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STRUCTURAL ELEMENTS RELATED TO MINERALIZATION

ENDAKO ORE DEPOSIT

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by

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ABSTRACT

Four major structural trends are inferred from topographic features over Central British Columbia. Directions are northwest, conjugate northeast, easterly and east-northeast. These trends are thought to have been developed as 1) shear and tensional structures along the prominent northwest Cordilleran strike, and 2) as a result of major tectonic activity across the region. The four regional trends are reflected on a local scale over the Endako ore deposit. It is postulated that regional structural activity controlled spatial setting and development of Endako stockwork.

Endako orebody is an elongated elliptically-shaped zone of stockwork. The westerly-plunging body strikes N60°W and gradually changes dip from 60° south at the west end to 40° south at the east end over the 11,000-foot length.

Molybdenite mineralization occurs with quartz as veins and fracture-fillings in a restricted stockwork which is developed in a quartz monzonite rock unit of the Topley Intrusions. Three types of pre-mineral dykes occur as two or possibly three cross-cutting swarms which are strongly aligned to regional northeast and northwest trends. Orientation of stockwork is controlled by a series of major subparallel south-dipping veins and complementary flat-lying, southeasterly and northwesterly-dipping vein systems. Attitude of unmineralized faults and joints is northeast, north-northwest and easterly with subordinate northwest and northerly trends. The major north-dipping South Boundary Fault delimits ore deposit at depth, and it is thought to be a principle control for pattern of stockwork elements.

A concept of elongated doming near or at an intersection of regional northwest and easterly structures is proposed for possible development of Endako stockwork. Longitudinal major faulting, with attendant antithetic faulting and repetitive periods of concomitant fracturing across domal structure, are visualized for localization of a favourable fracture system for hydrothermal alteration and economic mineralization.

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STRUCTURAL ELEMENTS RELATED TO MINERALIZATION ENDAKO ORE DEPOSIT

INTRODUCTION

The Endako molybdenum deposit occurs within a structurally-controlled fracture system which, in turn, is developed within a regional structural framework of the Cordilleran in Central British Columbia. It is proposed to illustrate in this paper, the significance of regional structural elements in relation to localization and development of a favourable stockwork for economic mineralization.

REGIONAL SETTING

The major tectonic elements across Central British Columbia are illustrated on Figure 1. Reference is made to CIM Special Volume No. 8 in which the Stuart Lake High is envisaged as an emergent region during Upper Triassic-Upper Jurassic period and the Skeena Arch as another emergent region extending from the Coast Crystalline to Omineca Crystalline Belts during the Upper Jurassic period. The location of Pinchi Fault and distribution of composite Topley Intrusions along the regional northwest trend are shown in relation to the tectonic elements.

The topography across the region is variously dissected by a number of large linear-elongated lakes and drainage systems. These topographic features can be inferred as major structural trends in the northwest, conjugate northeast, easterly and east-northeast directions. An interpretation of these trends is illustrated on Figure 2. The four trends are thought to have been developed as shear and tensional structures along the prominent north-west Cordilleran strike, and as a result of major tectonic activity across the region primarily during early and middle Mesozoic era. The northwest direction is the regional Cordilleran trend and is most prominently inferred from orientation of Babine Lake, Stuart-Takla Lakes and the Bulkley River valley.

