but is in dolomitic limestone at an open contact. The Suburban and Verona occurrences have the same setting as Arctic Chief but the ore is localised in and adjacent to beds of pyritic siltstone between the batholith and dolomitic limestone or within the dolomitic limestone. The ore at Best Chance and Grafter is also in and adjacent to pyritic siltstone beds

within the dolomitic limestone and the overall skarn sequence is similar to the upper skarn zone in the Gem-Brown Cub area. The Pueblo deposit is a specular hematite skarn localised in faults within a skarn zone that is otherwise similar to those at some Cu occurrences. Overall, the Cu Fe (Au Ag) deposits are transitional in setting between the Cu Fe Au Ag deposits and the Cu occurrences.

#### Arctic Chief

The Arctic Chief Cu Fe Au Ag (Mo) deposit and the geologically similar Suburban and Verona Cu Fe occurrences are within a large U-shaped pendant in the central part of the copper belt (Fig. 16). The north-trending pendant is approximately 3000 feet long by 1500 feet wide by 1700 feet deep. It is bound to the west by a bulbous apophysis of hornblende diorite and to the east by the inward dipping contact of the batholith. The pendant tapers to the south and is cut off to the north by the east-trending Iron Horse fault (Fig. 23). The core of the pendant is the limestone sub-facies of facies b of the Interbedded unit. It is everywhere underlain by the dolomitic limestone sub-facies which in turn is locally underlain by Pyritic Siltstone and Sandstone adjacent to the batholith and apophyse. The distribution and attitude of the units suggest the pendant is a syncline in which the sedimentary units are approximately parallel to the intrusive contact (Fig. 23). The mineral occurrences are localised by embayments within the pendant margin, are all within 200 feet of the contact, and are all hosted in the dolomitic subfacies close to but not at its contact with the Pyritic Siltstone (Fig. 24).

Although complicated by small scale faulting and folding in the open pits there is a consistent sequence of alteration, skarn zones and

