A Contribution to the Geology of Peko Mine and its Environs, Tennant Creek, Northern Territory

Colin Sinclair - Geologist, Geopeko Ltd., 1971 -

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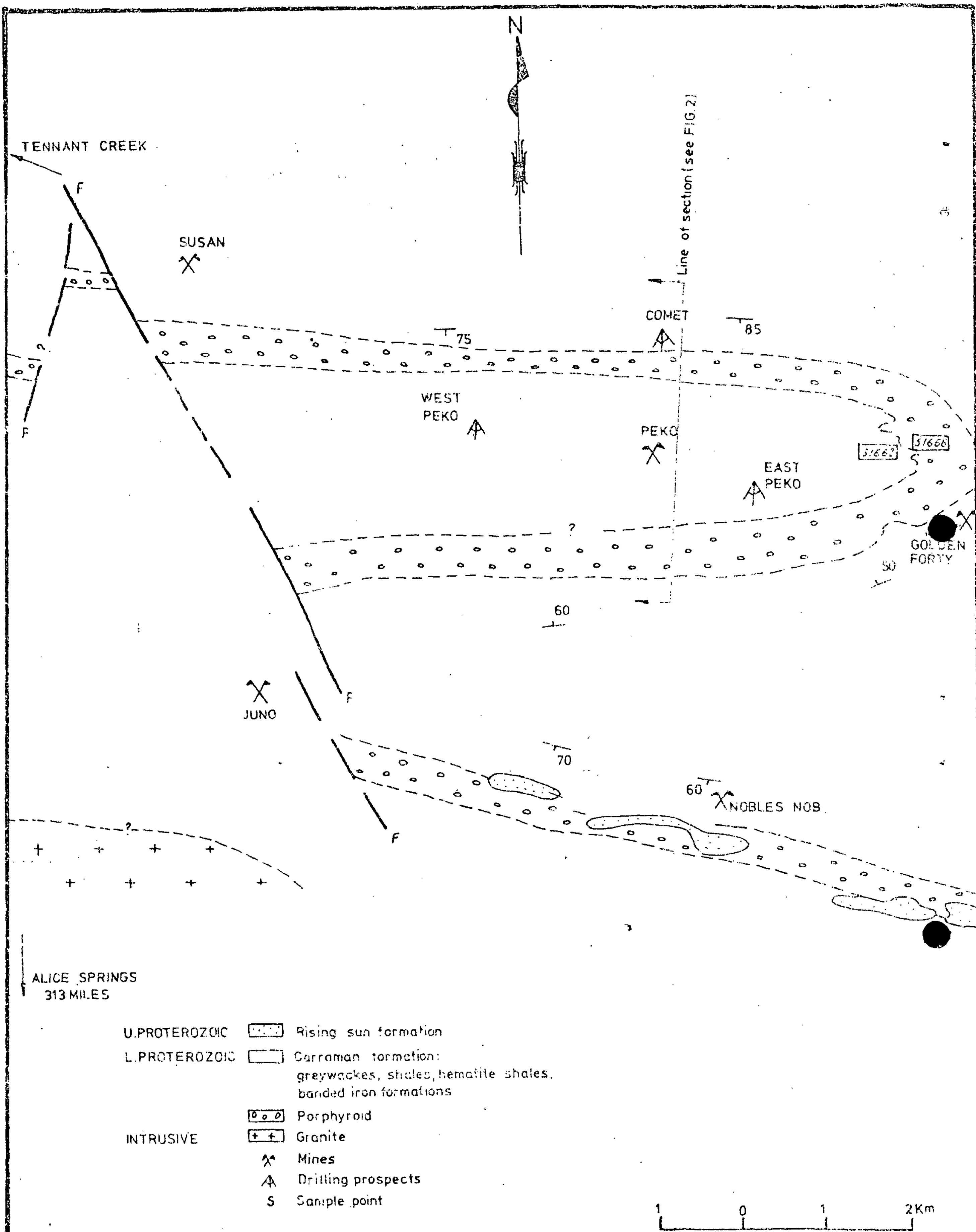


GEOLOGICAL SKETCH MAP OF PEKO ENVIRONS
(After Elliston & Large)

FIG.1

Colin Sinclair - Geologist Peko Mine

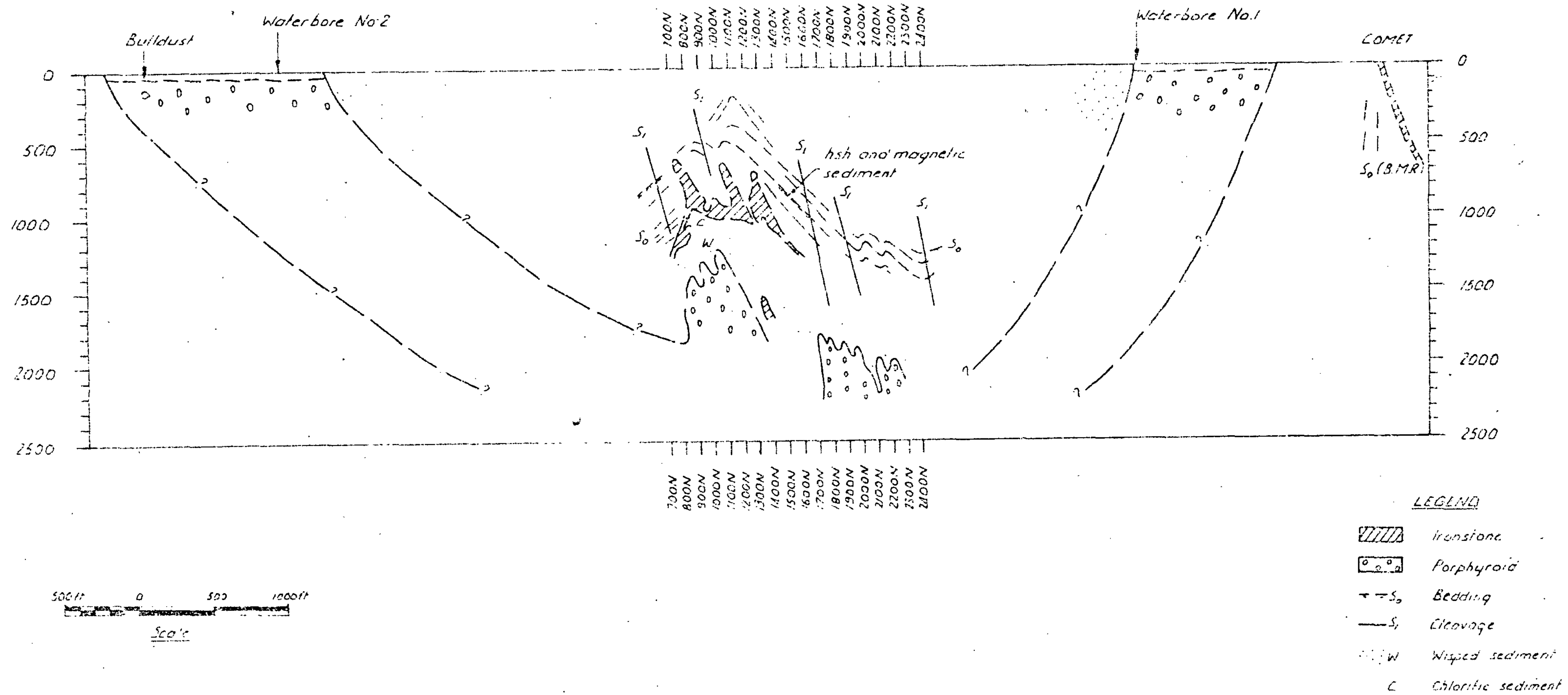
A Contribution to the Geology of Peko Mine and its Environs, Northern Territory

ABSTRACT

Peko Mine exists within and above a porphyroidal belt of rocks whose origin and relationship with the orebodies of Tennant Creek is obscure. The porphyroid exhibits a foliation which is consistent with axial plane cleavage (S_1) and not bedding (So), and textures observed are indicative of deformation while in an unconsolidated state. The presence and dewatering mechanism of pore fluids is well demonstrated within and immediately above the porphyroidal rocks where dewatering was particularly prevalent when the phyllosiciate particles were at some angle to the bedding. Slaty cleavage is a prominant fabric element and its tectonic origin is indicated by its mineralogical expression and close parallelism to axial surfaces. The existence of deformed ooids are important strain gauges and add to the evidence of deformation of the sediments in an unconsolidated state. Emphasis is placed on early deformation of the rocks with gravity gliding and folding by flexural slip. The non cylindrical fold system may have formed from a single complex deformation although the presence of kink bands by rotation of S_1 foliation suggests a second generation of deformation. An environment rich in pore fluids with active dewatering associated with S_1 deformation and the presence of diagenetic magnetite and hematite in the surrounding sediments could produce leaching and eventually pipe-like bodies if a convective ore-genesis model is invoked.

INTRODUCTION

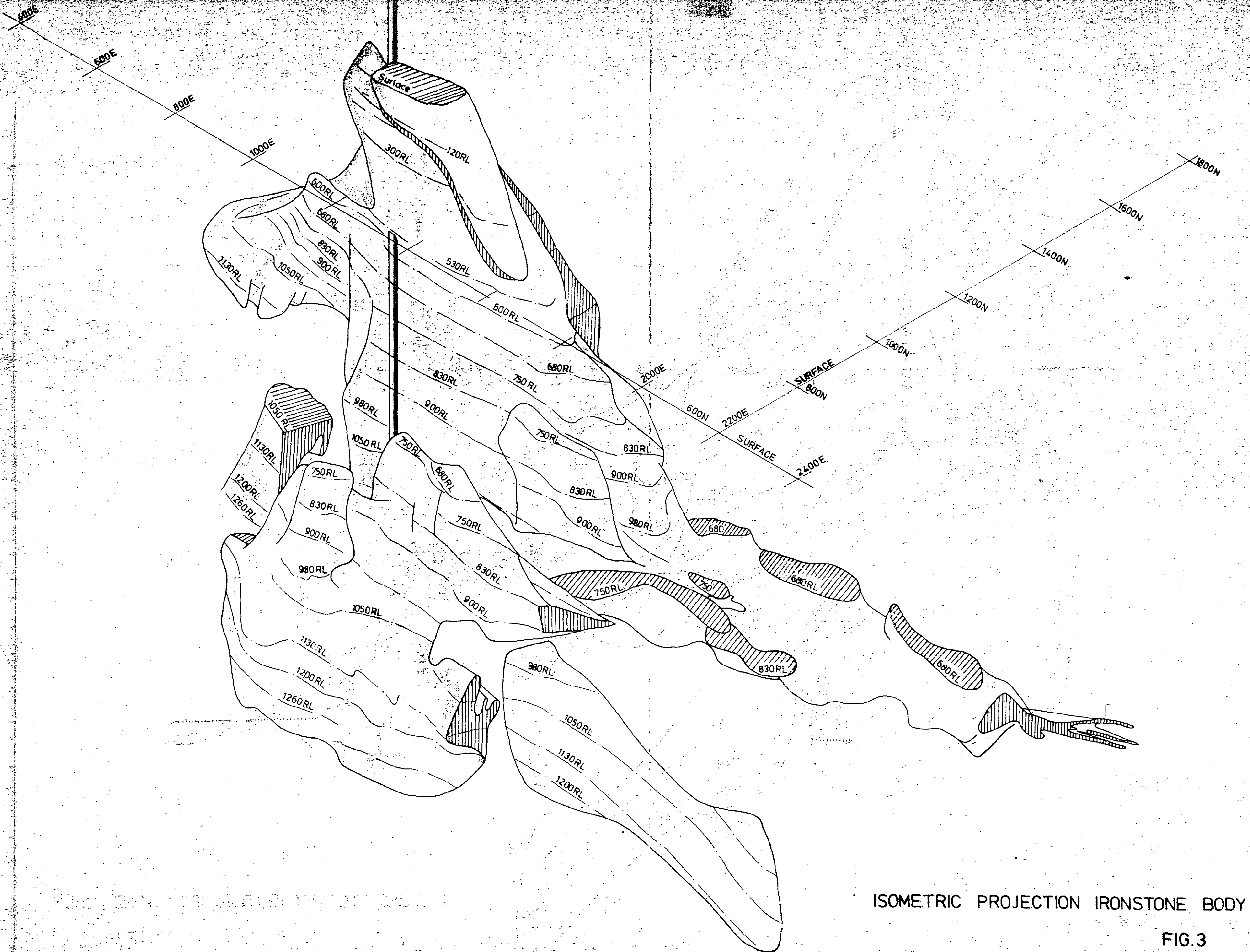
Observations made underground during routine mapping and logging of drill core as a mine geologist at Peko mine extending over a period of two years forms the basis of this investigation. 98 poles to bedding (So), 35 poles to cleavage (S_1) and 57 poles to joints were plotted on stereonets to aid structural interpretation. 20 thin sections were cut by Geopeko technicians to test the dependency relationship between cleavage, lineation and folding processes. The complex geometry of the Peko ironstone body became apparent



GEOLOGICAL CROSS SECTION BASED ON

1[illegible]5E PEKO MINE GRID

FIG. 2



ISOMETRIC PROJECTION IRONSTONE BODY

FIG.3

Diamond drilling to close off lode intersections proceeded to mid 1973 and it became apparent that the early structural appreciation of Peko required re-appraisel. The ironstone geometry remained a problem and to explain this a control was looked for. Lack of a distinctive marker bed hindered interpretation and the pervasive wisping of sediment below the ironstone body and above the porphyroidal rocks created problems. Above the ironstone body wisping is virtually absent and bedding (So) is well developed. Within the bedded sediments euhedral magnetite and hematite is, in places, well developed. Folding into a west plunging anticline with subsidiary folding was established with axial plane cleavage deformation dipping to the north at 75°. The dip and plunge of the ironstone pipe above 600 R.L. has geometry in agreement with cleavage and fold axis plunge, whereas the ironstone below 600 R.L. to 1300 R.L. resembled a saddle (fig. 5) in close agreement with the bedding although cross cutting.