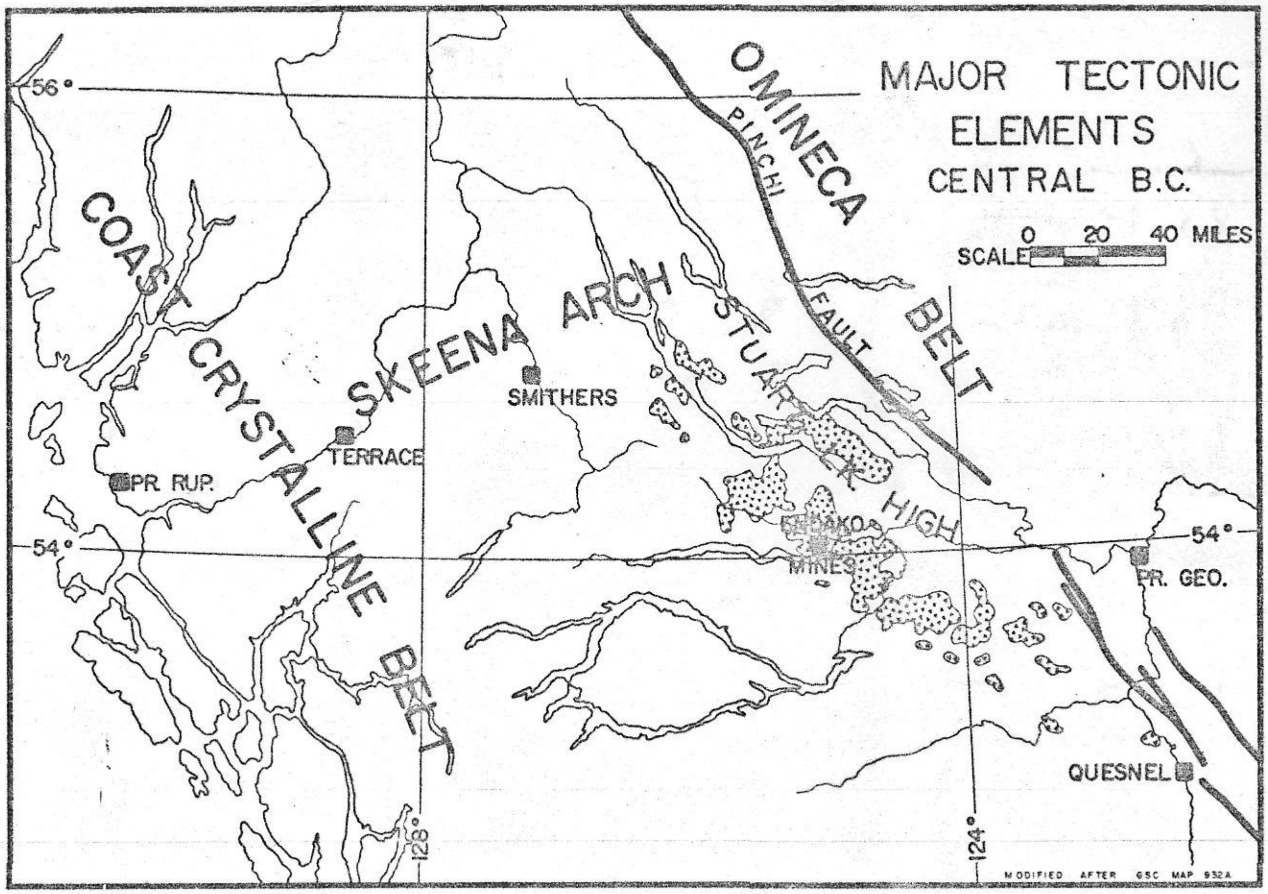

FIGURE 1

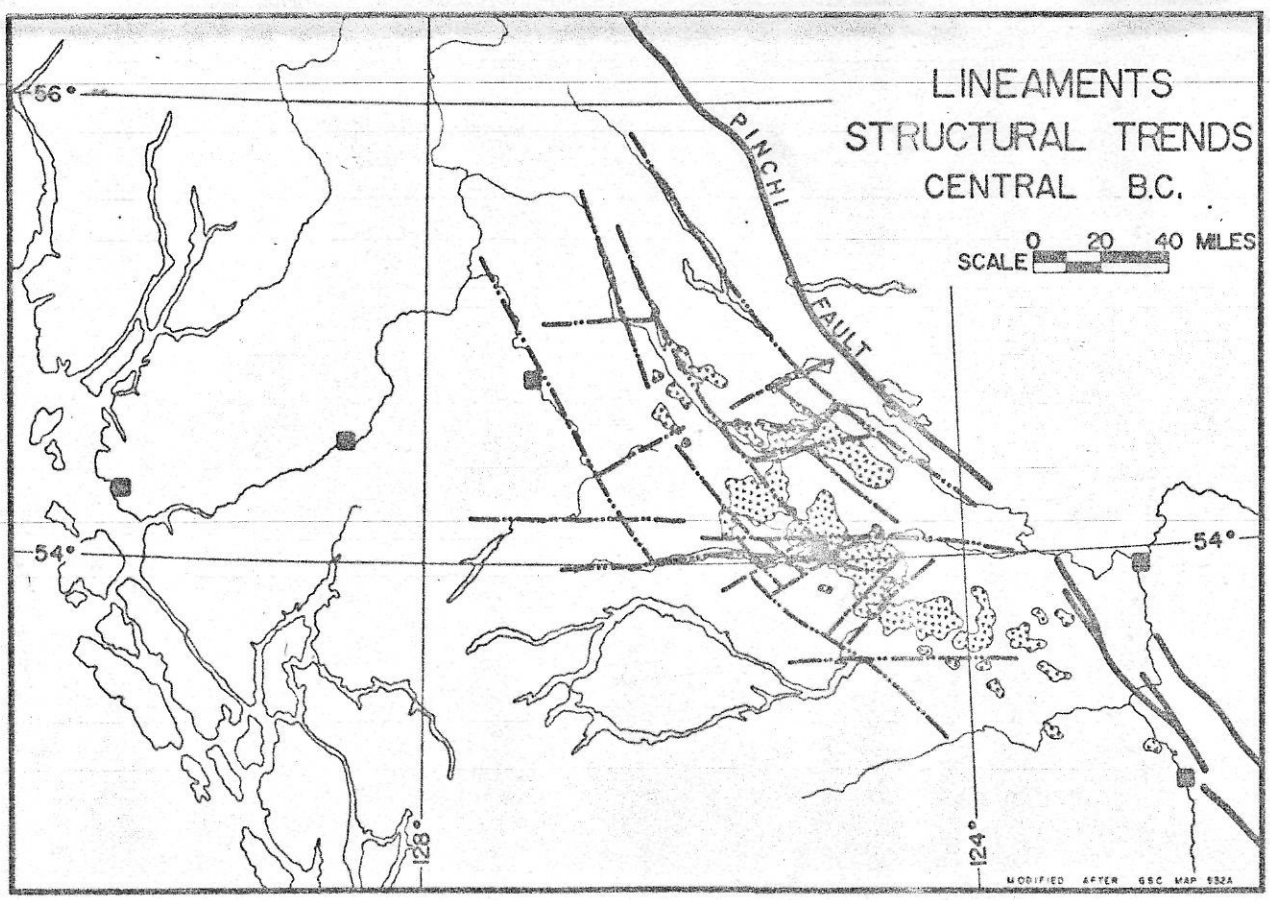

FIGURE 2

Francois Lake-Nechako River accentuates an east-west trend which could be suggested as a major crustal break on a broader continental scale rather than as a local regional imprint on the Cordilleran. The east-northeast trends may have partially been developed or influenced by activity across the Skeena Arch.

The Endako ore deposit is located within this structural framework at or near the junction of major northwest and easterly trends in the Topley Intrusions.