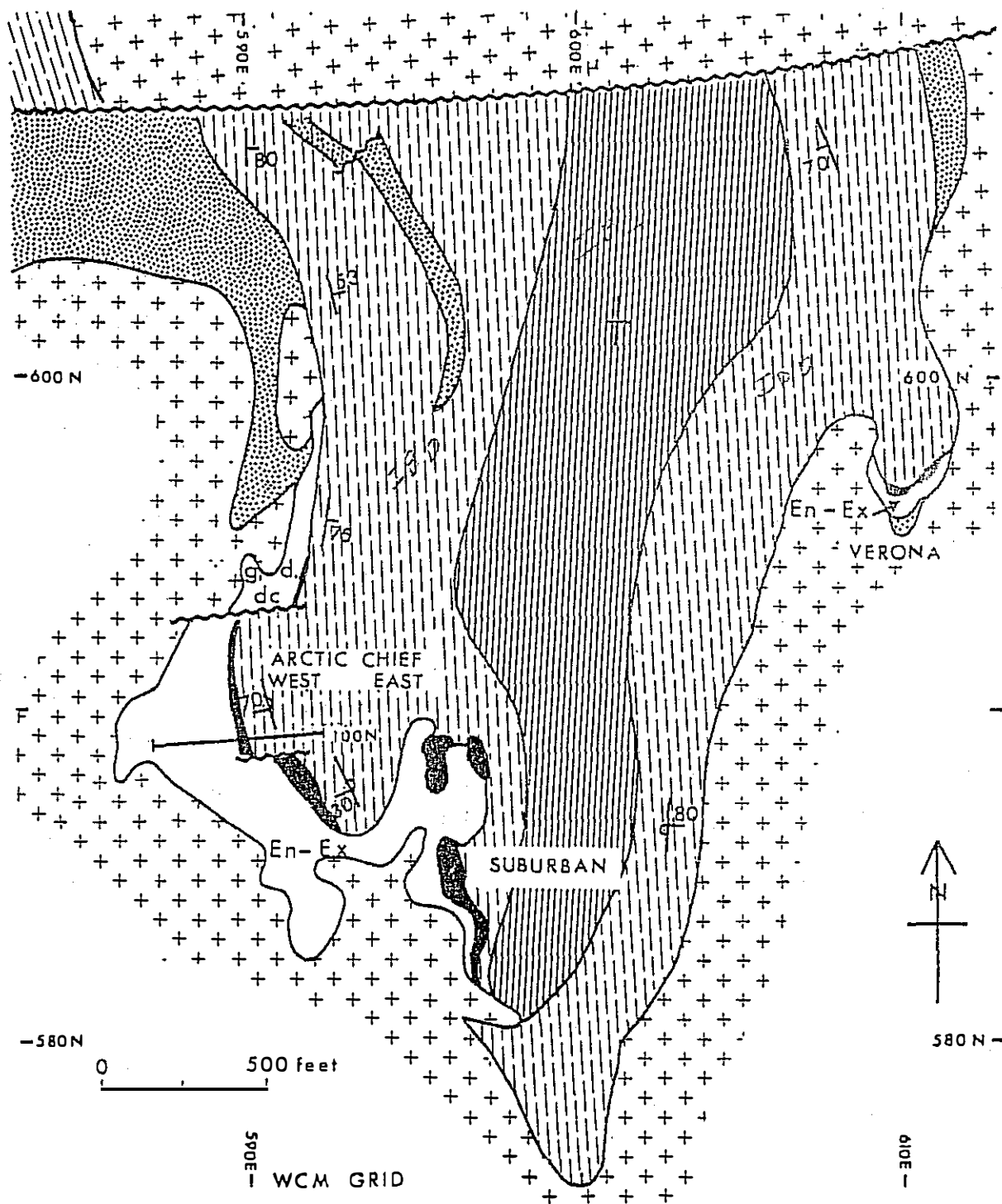


Figure 23: Simplified geologic map of the Arctic Chief pendant. The pendant is bound by the batholith in the east and an apophyse in the west and has a synclinal form. The Cu Fe (Au Ag) deposits are associated with irregularities in the pendant margin and are all hosted in the dolomitic limestone sub-facies of facies b of the Interbedded unit. The unit En-Ex includes all the recognised varieties of endoskarn plus garnet, diopside and diopside-calcite exoskarn zoned as shown in Fig. 24.