The existence of a wisped or disturbed zone above the porphyroid seems best explained in terms of pore fluids and dewatering of the sediment pile.

PREVIOUS LITERATURE AND PRODUCTION

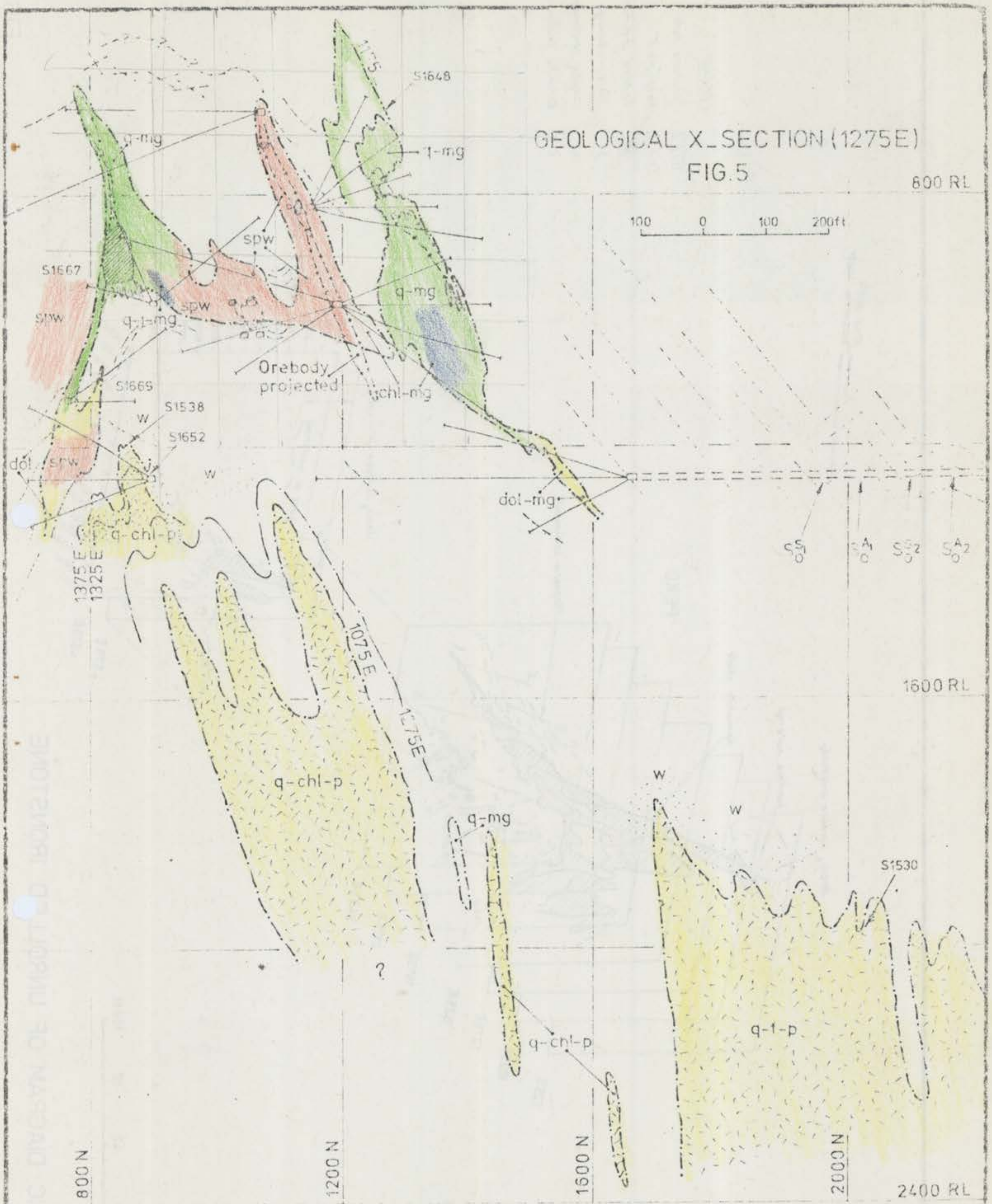
Gold was discovered in 1935 by J. Kaczensky next to a leached blue-black quartz hematite lode of dimensions 80ft. by 350ft. The mine became known as Peko after his dog and was situated seven miles south east of the Tennant Creek township in an extensive alluvial plain. A magnetometer survey conducted in 1936 revealed a major magnetic anomaly with maximum value of 5,500 gammas. In 1950, a diamond drill hole intersected 22ft. of ore averaging 7.3% Cu and 13.3 dwts Au. some 390ft. below the surface, and a copper orebody of some significance was founded which has since produced 2,900,000 tonnes of ore averaging 4.2% Cu and 3.5 g/t Au. 213,000 oz. of gold and 1,300,000 oz. of silver have been produced (June 1973).

The main contributors to previous literature on Peko have been Ivanak, Edwards, Elliston, Wright and Whittle. Ivanak regarded the mineralization as lying in the northern limits of a west plunging anticline in an area of flattening pitch with brecciation prior to mineralization. Elliston regarded the deposit as an example of mineralization localized by a pre-consolidation slump structure in the south limb of a west plunging syncline, with the porphyroid as a source rock. Whittle (1967) regarded the structural environment as a west plunging synclinal drag fold on the northern limb of the main anticline to the south, with basic intrusives as the source.

GEOLOGIC SETTING OF MINERALISATION

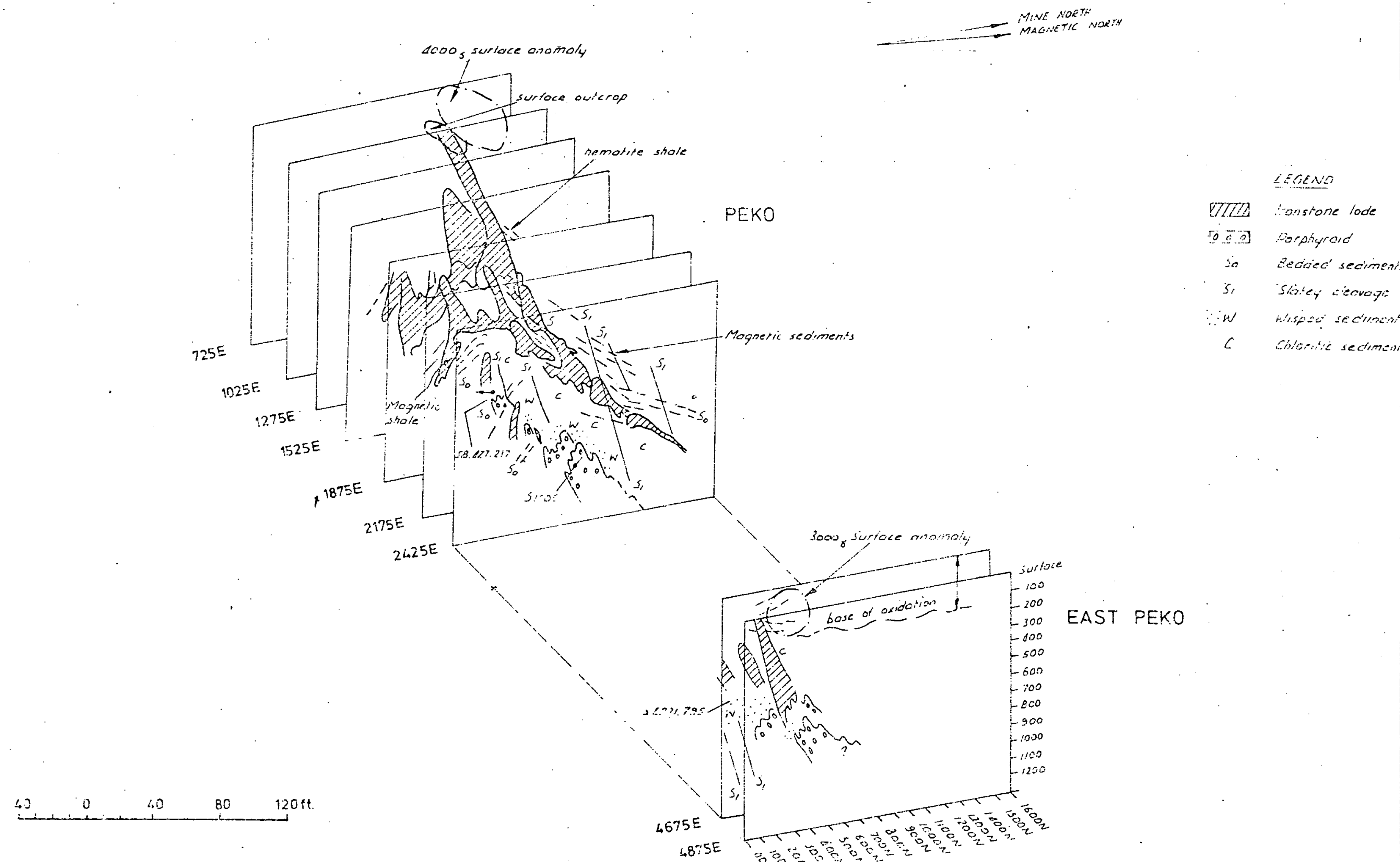
The country rocks surrounding the Peko lode consist of intercalated shales, siltstones, greywackes, and tuffaceous sandstones belonging to the Carraman formation of the lower Proterozoic. Numerous rhythmic sequences are exhibited, containing all five intervals of Boumas (1962) typical turbidite sandstone, although the interval of current-ripple lanimation is not well developed. Flame structures and other lode casts are present. Mud chips occur by erosion of the underlying muddy beds and are commonly aligned parallel to each other in the plane of cleavage. The most highly deformed portions of the turbidite sequence in the Peko area would not be considered a mélange or breccia due to lack of exotic rock types. Décollements have been described elsewhere in the Tennant Creek area by Elliston (1963). The sandstones contain illsorted angular grains of quartz, feldspar and rock fragments, the accessory minerals include magnetite, pyrite, chalcopyrite, sphere, zircon, apatite and tourmaline. Shales rich in enhedral magnetite, hematite or martite occur in Peko mine although are not as well developed as the hematite shales described by other workers in the Tennant Creek field, although may be of equal importance as a controlling media. (Large 1972). Highly cleaved slates are formed in narrow zones next to the ironstone lodes where shearing reached maximum intensity.

Considered with the sandstone shale sequence are the controversial porphyroids (Elliston et.al. 1963). Workers have regarded them variously as altered intrusives, retransported crystal tuffs, reconstituted mudflows or porphyritized sediments.