The location and orientation of regional structural trends are illustrated over the Endako district on Figure 3. The smaller lakes and drainage systems throughout the district reflect the major trends on a more detailed pattern. The subsidiary trends are superpositioned and subparallel to the northwest, northeast, easterly and east-northeast major trends. Visually on this scale the strong easterly trends become more emphasized across the district. The Endako ore deposit and Nithi Mtn. molybdenum prospect are located near the east end of Francois Lake where intersections of regional structure trends appear to be centrally focused. Air photos!

LOCAL SETTING

The local structural setting for Endako ore deposit is illustrated on Figure 4. The deposit occurs wholly within a quartz monzonite rock unit of the Topley Intrusions, and it is visualized to be straddled by two sub-parallel major easterly structures along Francois Lake and Endako River valley. These are complemented by an inferred northwest trend which is an extension from Babine Lake.

Several faults which have been recorded in drill holes and can also be depicted as topographic lineaments are shown in relation to orebody and major regional trends. The recognizable faults are the South Boundary, Casey Lake and Tailings Cr. Faults. Again, structural trends are predominantly northwest, northeast, easterly, east-northeast, and northerly directions.

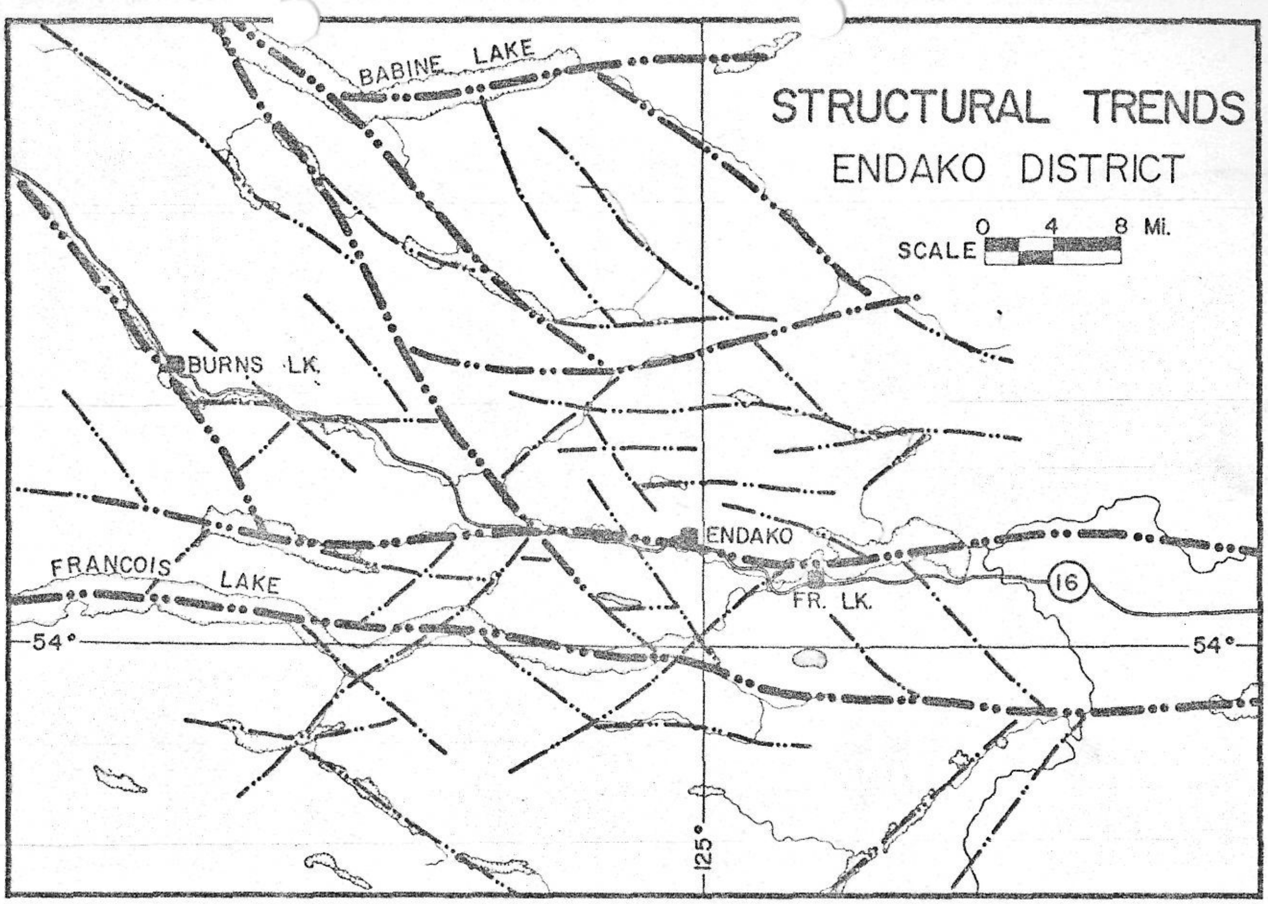

FIGURE 3

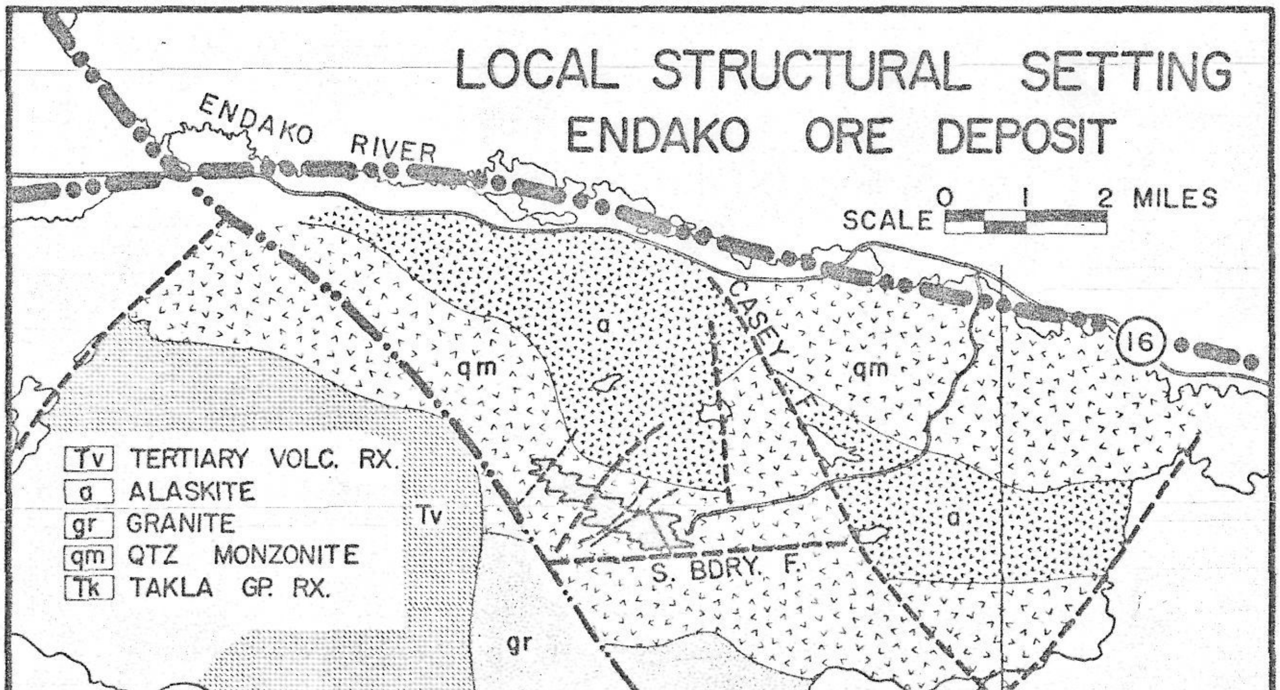

FIGURE 4

ENDAKO ORE DEPOSIT