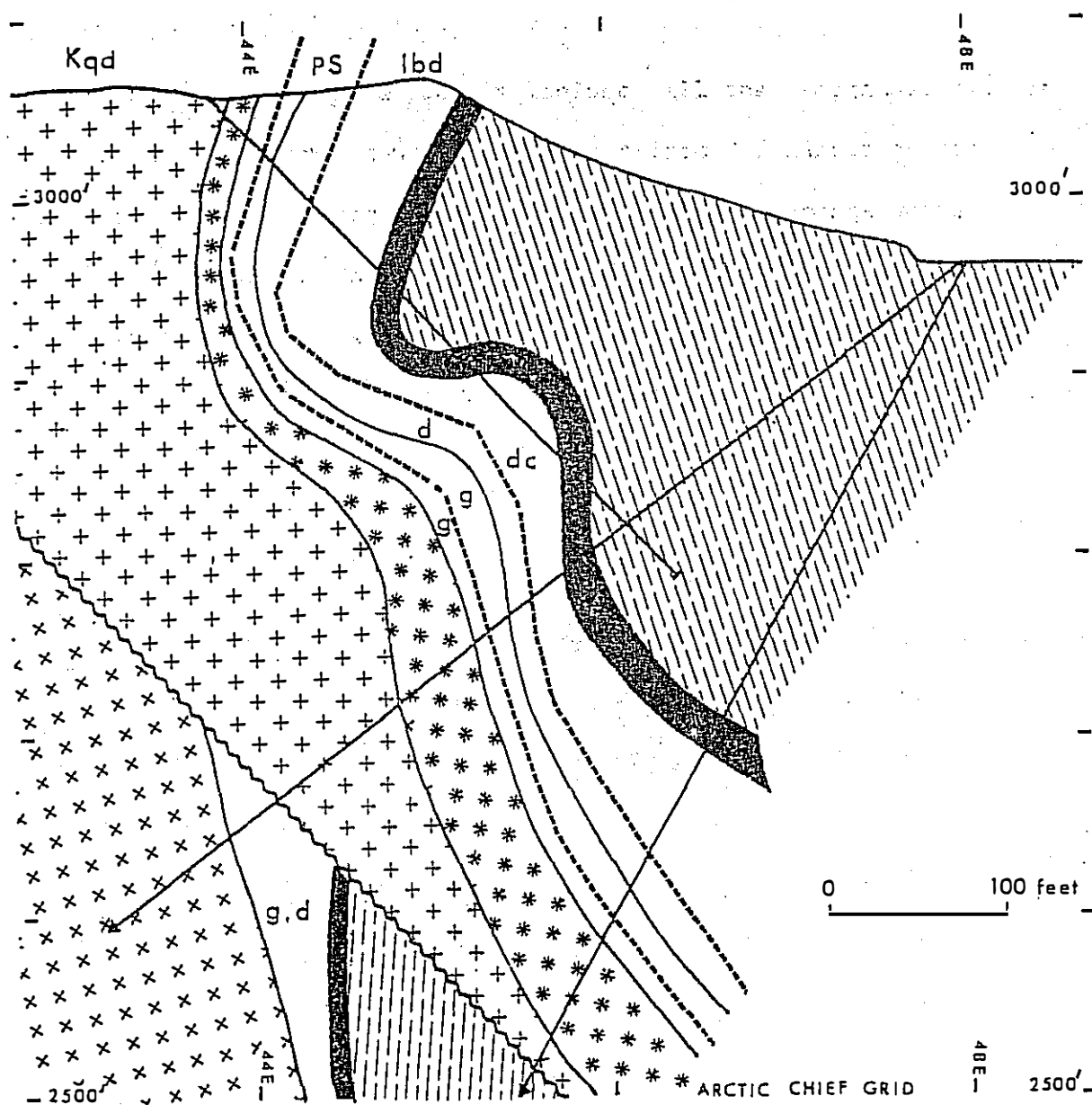


Figure 24: Geologic cross-section 100N, north of the Arctic Chief West Pit looking 355 degrees. The sequence illustrates the zonation from patchy vein and bleach contact alteration (not differentiated), to diopside and diopside-thulite endoskarn, to garnet endo- and exoskarn (g), diopside (d), diopside-calcite (dc) and magnetite (m) exoskarn. Ore is in the magnetite and diopside-calcite exoskarns.

ore minerals between the apophysis margin and recrystallised carbonate at the Arctic Chief mine (Fig. 24). An irregular contact alteration zone up to 100 feet thick is developed in the apophyse adjacent to the Arctic Chief deposits. The zone locally includes all the recognised contact alteration types zoned toward the contact from K feldspar-quartz to carbonate, chlorite-quartz and epidote-chlorite-carbonate veins and patches to diopside, diopside-thulite and garnet endoskarn. There are veins with pyrite and chalcopyrite in the vein and patch portion but none in the endoskarn. The garnet endoskarn is patchy on the diopside-thulite endoskarn but is continuous with dark brown garnet skarn that contains epidote and actinolite as well as fine-grained diopside skarn relics. This change is interpreted as the endoskarn-exoskarn boundary or the original contact between the apophysis and the Pyritic Siltstone. Neither type of garnet skarn contains copper-bearing minerals. However, locally where relics of diopside skarn are present they are separated from the garnet exoskarn by an irregular margin with magnetite-actinolite epidote-calcite-quartz-chalcopyrite. The mineralisation is similar to the ore at Cu occurrences such as Spring Creek but is not important here. The fine-grained diopside skarn contains relics of quartz and saussuritised plagioclase and is the along strike and up dip extension of the Pyritic Siltstone unit (Figs. 23, 24). It is in contact with pale green coarse-grained diopside-calcite that contains no relic quartz and plagioclase and is thought to be developed in dolomitic limestone. Both diopside and diopside-calcite exoskarns are cut by veins of actinolite-chalcopyrite with minor magnetite-epidote-quartz-calcite and rare garnet. Bornite may be present in the veins close to the contact with the magnetite zone. The veins are oriented perpendicular to the boundaries of the diopside skarns and either extend part way into or completely across this zone

from contact with the magnetite or garnet skarn. However, the veins do not cut the magnetite or garnet zones.

The magnetite skarn is in sharp, planar, locally faulted contact with the diopside-calcite skarn but in sharp irregular contact with the altered dolomitic limestone. The skarn may be massive barren magnetite, magnetite-phlogopite-bornite-chalcopryrite or magnetite-serpentine-bornite locally with valleriite or chalcocite. Relics within the skarn, partial replacements within the dolomitic limestone and textures of the magnetite skarn suggest the three magnetite types replace beds of dolomitic limestone, silty dolomitic limestone and dolomite, respectively. The ore zone in both Arctic Chief pits was the magnetite skarn but there were also pods of massive chalcopryrite at the diopside-calcite skarn-magnetite skarn contact in the East pit and minable ore locally where actinolite-chalcopryrite veins cut the diopside and diopside-calcite skarns. The grade within the ore zone was quite variable due to the irregular distribution of copper minerals within the magnetite skarn and the presence of chalcopryrite pods. Mill head grade was 1.44 per cent Cu, 0.03 oz/ton Au and 0.5 oz/ton Ag.