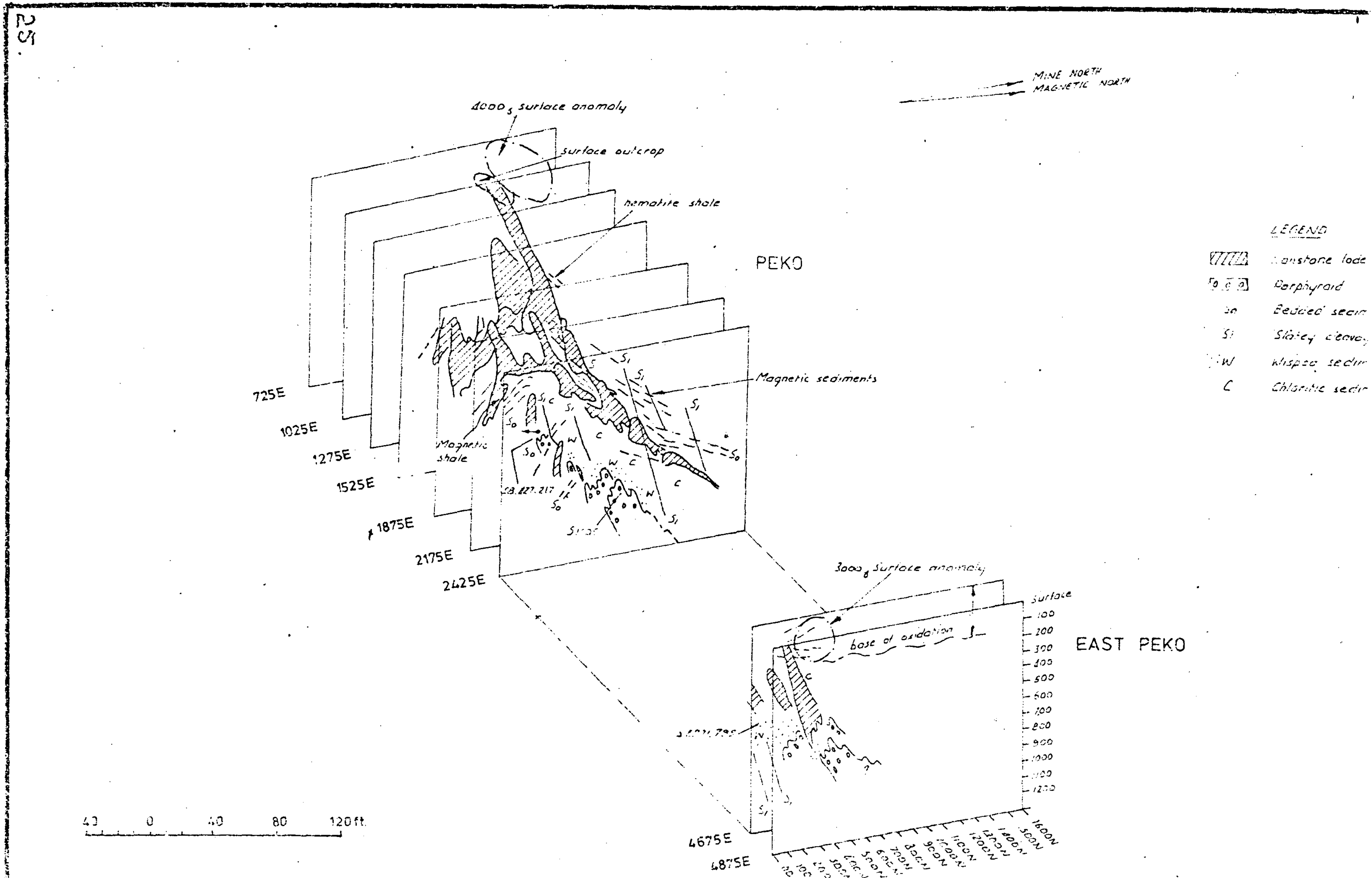
	:Stope		Bedding Trend	q-j-mg	:Quartz Jasper Magnetite
	:Porphyroid	q-chl-p	:Quartz Chlorite Porphyroid	q-mg	:Quartz Magnetite
	:Drive and Drill Hole	q-f-p	:Quartz Felspar Porphyroid	dol	:Dolomite
	:Ironstone Boundary	chl-mg	:Chlorite Magnetite	spw	:Spewstone (talc magnetite)
	:Ore Boundary	dol-mg	:Dolomite Magnetite	w	:Weathered sediment

25.



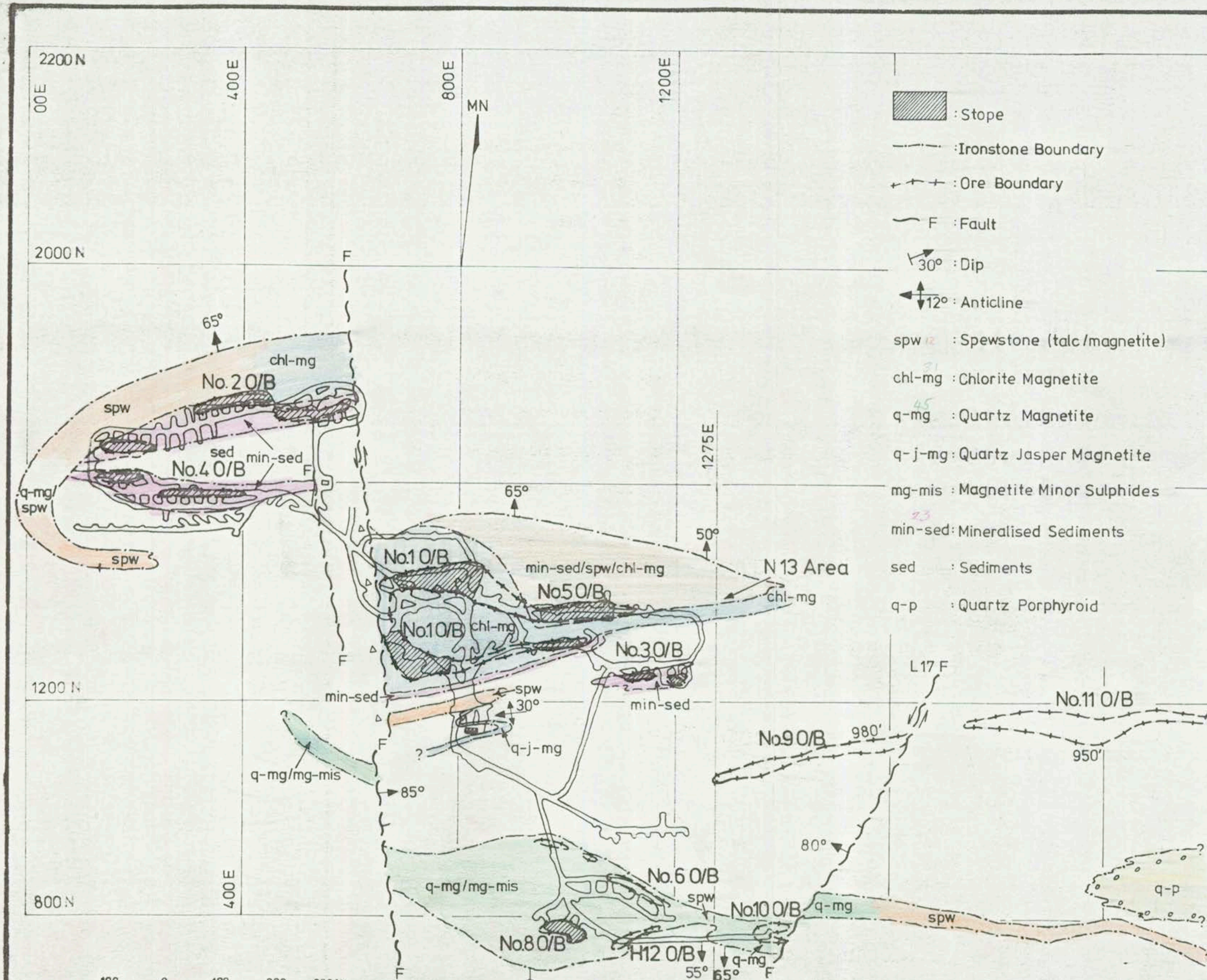
ISOMETRIC DIAGRAM OF UNROLLED IRONSTONE

FIG.



ISOMETRIC DIAGRAM OF UNROLLED IRONSTONE

F1



PEKO GEOLOGICAL SKETCH PLAN 9LEVEL (1130RL)

FIG.4

Structure and textures within the porphyroids are discussed later.

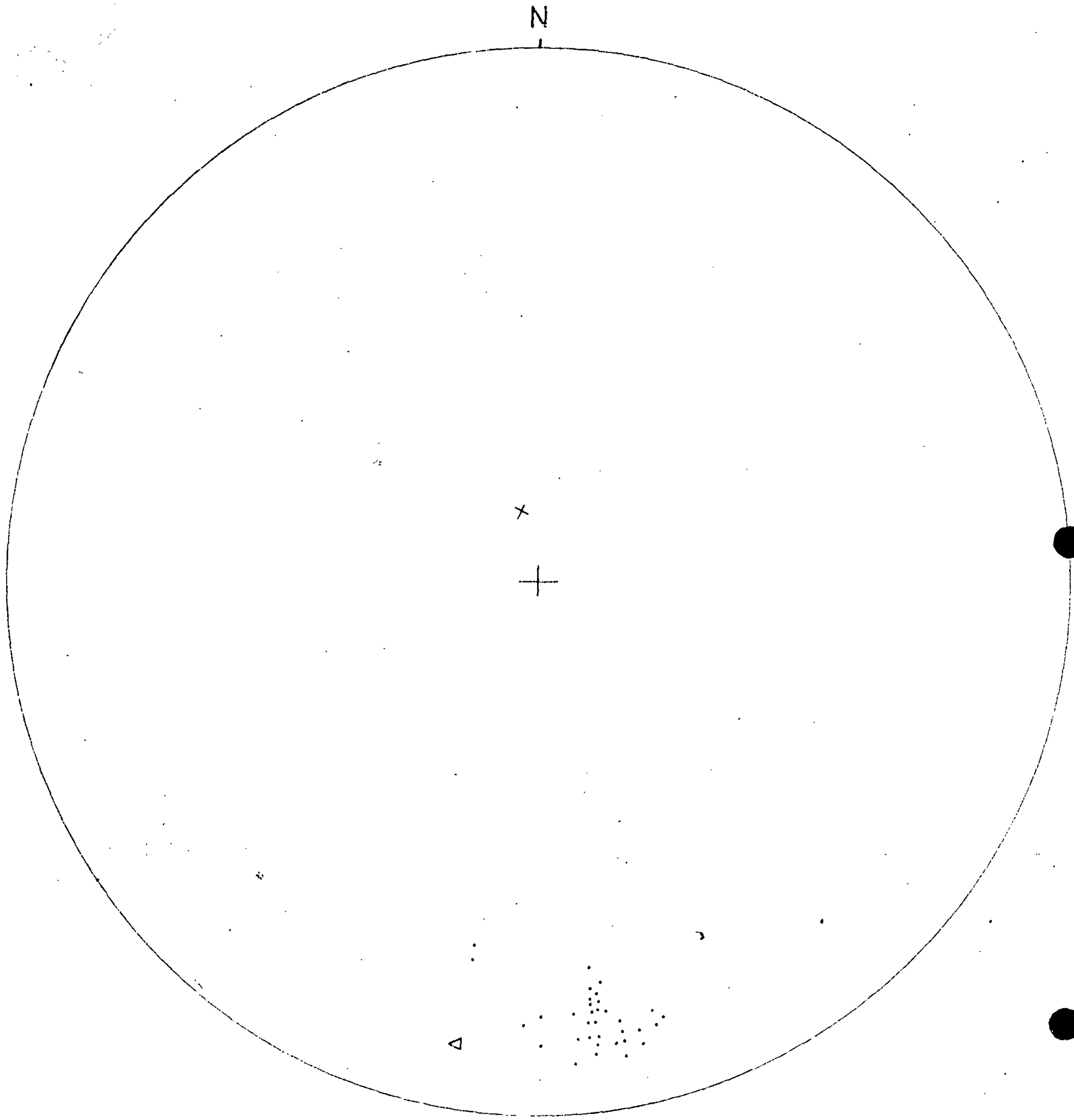
The Peko ironstone lode is an epigenetic replacement deposit tapering as a surface exposed pipe above the 680ft. R.L. (fig. 3). Below the 680 ft. R.L. the ironstone forms a saddle tapering downwards to the north and south although extensions above the 980ft. R.L. (fig. 5) occur with geometry similar to the main surface reaching pipe. The northern and southern limbs of the ironstone intersect the bedded sediments at shallow angles (figs. 5 and 6). The ironstone possesses a general vertical zonation passing downwards from a quartz magnetite envelope into a chlorite and talc rich magnetite. A lateral zonation was identified by Whittle (1972) who refers to metasomatic changes providing evidence of the action of heated, chemically active waters during mineralisation. The anthophyllite-talc zone of Whittle represented a stage of chlorite alteration by hydrolytic solutions rich in magnesia and silica. Dolomite rich rocks occur in sections of the lode (fig. 5) particularly the lower extremities. The continuation of the mineralised zone with depth below the 1300ft. R.L. is manifest in chloritic and wisped sediments which are veined and impregnated with quartz, magnetite, chlorite and sulphides, particularly along S_1.