Endako orebody is elongated in the N60° W direction and gradually changes inclination from steep 60° to 70° south at the west end to 30° to 40° south at east end over its 11,000-foot length (Figure 5). The orebody plunges westerly from a very shallow depth at east end to over 1,100 feet near central position of open pit; the actual depth of ore has not been delineated at the west end. Two or possibly three pre-mineral dyke swarms cross-cut the orebody. A pyrite zone is recognized along south periphery of economic mineralization.

STRUCTURAL ELEMENTS OF ENDAKO OPEN PIT

The major or larger structural features for the open pit are represented on Figure 6. Minor features have been omitted due to overcrowding.

I. Pre-Mineral Dykes

The most prominent features on the map are the two cross-cutting pre-mineral dyke swarms. Three separate periods of dyke intrusion are represented within the swarms with aplite being oldest, then porphyritic granite and quartz-feldspar porphyry the youngest. The dykes, particularly the quartz-feldspar porphyry, are very intensely fractured or jointed. They vary in width from several inches to 150 feet. Angular and jagged sharp contacts with quartz monzonite host rock or with older dykes suggest that dykes were intruded into tension fractures. This contact relationship can be viewed in either detail or on large scale.

Dykes trend in two major directions. The east swarm predominantly trends N40° E with subsidiary N25° W direction, whereas the west swarm is oriented in conjugate northwest and northeast directions. The east swarm is vertical and the west swarm dips approximately 70° west.

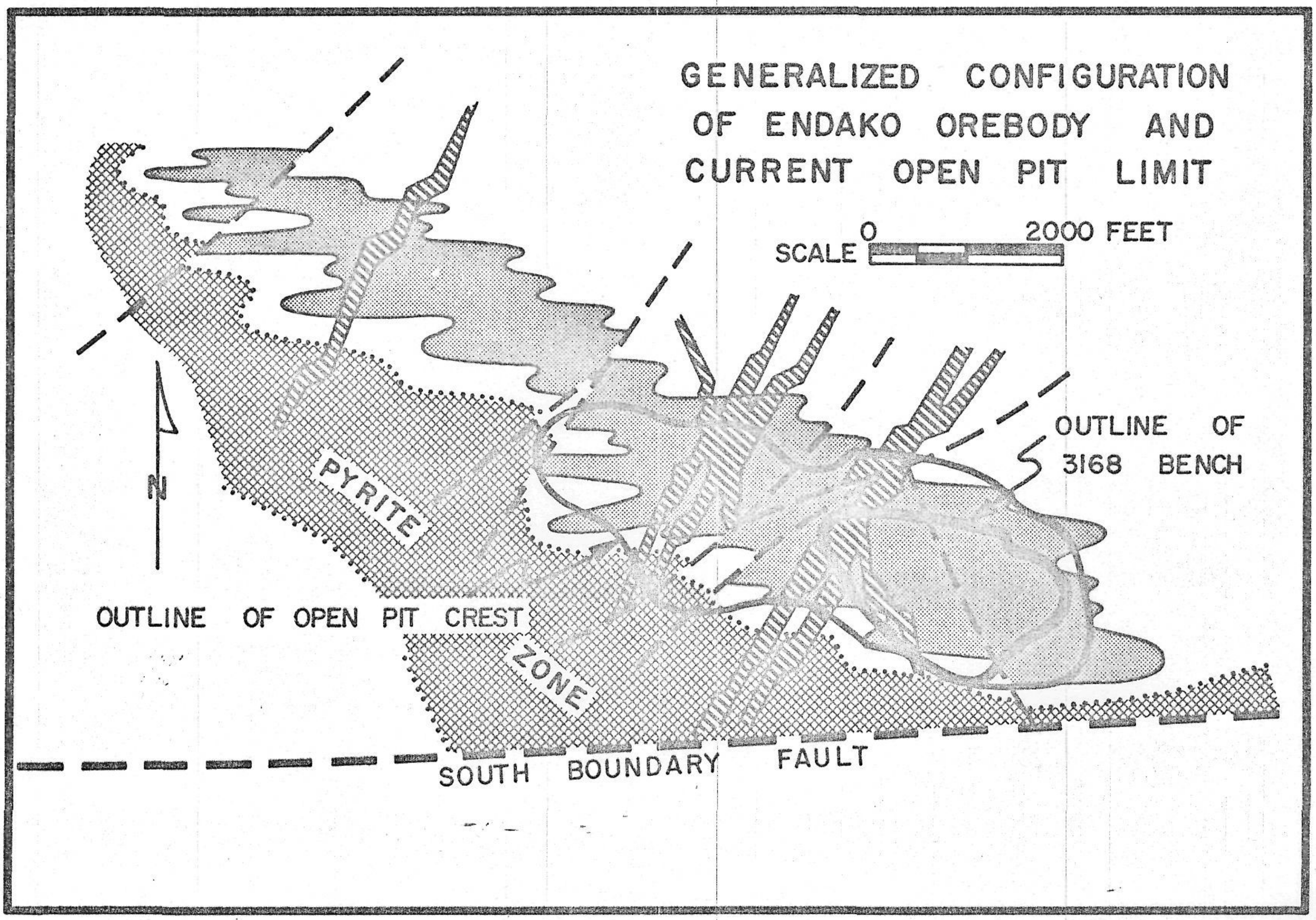
GENERALIZED CONFIGURATION
OF ENDAKO OREBODY AND
CURRENT OPEN PIT LIMIT
SCALE 0 2000 FEET
N
PYRITE
ZONE
OUTLINE OF OPEN PIT CREST
OUTLINE OF
3168 BENCH
SOUTH BOUNDARY FAULT