The general zoning sequence: quartz diorite; K feldspar-quartz; epidote-chlorite-saussurite; diopside; diopside-thulite; garnet; diopside; magnetite; carbonate rocks, exhibited in the Arctic Chief West pit is typical of many parts of the copper belt and is used as a model for contact-related zoning. Variations in the associated and ore minerals within these zones are related to the composition of the rocks in which each zone is developed.

### Suburban and Verona

The Suburban and Verona showings are small copper-bearing magnetite skarns that are localised by irregularities in the margin of the Arctic Chief pendant and hosted in the dolomitic sub-facies of facies b of the Interbedded unit (Fig. 23). In detail, both showings and other small occurrences found by drilling in this area are localised by interbeds of pyritic siltstone within the dolomitic limestone or by Pyritic Siltstone that separates the dolomitic limestone and intrusive rocks. The pyritic siltstone is partly converted to fine-grained diopside skarn which may contain veins and patches of diopside-quartz-bornite-chalcopyrite and molybdenite (W.C.M.D.D.H. AC57, 319 to 324 feet). Dark garnet overprint skarn adjacent to the diopside skarn has cavities and veins with calcite-epidote-hematite-platy magnetite-chalcopyrite-bornite. Locally, lenses of massive magnetite containing bornite and chalcopyrite separate the garnet skarn from marble. Endoskarn with diopside and patchy epidote-chlorite and saussurite locally has chalcopyrite-epidote-quartz-calcite veins in hornblende-rich diorite adjacent to garnet skarn. The skarn associations and zonation relative to the intrusive contact in these occurrences is similar to Arctic Chief, but the localisation of skarn by pyritic siltstone interbeds within the dolomitic limestone is similar to the Spring Creek Cu occurrence.

### Best Chance - Grafter

The Best Chance Cu Fe and Grafter Cu (Fe Au Ag Mo) deposits are two geologically similar skarns associated with an irregular apophyse between the Bork Lake and Iron Horse faults (Fig. 16). The Spring Creek, Empress of India and Retribution occurrences are in the same fault block but north

of Best Chance-Grafter and the Arctic Chief deposit is approximately one mile south in the next fault block (Fig. 16). The overall structure within the block is an asymmetric syncline with a moderate dipping west limb in which interbedded black and white limestone is underlain by interbedded black and white dolomitic limestone, pyritic siltstone and sandstone. The east limb is steep dipping and irregularly cut by the batholith so that in the south the lower part of the section is in contact with the batholith and in the north the upper part is in contact (Fig. 25). As well as the broad structure, the batholith and apophysis superimpose local subisoclinal folds with vertical axial planes and a north trend. The apophyse has outward dipping contacts at its north end, inward dipping contacts at its south end and is probably of bulbous shape in cross-section. Hence, although the Best Chance deposit appears to be part of a narrow north-trending pendant at surface, at depth it probably connects with the Grafter occurrence (Fig. 25).

The orientation of the orebodies and the distribution of skarn and carbonate rocks in the Best Chance-Grafter area appears to be controlled by north-trending folds rather than by zonation relative to intrusive contacts (Fig. 25). However, there is insufficient core available to interpret the distribution of units in section. Skarn host rocks include generally thick-bedded white and black dolomitic limestone, white and black limestone and a few intercalated pyritic siltstone beds. These rocks have been assigned to facies b of the Interbedded unit where mapped nearby. The Pyritic Siltstone unit has not been encountered in the drillings. Banded diopside-calcite-garnet skarn with veins, patches of bands of epidote-actinolite-magnetite-chalcopyrite and relics of bleached pyritic siltstone, carbonaceous limestone and serpentinised dolomitic limestone is the major skarn type but barren coarse-grained