The emplacement and deformation of the magnetite facilitated the introduction of sulphides in the general order; pyrite, arsenopyrite; chalcopyrite, pyrrhotite, sphalerite and bismuthinite; galena and wittichenite. Gold in the lower levels is paragenetically closely related with chalcopyrite and bismuthinite, although occurrences with pyrrhotite and magnetite have also been noted. The sulphides commonly entered the lode along closely spaced parallel shears and oblique tension fractures. The sulphide mineralization can be subdivided into three zones viz:

- (i) the oxidised zone
- (ii) the zone of secondary enrichment and
- (iii) the hypogene zone.

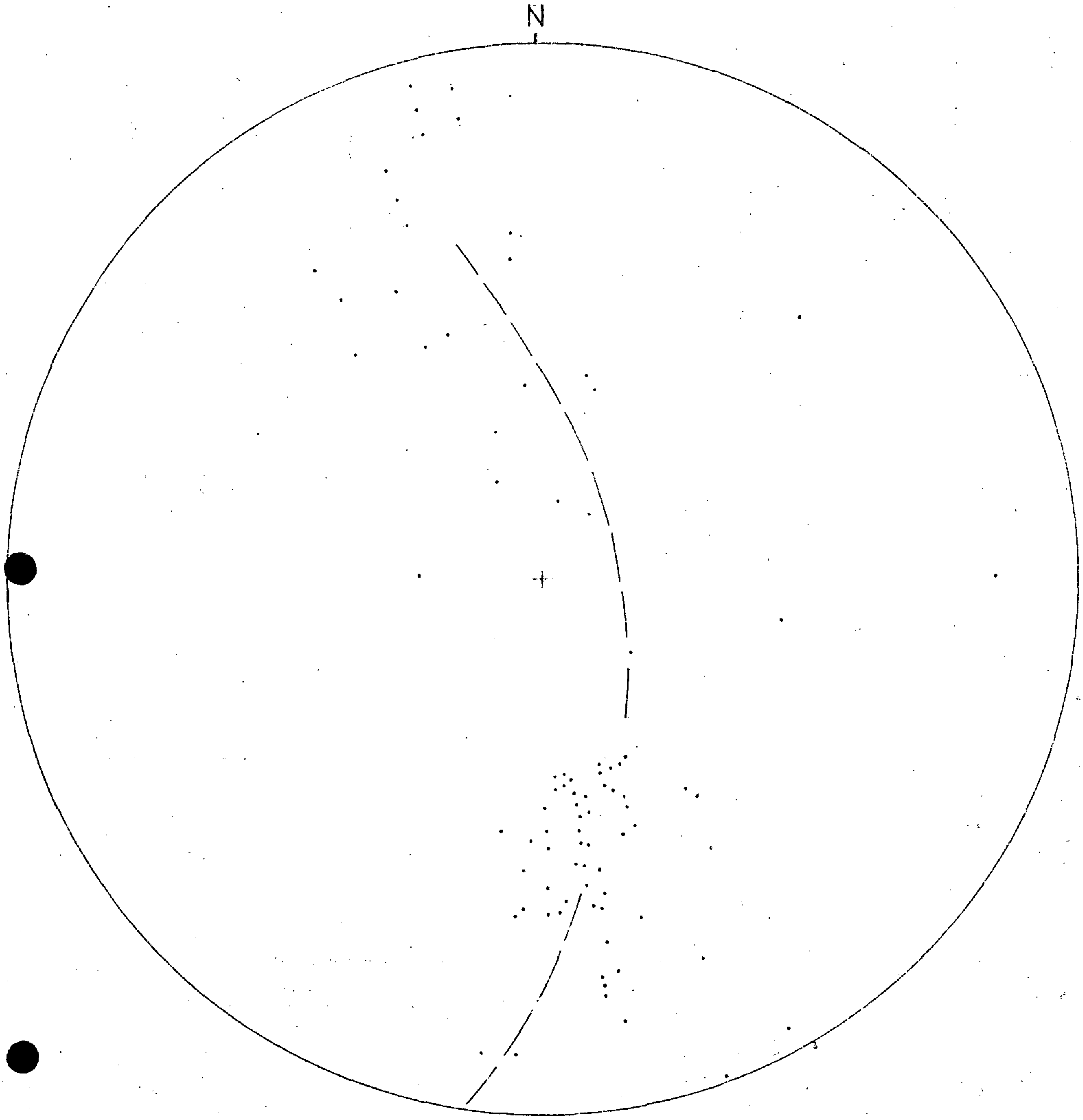
The sequence of events involved in the mineralization of the Peko lode can be identified as follows:-

- (1) chloritisation and silification
- (2) emplacement of magnetite and quartz with associated jasper, formed ahead of the sulphides, moving upwards into fold closures and along slaty cleavage deformation paths.



EQUAL AREA LOWER HEMISPHERE PLOT OF
35 POLES TO SLATY CLEAVAGE
Δ Pole to axial plane
x Kink plane pole

FIG. 7

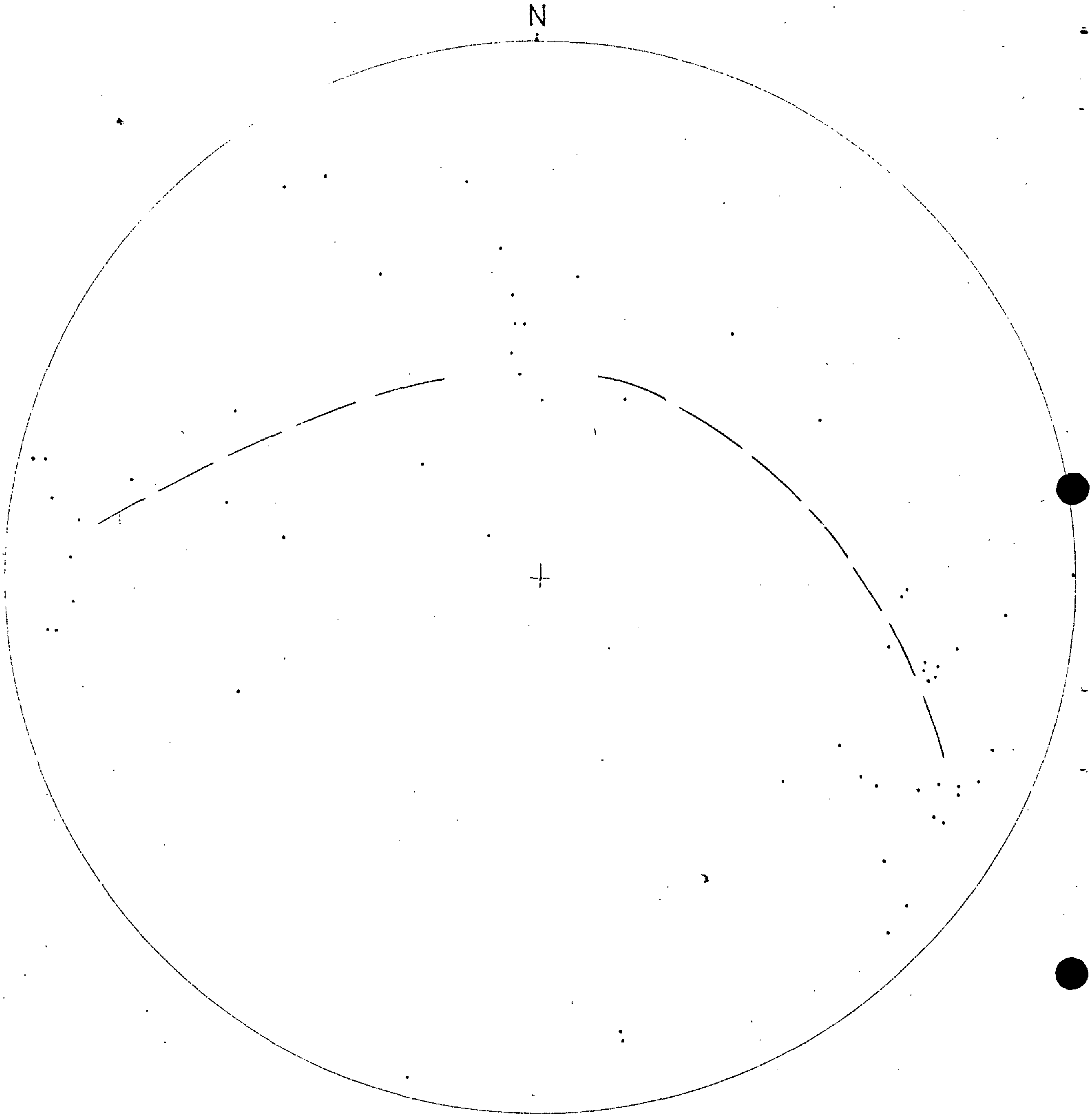


EQUAL AREA LOWER HEMISPHERE PROJECTION

π DIAG. 98 POLES TO BEDDING

Bedding girdle approximates a small circle indicating slightly conical folding

FIG. 8



EQUAL AREA LOWER HEMISPHERE PROJECTION

57 POLES TO JOINT PLANES

FIG. 9

SAMPLE 1667

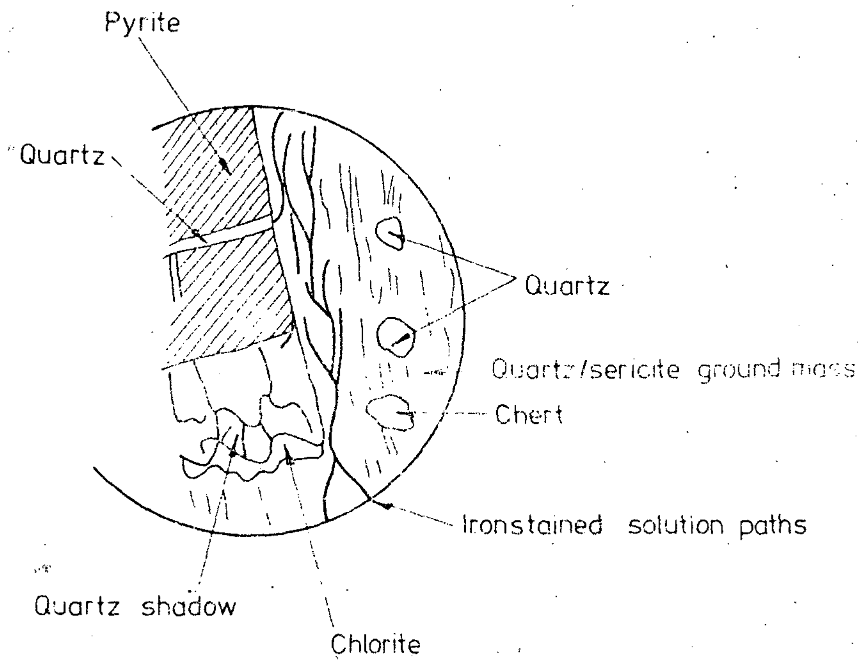


FIG. 10

SAMPLE 1669

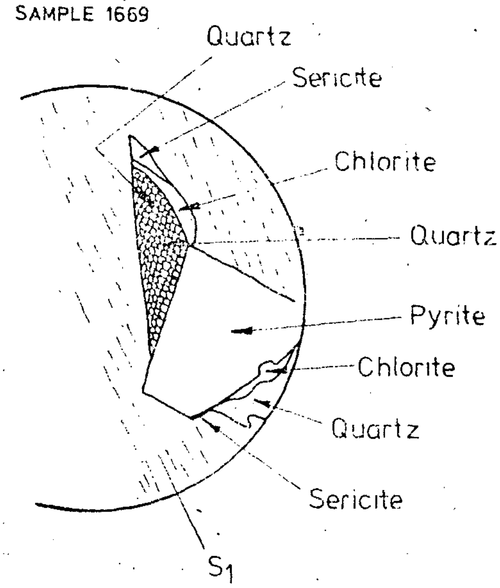


FIG. 11

SCALE: 0·5mm $\frac{1}{2}$ diam.