FIGURE 5

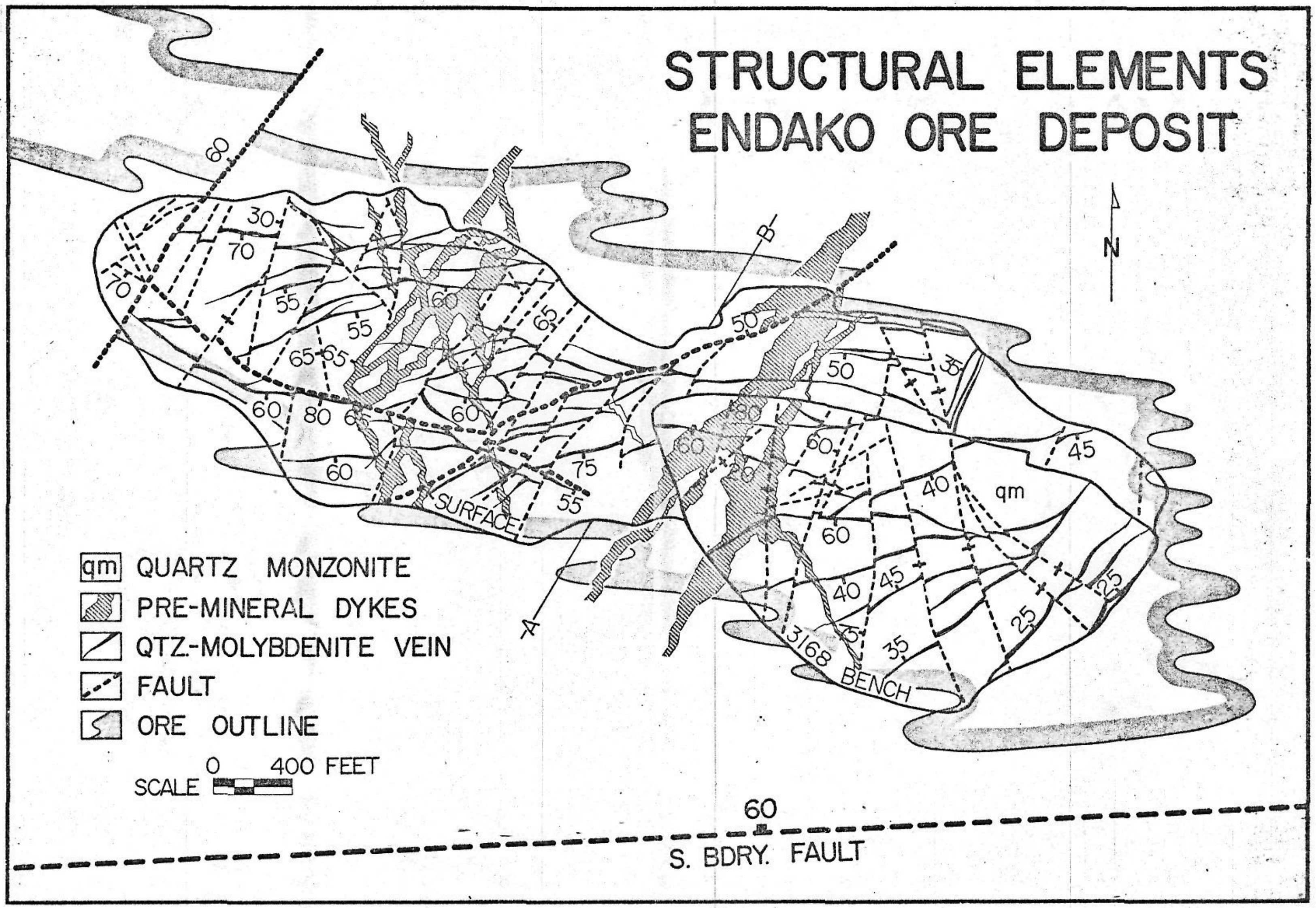
STRUCTURAL ELEMENTS
ENDAKO ORE DEPOSIT
N
qm QUARTZ MONZONITE
PRE-MINERAL DYKES
QTZ-MOLYBDENITE VEIN
FAULT
ORE OUTLINE
SCALE 0 400 FEET
SURFACE
3168 BENCH
qm
A
B
S. BDRY. FAULT
60