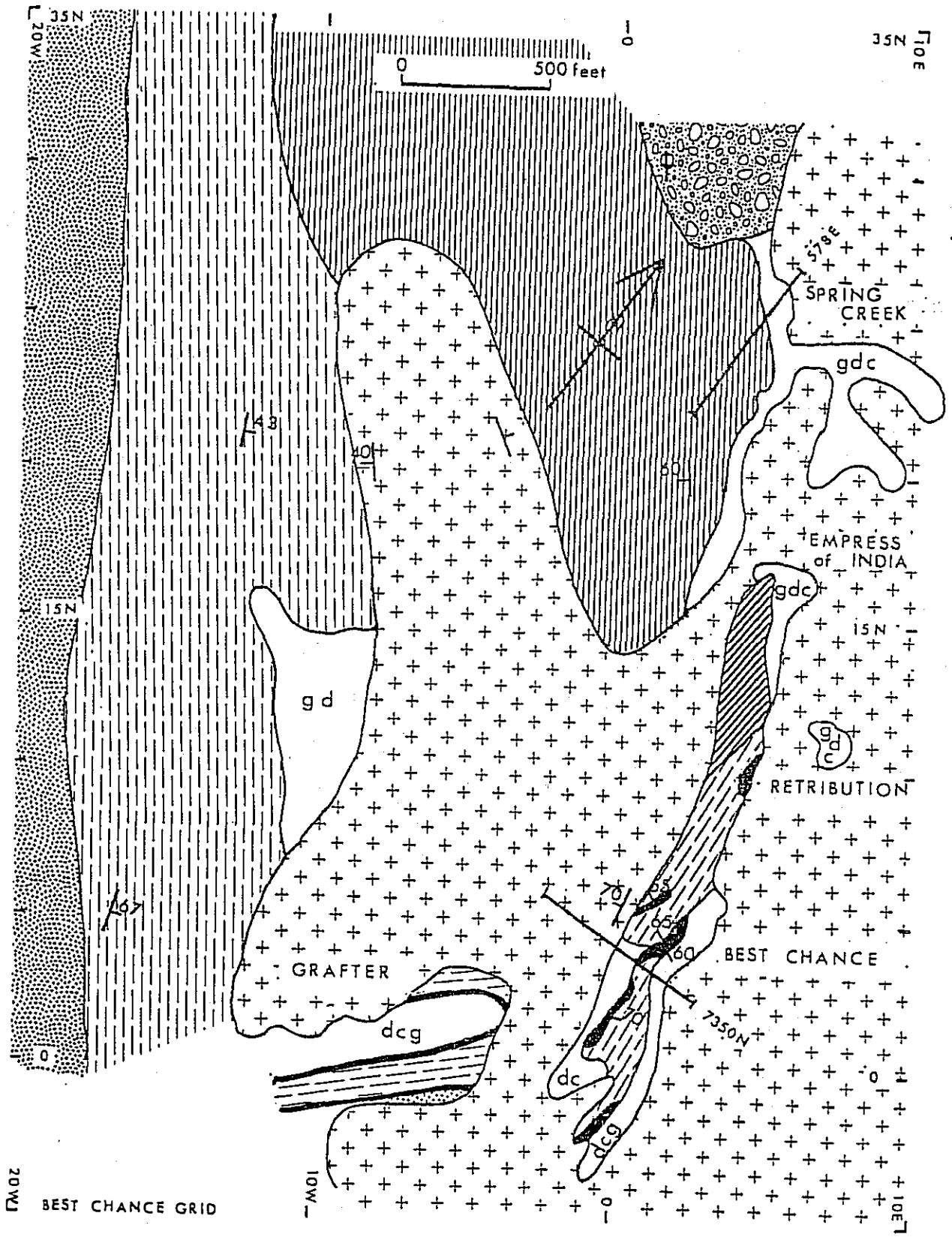


FIGURE 25

diopside-calcite skarn and massive magnetite locally with chalcopyrite, bornite and chalcocite are also present especially at Best Chance. Patches of endoskarn less than five feet thick and locally with veins of epidote-magnetite-chalcopyrite occur in both the apophyse and the batholith.

One sequence observed at Best Chance (Fig. 26) includes: endoskarn in the apophyse; diopside-calcite skarn; recrystallised black and white dolomitic limestone; massive barren magnetite; epidote-magnetite with calcite-chalcopyrite-bornite; banded diopside-calcite and garnet-diopside-calcite skarn; relic siltstone with veins and patches of epidote-actinolite-magnetite-chalcopyrite; garnet skarn; and endoskarn in the batholith.