(3) influx of early sulphides, pyrite and arsenopyrite

(4) introduction of chalcopyrite, bismuthinite, pyrrhotite and sphalerite along S_1 deformation structures

(5) gold and bismuth accompanied the sulphur rich fluid and were concentrated with the most mobile fraction of this fluid

(6) introduction of galena

Exsolution bodies of chalcopyrite contained in sphalerite in association with chalcopyrite from which sphalerite may have exsolved indicates together with pyrrhotite a temperature of the order 500°C. (Edwards 1955). Edwards suggested a range of temperature during ore deposition between 300° - 350°C. Elliston (1965) regards concentric colloform and spherical textures as indicative of low temperature deposition.

STRUCTURE

(1) Cleavage (S_1)

The various structural elements observed in Peko fall into the main groups:-

So bedding - lithological layering

S_1 slaty cleavage foliation

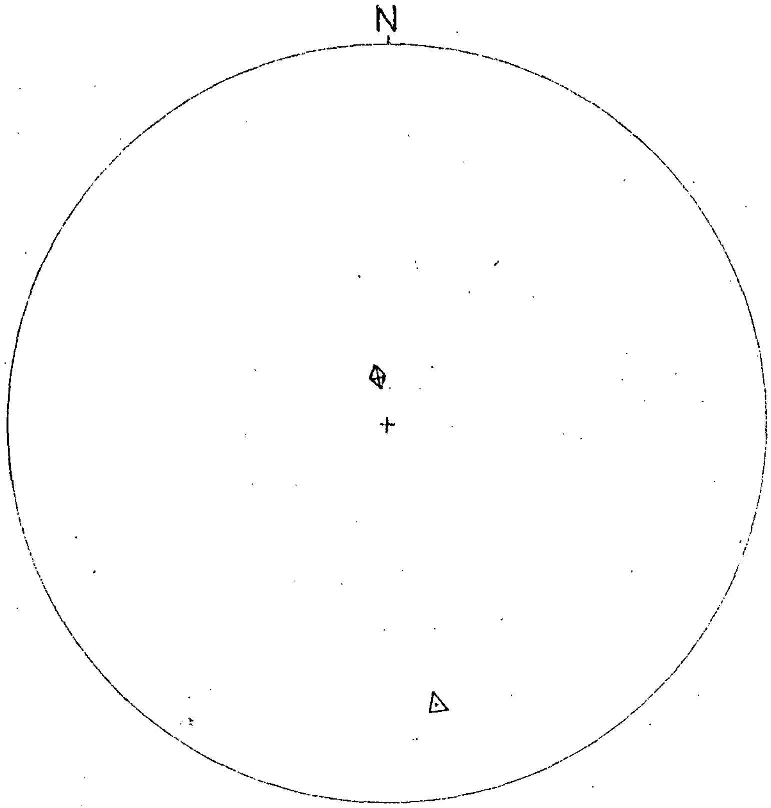
L_1 mineral lineation contained in S_1

F_1 first folds

Sa kink bands

σ maximum principal stress
(all bearings magnetic)

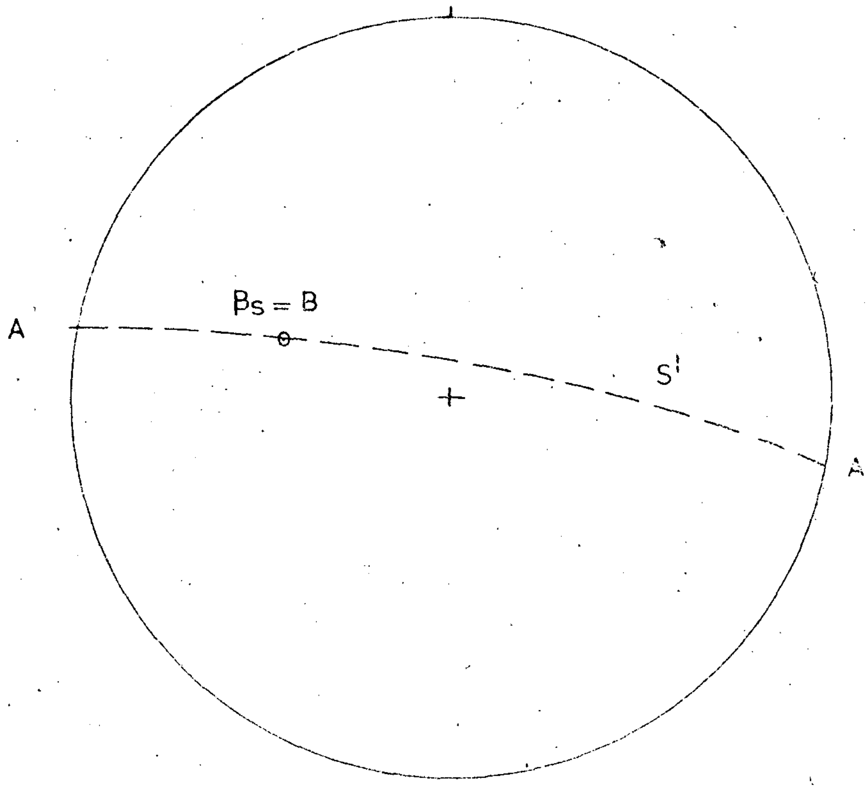
The cleavage is a function of penetrative platy mineral orientation varying in intensity and visibility from paper thin partings in the chloritic sediments to a subtle planar fabric trending across bedding contacts. Thin sections show cleavage is made up of sericite and chlorite flakes, oblique to bedding in many sediments. Cleavage in the porphyroids and ooids wraps around the feldspar grains, quartz grains and carbonate ooids. Pressure shadows (figs. 10 and 11) external domains of distinctive mineralogy and texture are developed in the immediate vicinity of porphyroblasts. They post date the development of porphyroblasts and are elongated in the plane of schistocity (slaty cleavage) of the enclosing matrix. Their growth is controlled by late tension acting parallel to schistocity.



EQUAL AREA LOWER HEMISPHERE PROJECTION

◈ Kink plane pole

△ Poles to slaty cleavage



LOWER HEMISPHERE STEREOGRAPHIC PROJECTION

ORIENTATION OF AXIAL PLANE S' DETERMINED FROM

DETERMINED FROM B_S & AA [Trends N 80°W 280° dipping 78° to the N 10° (010°)]

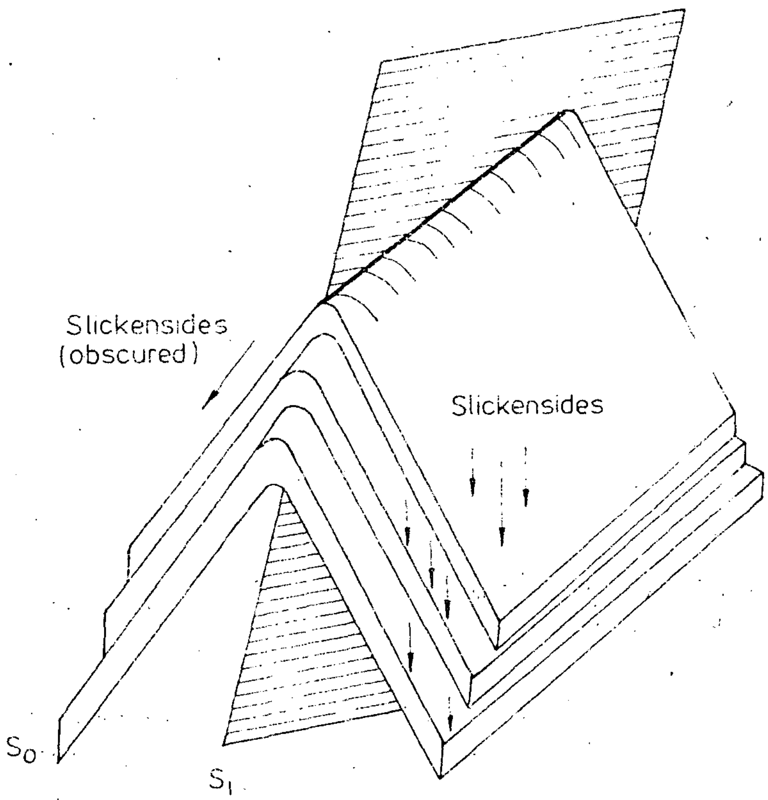
FIG. 12

The tails have been filled by quartz deposited from solution in the pressure relief shadows which have grown in the direction of tectonic elongation as the rock was deformed. The interface between rigid particle and ductile matrix is a sharp discontinuity in material properties. Quartz always tries to grow normal to the face of the rigid particles (fig. 10).

35 poles to cleavage (fig. 7) were plotted from observations made from every opening within the mine. The point maxima can be seen to define a plane striking S. 82°W(262°) with a steep dip to the north of 75°. This plane is consistent throughout the mine in differing fabric types (shales, sandstones, wisped sediment, chloritic sediment and porphyroid) and bears symmetric relationship to the axial plane of the folds (fig. 12). The cleavage may be referred to as slaty cleavage. Slaty cleavage is a penetrative surface normal to the maximum finite compressive strain direction (Ramsey 1967). It is therefor apparent that the folds and cleavage were formed in response to the same stress system with axial plane schistocity normal to the compression approximating AB of the strain elipsoid. Fanning symmetric and close to the axial plane may be present although has only been identified in drill core and must be of questioned value.

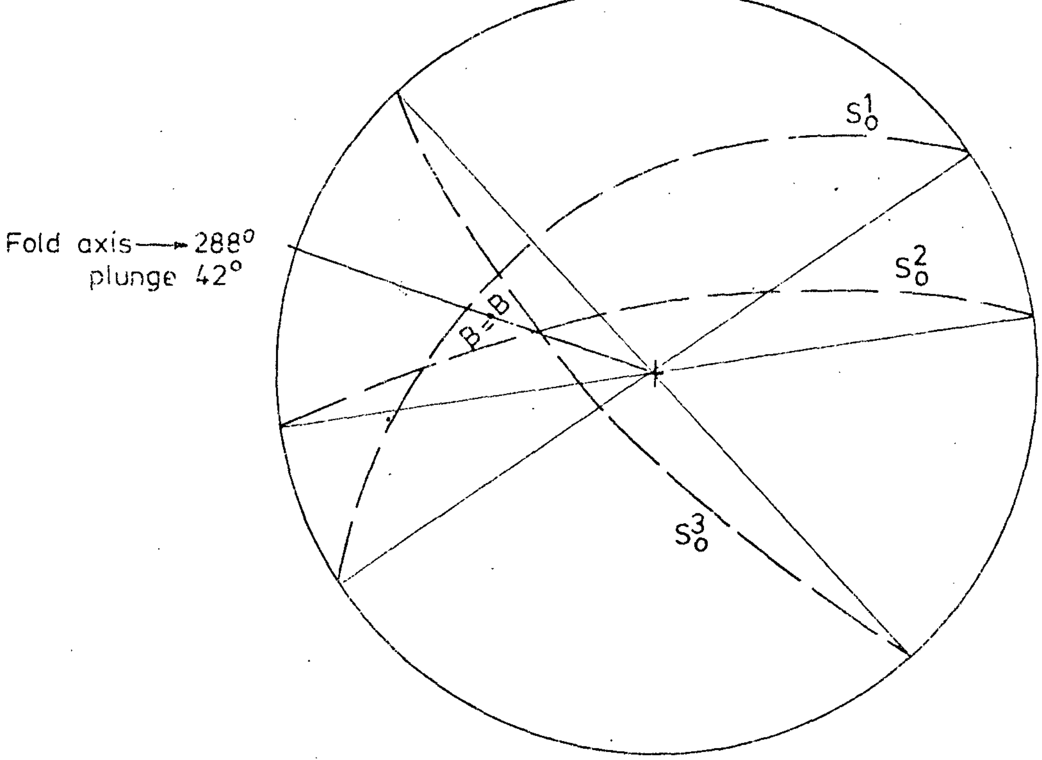
The metamorphic grade is lower greenschist facies developed between 300 - 400°C and pressures upward of 4000 bars (Turner and Verhoogen 1960).

Slaty cleavage is a prominant fabric element of the formation and its tectonic origin is indicated by its mineralogical expression and its close parallelism to axial surfaces. The presence of porphyroid and clastic dykes and the deformation of ooids parallel to the slaty cleavage is evidence of an unconsolidated state during first deformation of the sediments. In view of the pressure shadows and the discussion above, the various structural features suggest different degrees of mobility during deformation. Spry's (1963) statement that cleavage occurred in consolidated sediments in the "hard-rock" state is not in agreement with the observed facts in Peko, and Elliston's (1973 C12) observation that cleavage in mudflows and rheopelites is generally parallel to the bedding, does not receive support. The cleavage examined in openings and drill core had marked foliation parallel to S_1 and not So.