FIGURE 6

II. Quartz-Molybdenite Mineralization

Molybdenite mineralization is intimately associated with quartz and occurs exclusively as veins and fracture coatings. The larger or major quartz-molybdenite veins range in thickness from two inches to over four feet and generally pinch, swell and horsetail along structurally continuous lengths of over 2,500 feet. Metallic mineralization occurs typically as thin laminae in quartz veins; the ribbon structure is indicative that repetitive pulses of movement and mineralization occurred along vein structures. The major veins control trend of the bounding stockwork type of mineralization to form ore bands which range in width from 40 to 400 feet. Normally, veins within economic stockwork are spaced from inches to several feet apart with average vein width being from a "hairline" to one-quarter inch.

In order to facilitate structural analysis of mineralized features, the open pit has been divided into two sub-areas. The divisional boundary is established along western margin of the east dyke swarm (see Figure 6). Poles to various structural data have been plotted on lower hemisphere equal-area projections, and the following structural analyses are re-presented for the area west of line AB: -

1. Major quartz-molybdenite veins are striking east in en echelon pattern. The veins are dipping 60° - 70° south at west end of open pit, and gradually change to 50° south in the area between the two dyke swarms.
2. Several major flat-lying veins up to three feet thick have been recorded.
3. Smaller veins which form the main stockwork show no preferred orientation.

4. It is notable that limits of economic stockwork are not extensively developed around major veins at west end of orebody. Ore bands are often confined to 40- to 100-foot-wide zones.

For the area east of line AB: -

1. Major quartz-molybdenite veins again strike east but dips flatten to 40° south and locally down to 20° south. These veins are complemented by N70° E/ 40°-50°S veins.
2. The above veins are intersected by prominent sets of N55°E/ 25°NW veins at extreme east end of open pit.
3. Flat-lying veins are also encountered.
4. The finer stockwork type of mineralization is again unoriented. It is very well-developed at this end, and economic limits of uniform mineralization extend up to 200 feet on either side of controlling veins.

A sequence of relative vein ages and hydrothermal alteration phases has been determined from cross-cutting relationships. Molybdenite and three phases of hydrothermal alteration were introduced during initial three of five separate stages of mineralization. Quartz in ubiquitous with all five stages. The numerous stages of mineralization are again indicative of repeated periods of fracturing to produce the resultant stockwork.

III. Unmineralized Faults and Fractures

Numerous unmineralized faults and joint sets are encountered across Endako orebody. The last movement along majority of faults is post-mineral, but it is presumed that many of these features could be the result of minor adjustments or movements along previous pre-mineral or intra-mineral structural trends. Aside from several major faults, the displacements along most faults are in the order of 10 to 30 feet.

Several major faults strike N35° E to N60° E and dip northwest; these are represented on the map as heavier dashed lines (see Figure 6). An apparent right lateral movement is indicated along several of these northeasterly faults. The most notable fault is encountered at extreme west end of open pit where an apparent 900-foot offset is inferred.

Stereographic projections of unmineralized features show that prevalent attitudes are: -

1. N35° E/ 60°-70°NW; these are primarily subparallel and probably sympathetic to movements along major faults.
2. N20° W/ 90°; these are mainly encountered at east end of open pit and usually show apparent dip-slip movement as evidenced by displacements of veins.
3. Northerly strike with 75° W dip; this is a minor population at the east end of orebody.

A major easterly- to southeasterly-striking fault has been traced along the orebody trend; this fault is locally intruded by post-mineral basalt.

In many instances fault gouge and occasionally five- to 20-foot-wide shatter zones are present along major quartz-molybdenite veins. These fault trends are primarily easterly, east-northeast and northeast.

IV. South Boundary Fault

The South Boundary Fault is a major 60° north-dipping structure. The fault has been intersected by several drill holes and can be traced as a five-mile easterly-striking topographic lineament. This structure is considered to be pre-mineral and a major control for structural development of Endako stockwork. Movement during pre-mineral stage is assumed to be normal. The last observed movement from drill core is however, post-mineral; no direction or magnitude for displacement are indicated.

It is notable that veining and alteration extend to the fault on the hanging wall, but stockwork is undeveloped on footwall of fault zone.

DETAILED STRUCTURE 3168 BENCH

The structural elements for 3168 Bench are illustrated on Figure 7.

1. Part of the east dyke swarm is encountered on this bench and the angular and irregular dyke contacts are clearly illustrated.
2. Three major vein trends are represented: -
   a) N89° E/ 40°S.
   b) N70° E/ 20°-40°SE.
   c) Prominent N55° E/ 25°NW vein sets at the east end of Bench.
3. Three major fault and joint attitudes are exhibited: -
   a) N35° E/ 50°-60°NW.
   b) N30° W/ 90°.
   c) North-striking / 75°W.

The relative dip-slip movements are more clearly recognized on this illustration by vein displacements along some faults.