The patchy, irregular nature of the mineralisation makes the overall grade at Best Chance subeconomic and the low ratio of bornite and chalcocite to chalcopyrite probably accounts for the low Au content (Table 2). Low bornite and chalcocite content is a typical feature of magnetite skarn spatially associated with garnet and epidote at the Spring Creek occurrence and in the upper skarn zone in the Gem-Brown Cub area. These skarns are also Au-poor. The small ore zone that was mined at Grafter consisted of veins and pods of chalcopyrite with minor bornite cutting diopside skarn that was part of an endoskarn, garnet, diopside, barren magnetite, carbonate rock sequence approximately 50 feet thick. This sequence is similar to that at Arctic Chief and Suburban whereas that at Best Chance is more like Verona or the upper skarn zone in the Gem-Brown Cub area.

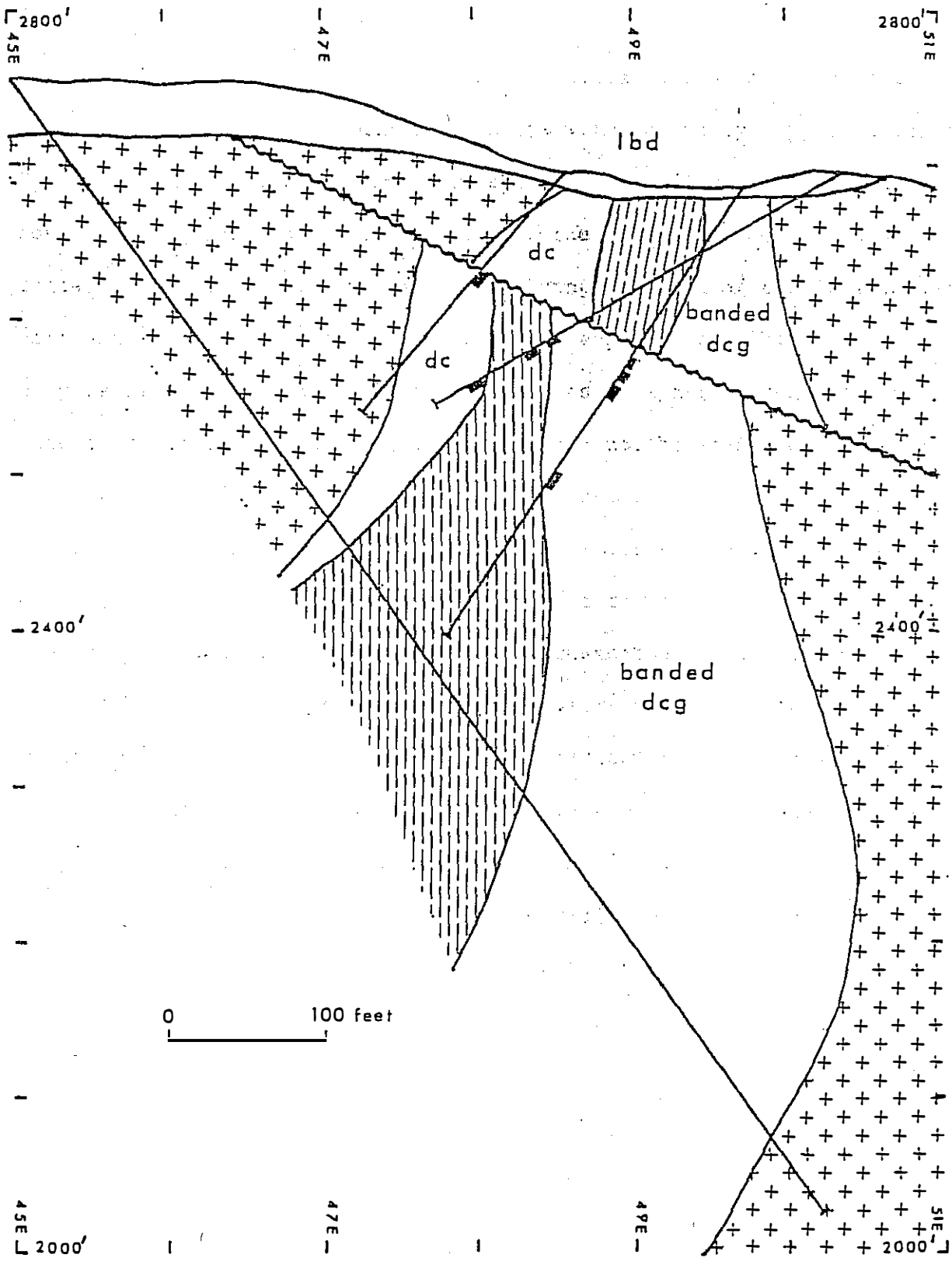


FIGURE 26