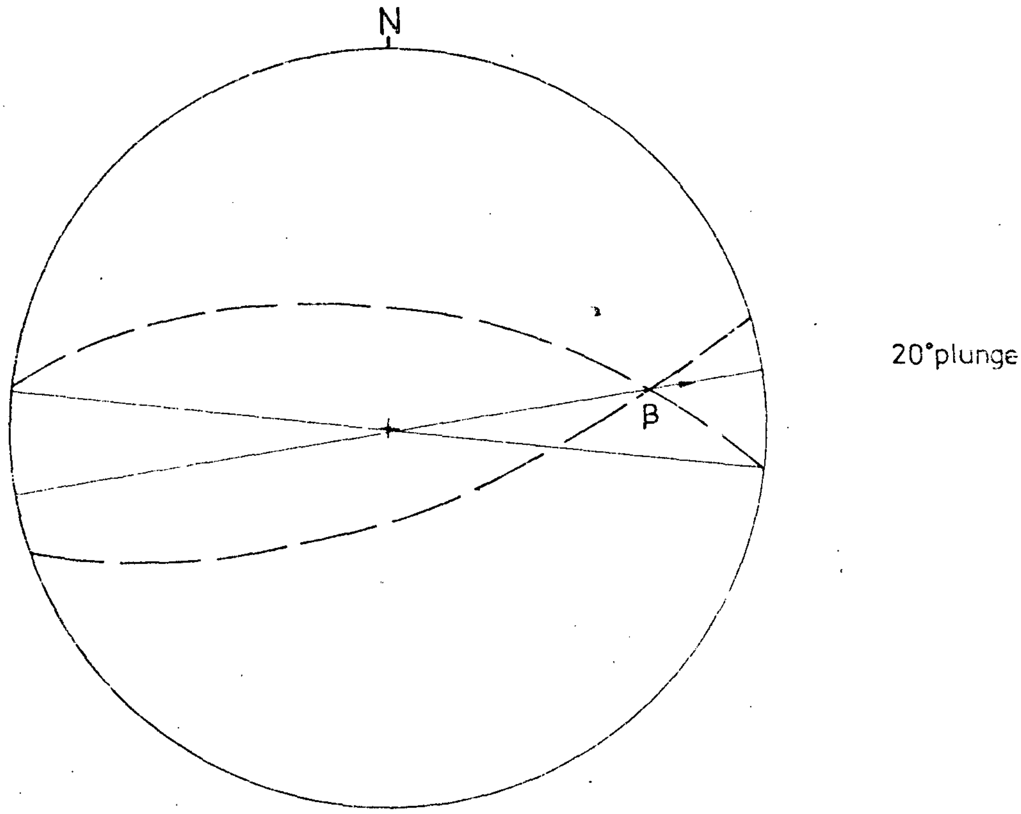
DIAGRAMATIC SKETCH: FLEXURE SLIP FOLDING
WITH OBSERVED SLICKENSIDES

FIG. 13



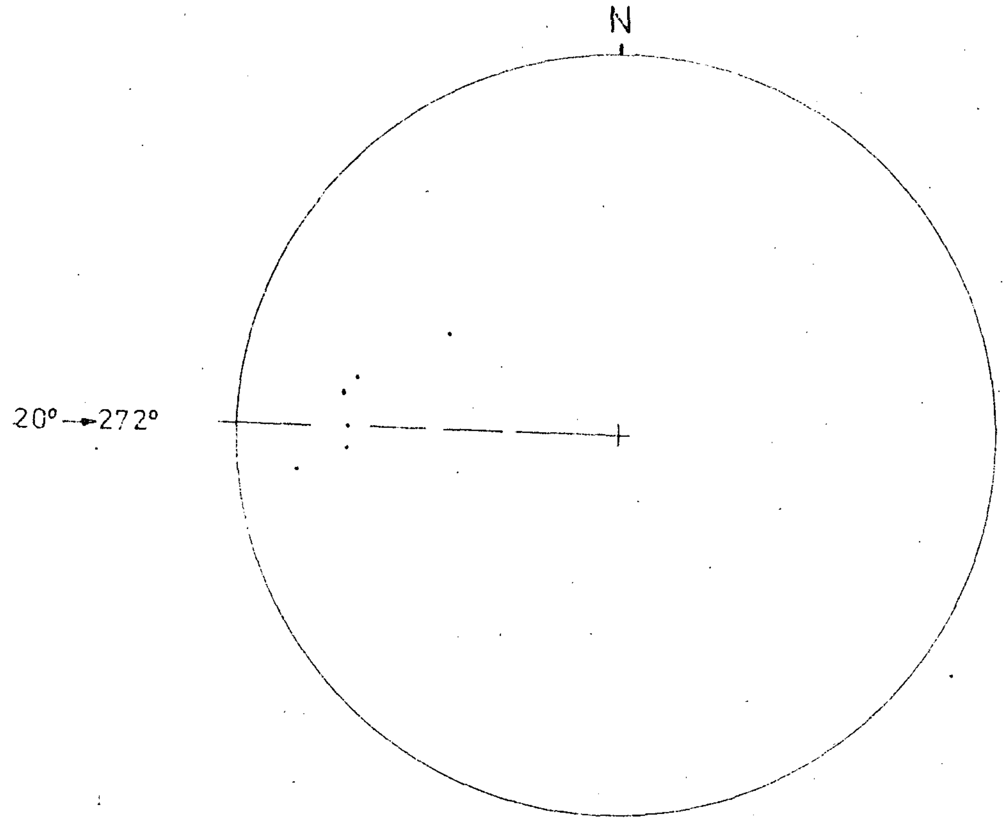
LOWER HEMISPHERE STEREOGRAPHIC PROJECTION
OF BEDDING PLANES FROM NOSE OF FOLD 2 LEVEL
Traces of S_o (β diag.)

FIG.14a



LOWER HEMISPHERE STEREOGRAPHIC PROJECTION
MEAN BEDDING PLANES 400 PILLAR EAST OF 1000E
Traces of S_o (β diag.)