SUMMARY OF STRUCTURAL ELEMENTS

In summary, the regional structural trends are northwest, northeast, easterly, east-northeast and minor northerly directions. These trends are reflected on a local scale for structural features over Endako ore deposit, namely, pre-mineral dykes are principally northeast and northwest; major veins strike east, northeast and east-northeast; and unmineralized faults and joints strike northeast, northwest, easterly and north-northeast. The correspondence of these local trends with regional trends is suggestive that regional structural activity possibly controlled or influenced the localization and basic development of the structural pattern over Endako ore deposit.

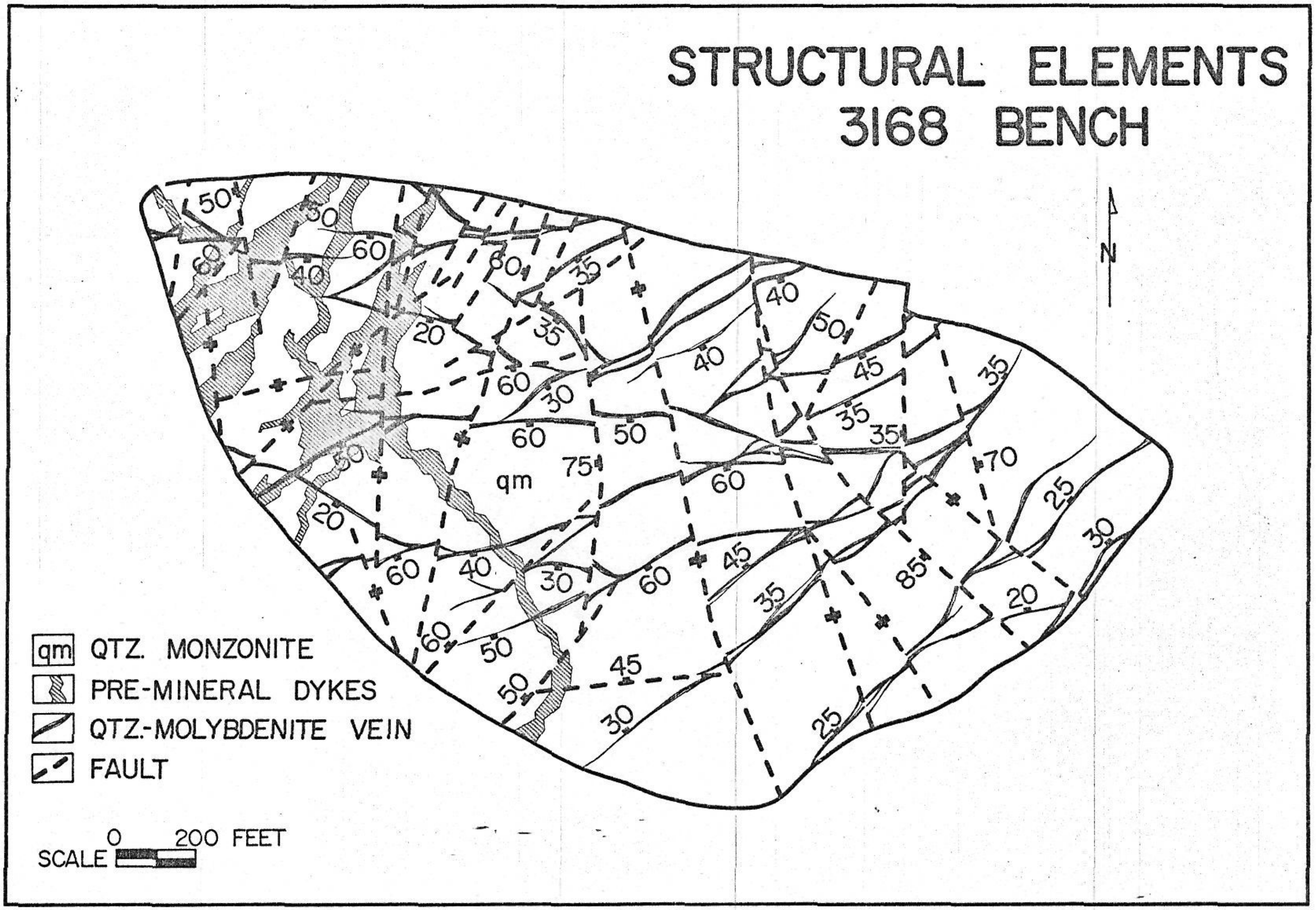
STRUCTURAL ELEMENTS
3168 BENCH
N
qm
qm QTZ. MONZONITE
PRE-MINERAL DYKES
QTZ.-MOLYBDENITE VEIN
FAULT
SCALE 0 200 FEET

FIGURE 7

STRUCTURAL MODEL

Schematic illustrations to explain possible structural development of Endako stockwork are shown on Figure 8. The spatial orientation of the orebody with respect to the South Boundary Fault is shown on the upper diagram. The fracture system for the ore zone is thought to have been formed along an elongated easterly domal uplift during repeated periods of uplift, collapse, and dyke intrusion. The dome formed near or at an intersection of regional easterly and northwest structures. The evidences for citing a domal structure are firstly, the restricted peripheral extent of hydrothermal alteration and mineralization; secondly, the attitude of major structures of which the flat-lying veins are visualized as sheet-like tension fractures; and thirdly, three periods of dyke intrusion.

Reference is made to Wisser's investigations and interpretations of structural uplifts in order to construct a structural model that can be adapted to Endako structural elements. For this purpose, the easterly-trending elongated dome is represented by a series of elliptical structural contours (see center diagram on Figure 8). The repeated conditions of uplift and collapse along this elongated dome are pictured as being the main influence for development of: -

1. Conjugate pattern of transverse tensional cracks across the crest along which the pre-mineral dykes were intruded.
2. A major longitudinal north-dipping normal fault which is envisaged as the South Boundary Fault.
3. A series of attendant antithetic south-dipping curvo-planar faults which would correspond to major sets of easterly-striking quartz-molybdenite veins.

SCHEMATIC ILLUSTRATION FOR POSSIBLE STRUCTURAL DEVELOPMENT OF ENDAKO STOCKWORK

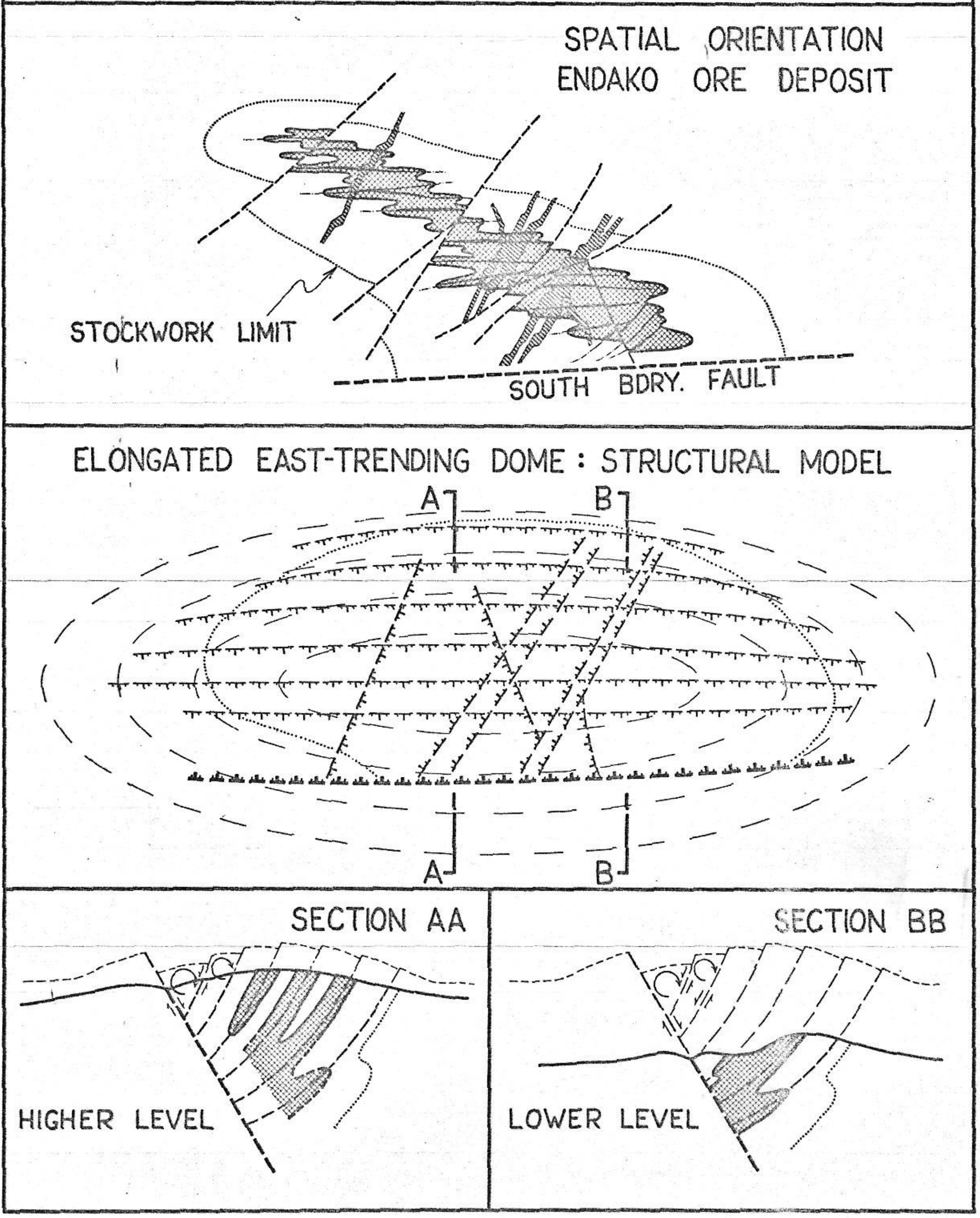

FIGURE 8

The structural model is also applied in order to interpret the gradual change in dip along the length of the deposit and the spatial location of the stockwork in relation to the South Boundary Fault. By employing a 10° to 15° downward westerly tilt to the model, and then eroding this tilted block to the present exposed datum, it would allow the west end to occupy a more steeply-dipping and structurally high level (lower left diagram on Figure 8) as compared to the more flatly-dipping and structurally low level east end (lower right diagram on Figure 8). Thus, the higher level west end would spatially have been farther from the South Boundary Fault relative to the lower level east end which abuts against this major fault. The concept of structural levels also explains the westerly plunge of the orebody.

The associated fracture zones along individual antithetic faults would be widely-spaced within higher level, whereas curvo-planar antithetic fault and associated fracture zones are converging at the lower level. In this manner the structural model is again applicable for explaining the confined stockwork development along major veins for westerly portion of orebody as compared to the unified and extensively-developed stockwork for easterly half of orebody.

CONCLUSION

In conclusion, it is thought that Endako stockwork was formed during several periods of uplift and collapse of an elongated dome under localized stress conditions at the intersection of regional northwest and easterly structures. Antithetic faulting and repetitive periods of concomitant fracturing within this domal structure developed and controlled a favourable fracture system for hydrothermal alteration and economic mineralization.

ACKNOWLEDGEMENT

The authors are indebted to the geologists and technical assistants who are currently and who were previously associated with Endako Mines Limited for their part in geologic mapping and the compilation of data.

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