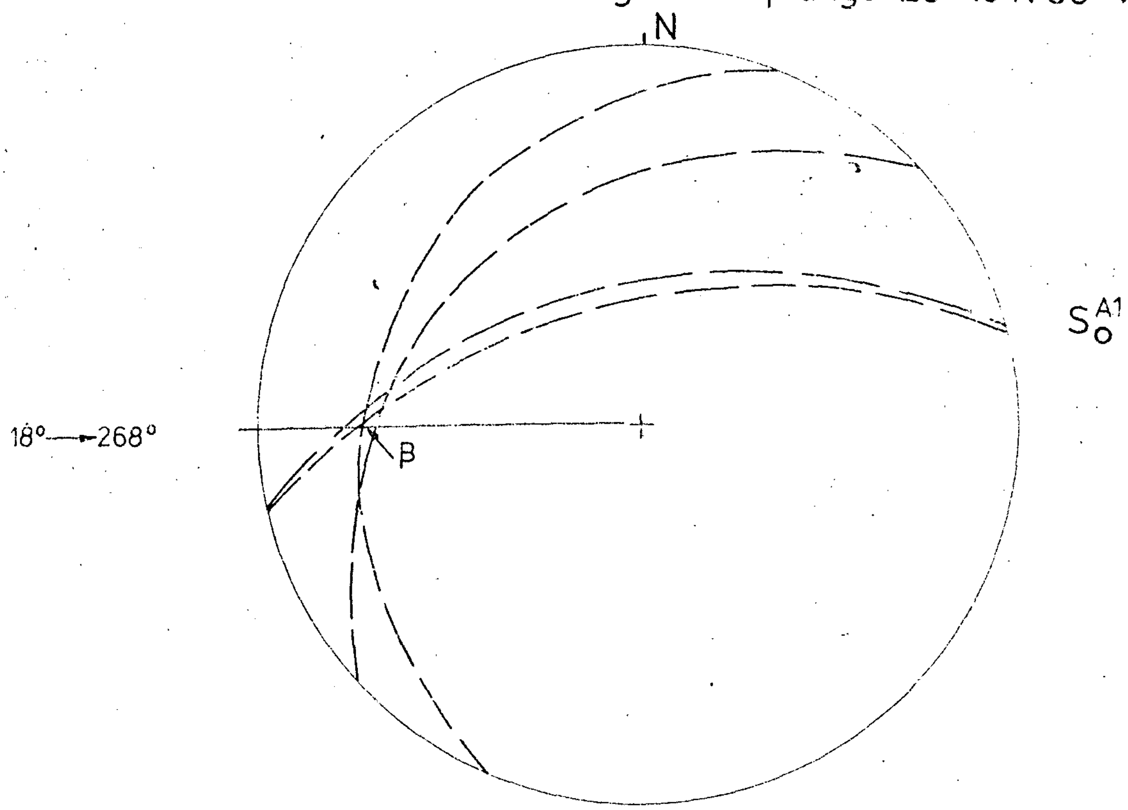
FIG. 14 b



LOWER HEMISPHERE STEREOGRAPHIC PROJECTION

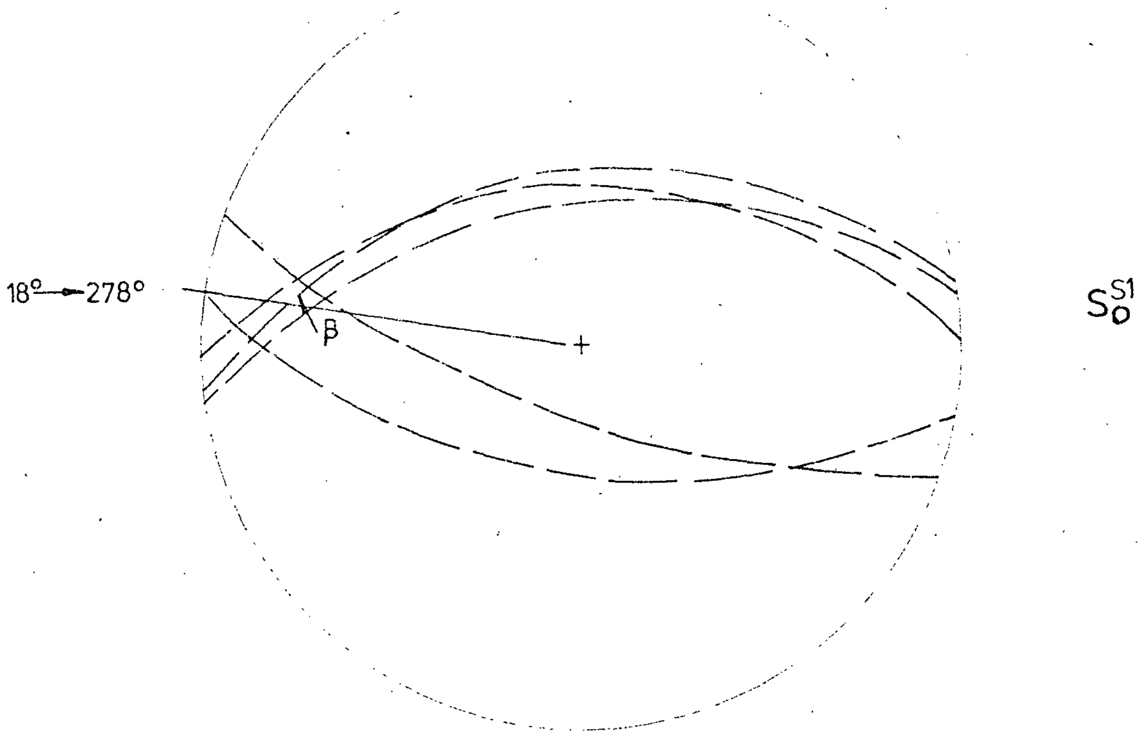
5 AXES PLOT OF ANTICLINES AND SYNCLINES

PEKO 10 Level showing mean plunge 20° to N 88° W



LOWER HEMISPHERE STEREOGRAPHIC PROJECTION

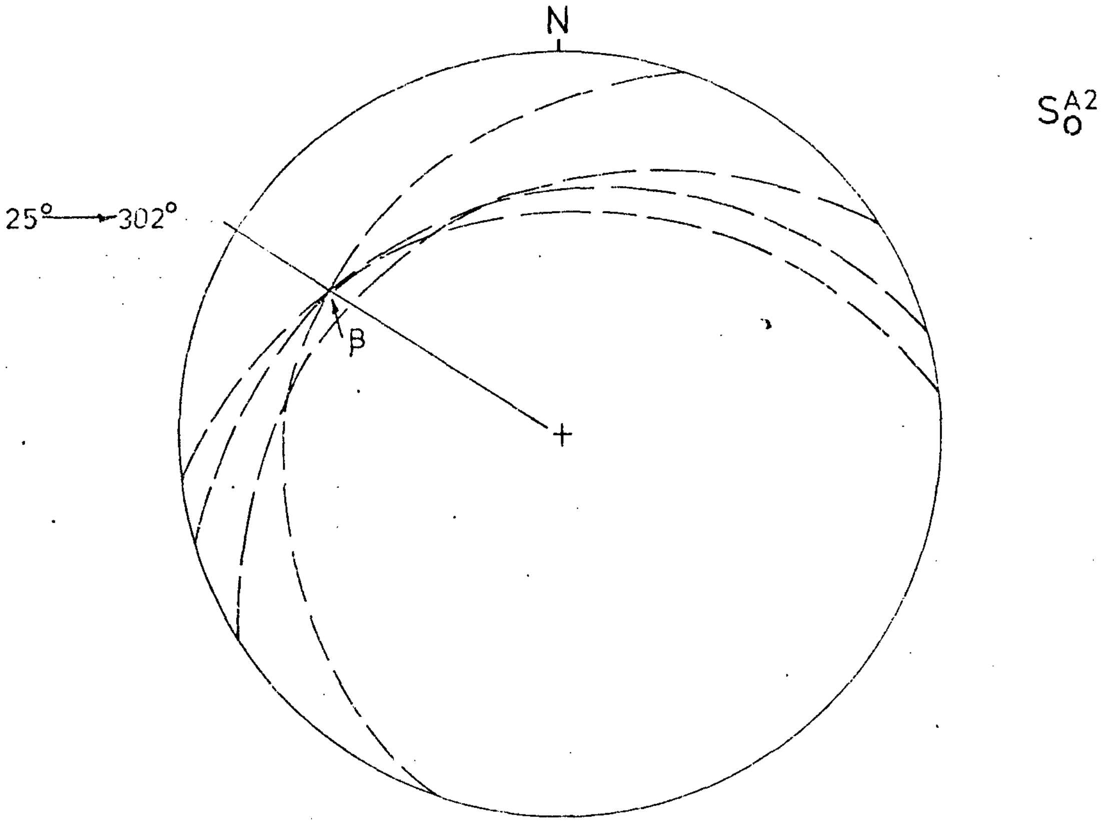
S PLANES DRAWN IN CYCLOGRAPHIC REPRESENTATION



LOWER HEMISPHERE STEREOGRAPHIC PROJECTION

S PLANES DRAWN IN CYCLOGRAPHIC REPRESENTATION

β diag. defines fold axis of S_o^{S1} 10L plunging 18° N 82° W

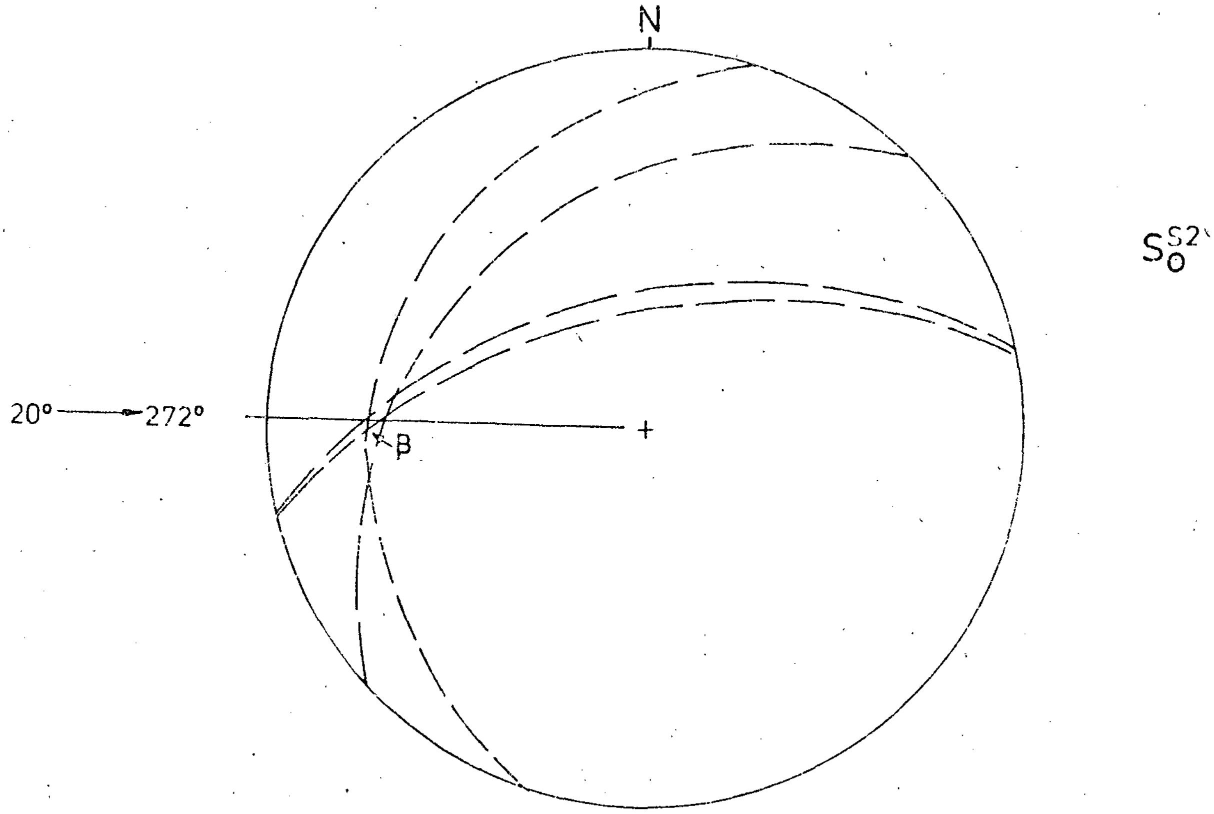


LOWER HEMISPHERE STEREOGRAPHIC PROJECTION

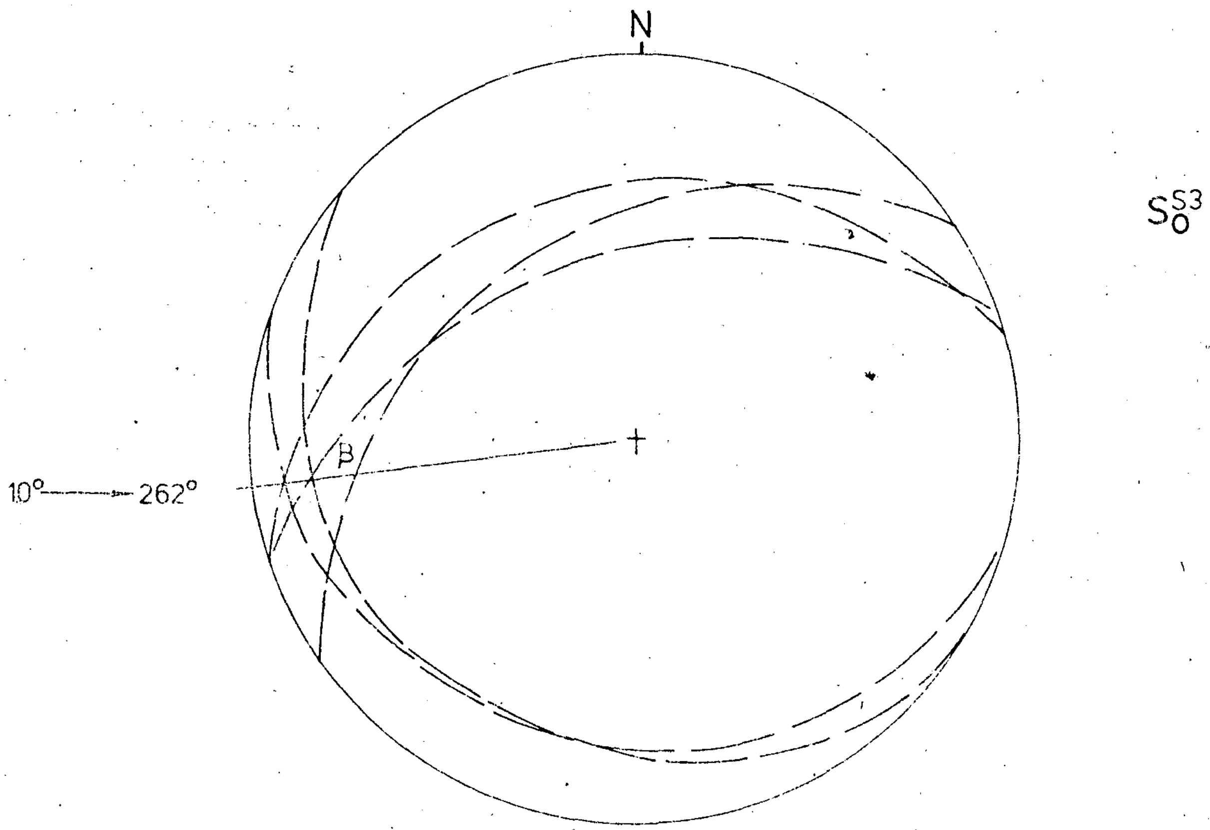
S PLANES DRAWN IN CYCLOGRAPHIC REPRESENTATION

β diag. defines fold axis of S_o^{A2} 10L. plunging 25° N 58° W

FIG. 14d



LOWER HEMISPHERE STEREOGRAPHIC PROJECTION
S PLANES DRAWN IN CYCLOGRAPHIC REPRESENTATION
β diag. defines fold axis of S_o^{S2} 10L plunging 20° N 88° W



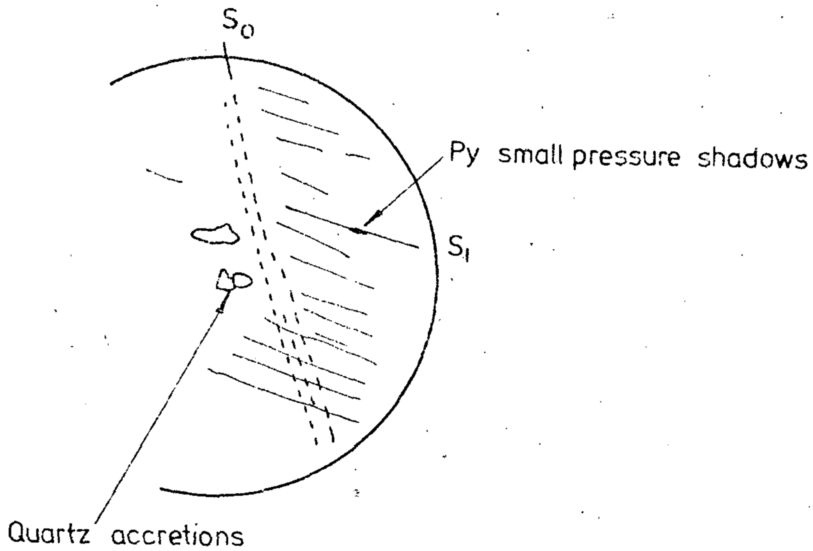
LOWER HEMISPHERE STEREOGRAPHIC PROJECTION
S PLANES DRAWN IN CYCLOGRAPHIC REPRESENTATION
β diag. defines fold axis of S_o^{S3} 10L. plunging 10° S 82° W

(ii) Folding (F_1)

Folding in the Peko area was examined from the onset with ideas consistent with the general philosophy of structural analysis and it is apparent that the folded S- surface was kinematically active. Abundant slikensides (fig. 13) on bedding surfaces indicated that slip between beds was an important deformational mechanism. The presence of two sets of differently oriented slickensides on the main north limb and south limb suggest a plunge during deformation of $34^{\circ} \rightarrow 290^{\circ}$ (fig. 17). The possession of planar limbs (fig. 5) with narrow hinges and abundant slickensides is consistent with flexural slip folds (Faill 1973) ~~(fig. 25)~~. Characteristic of layers deformed by flexural slip buckling (Turner and Weiss 1963) are occasional disharmonic or crumpled folds (localized décollement is not uncommon) in the less competent finely laminated layers between flexed layers. Similarity of geometry between the observed fold axes (fig. 14) axial plane (fig. 12) and cleavage (fig. 7) indicate a genetic relation. The presence of axial-plane foliation (S_1) precludes simple flexural-slip folding (Turner and Weiss 1963) however, as the sole mechanism, and the folds were probably located first by flexural slip on So, and the folded surface remained kinematically active during later development of S_1.

The lower hemisphere plot of 98 poles to bedding fabric planes (So) (fig. 8) show a general axial trend plunging to the east consistent with hinge observations, and selected domains from 10 level, the respective axes of which were defined using β diagrams (see fig. 14). The bedding girdle defined in fig. 8 approximates a small circle indicating slightly conical folding (J.C. Moore 1973). In many geologic bodies plane non cylindrical fold systems may have formed in a single complex deformation usually composed of individual folds of canoe or basin shape (Large 1973) (Peko 430 R.L. figs. 14a and 15). The commonest cause of non cylindrical systems is the oblique superposition of a second generation of folds on an earlier system as a result of repeated deformation, the existence of which is conclusively demonstrated by kinking of S_1 deformation (fig. 16).

SAMPLE 1619



SAMPLE 1646

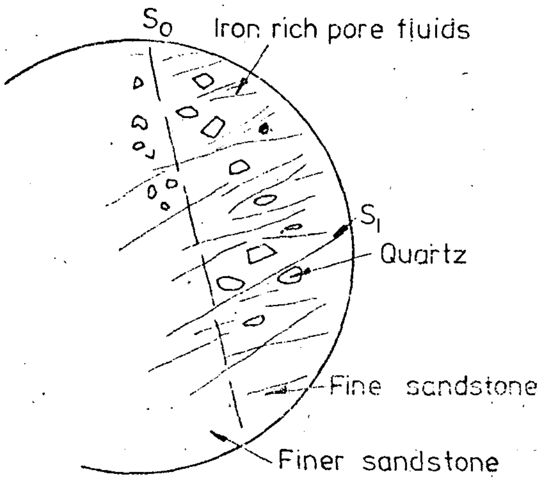
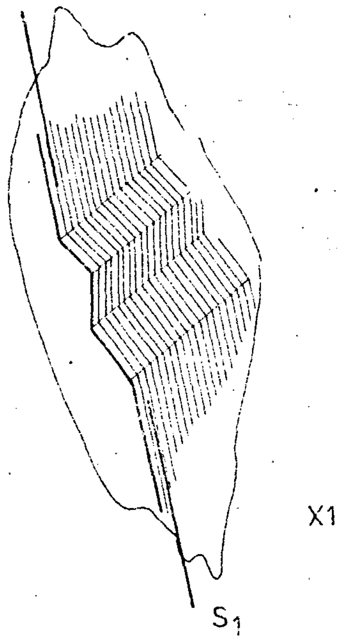


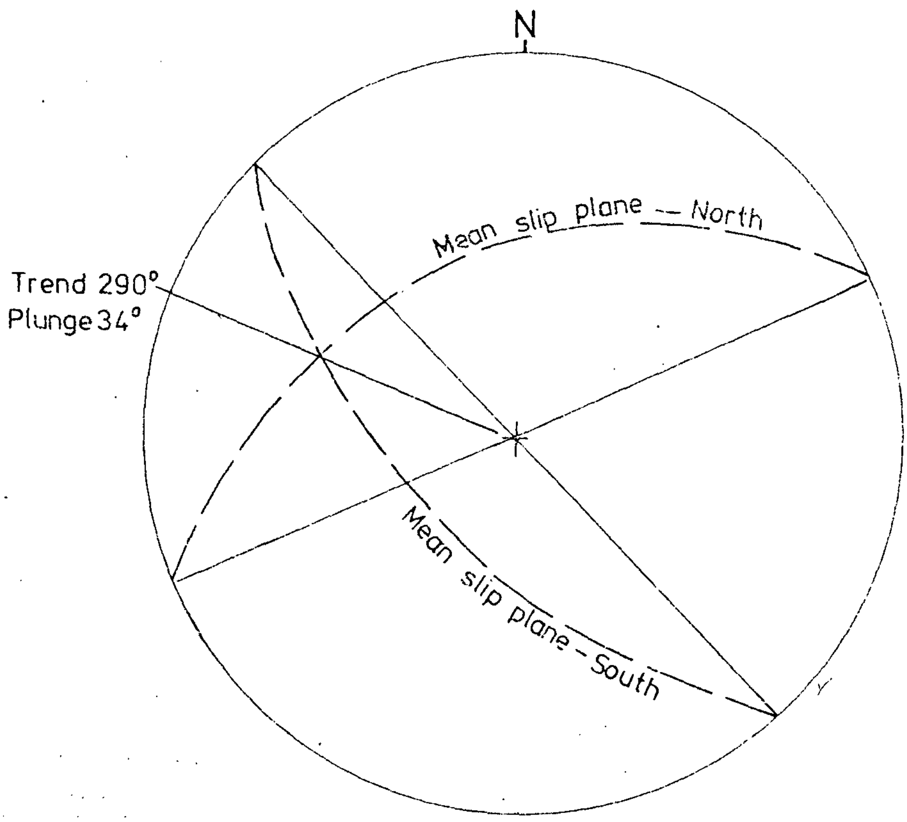
FIG. 15

SAMPLE 1665



Sketch showing kinking of S_1 slatey cleavage

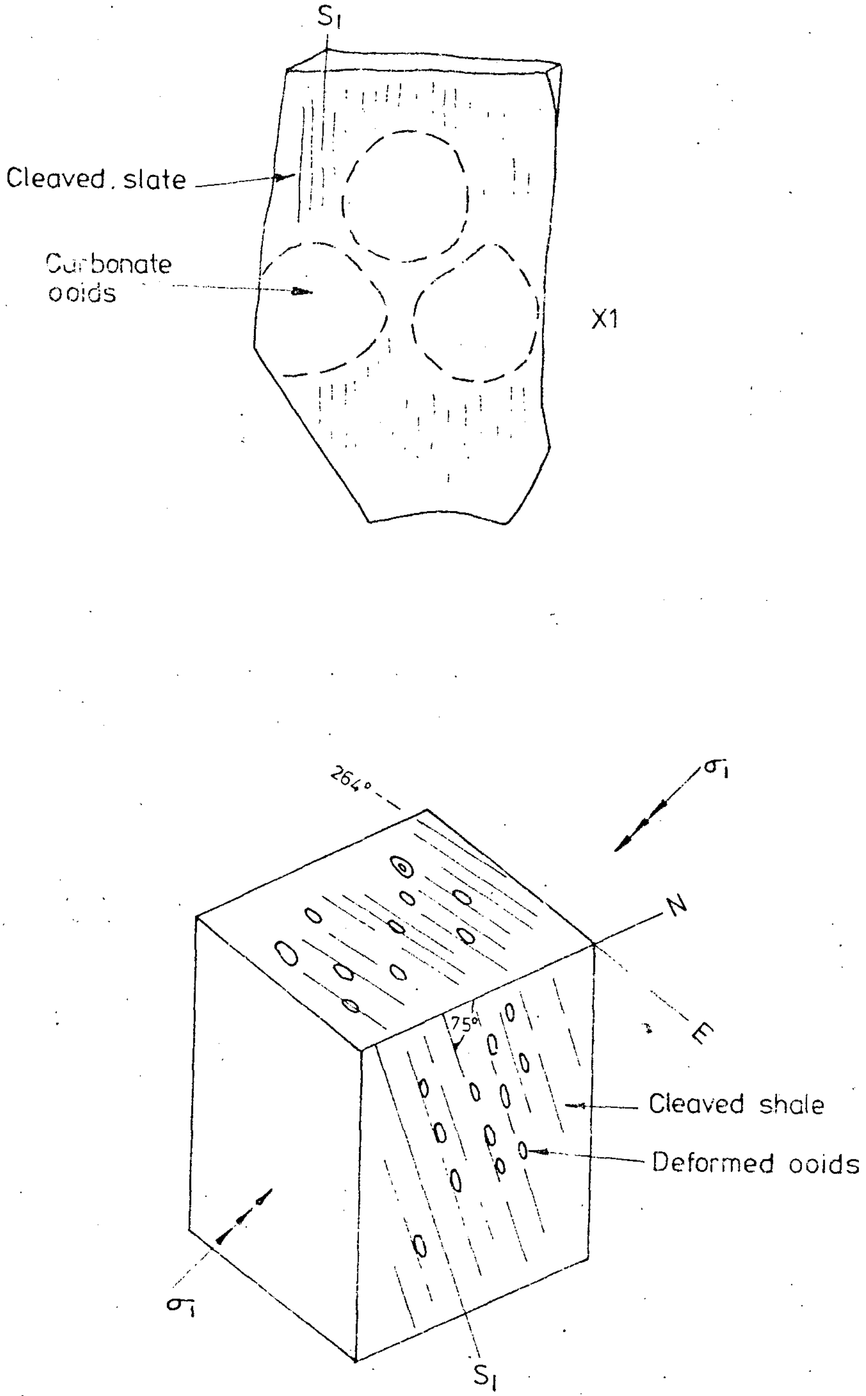
FIG. 16



LOWER HEMISPHERE STEREOGRAPHIC PROJECTION
TRACES OF SLIP PLANES

FIG.17

SAMPLE 1648



SKETCH AND GEOMETRY OF OOIDS

FIG.18

Both the half wave length and amplitude of the large fold and second order congruous minor folds are difficult to measure because marker beds are relatively lacking, although estimates of 600ft., 80ft. and 350ft., 50ft., appear to be of the correct magnitude. J.C. Moore examining trench deposits of S.W. Alaska indicated that large folds are often directly proportional to the sand:shale ratio and the thickness of beds. This may have direct application to the Peko environment where thicknesses of over 40ft. of coarse greywacke have been identified.

It is unlikely that deformation is the result of plastic flow at high temperature and pressure and it is evident that folding occurred while the sediments were semilithified and retained a significant amount of pore water, although later deformation in the well-lithified state is demonstrated by kinking of S_1 fabric. The style of folding discussed is consistent with, although not diagnostic of gravity gliding. Surface slumping and gravity phenomena are expected on steep slopes covered with poorly consolidated sediments. Chaotic slump deposits occur in the Tennant Creek area (Elliston 1963) and numerous cases of sedimentary deformation due to slumping have been documented from slope rise and trench provinces (Ross and Shor 1965) (Von Henne 1972). Although the environment of folding, response of the rock sequence, and tectonic interpretation will be discussed later, emphasis must be placed on early deformation of the rocks with gravity gliding, folding by flexural slip, accompanied by development of slaty cleavage parallel and sub-parallel to the axial planes.

(iii) Ooids

Elliptical or eye-shaped bodies up to 3" long occur locally in the sedimentary sequence and are well exposed on the No. 6 level (680 R.L.). Bedding (So) in the sample locality is inconspicuous although within 50ft, bedding strikes 258° and dips 40° to the north. The ooids may be regarded as deformed dimensional markers indicating bulk elongation along the fold axis and in the axial plane normal to the fold axis and bulk shortening normal to the axial plane (fig. 18). The ooids in hand specimen consist of whitish calcite in a grey/green matrix, they occasionally are in contact and impinge, some (usually the smaller ones) have smooth circular outlines although most are deformed with S_1 foliation wrapping around the ooids rather than penetrating.

Many cores have angular sediment interclasts acting as nuclei which have not suffered rotation by S_f. The outward boundary against the matrix is sharp with colour changes giving a concretionary appearance.

In thin section (fig. 21a) the ooid boundaries are irregular against a chlorite sericite matrix containing rounded grains of quartz and chert. The ooids are relatively undeformed and contain quartz, chert, sericite, zircon and shard-like textures.

A localized basin or depression is envisaged with the initial sediment being a carbonate rich mudstone. Winnowing could produce concentration with nucleation and growth around transported and redeposited fragments of penecontemporaneous sediment interclasts. The existence of curved spicule shard-like textures within the ooids (fig. 21a) has been previously noted by Jephcot (1971) and require some explanation. The existence of shard-like textures in carbonate rich rocks has been observed by Hatch and Rastall (1965) due to volume change during crystallisation to produce diagenetic cracks extending vertically, horizontally and diagonally through the limestone. Dimroth and Chauvel (1973) identified shards in the Sokoman formation of Quebec and implied no genetic connotation although referred to formation by compaction or accommodation of interclasts to an extreme degree. The Peko shard-like textures do not resemble those of the Sokoman formation and their symmetry more closely resembles volcanic shards. Their existence could be tenuously explained by preservation in a gel-like globule which during deformation was capable of elongation in a plane normal to the maximum strain but did not suffer complete penetrative deformation by S_f.

The existence of deformed ooids, are important strain, gauges in meaningful determination of total strain and is an important parametre in deformation of sediments in the unconsolidated state.

(iv) Kink Bands (S_2)

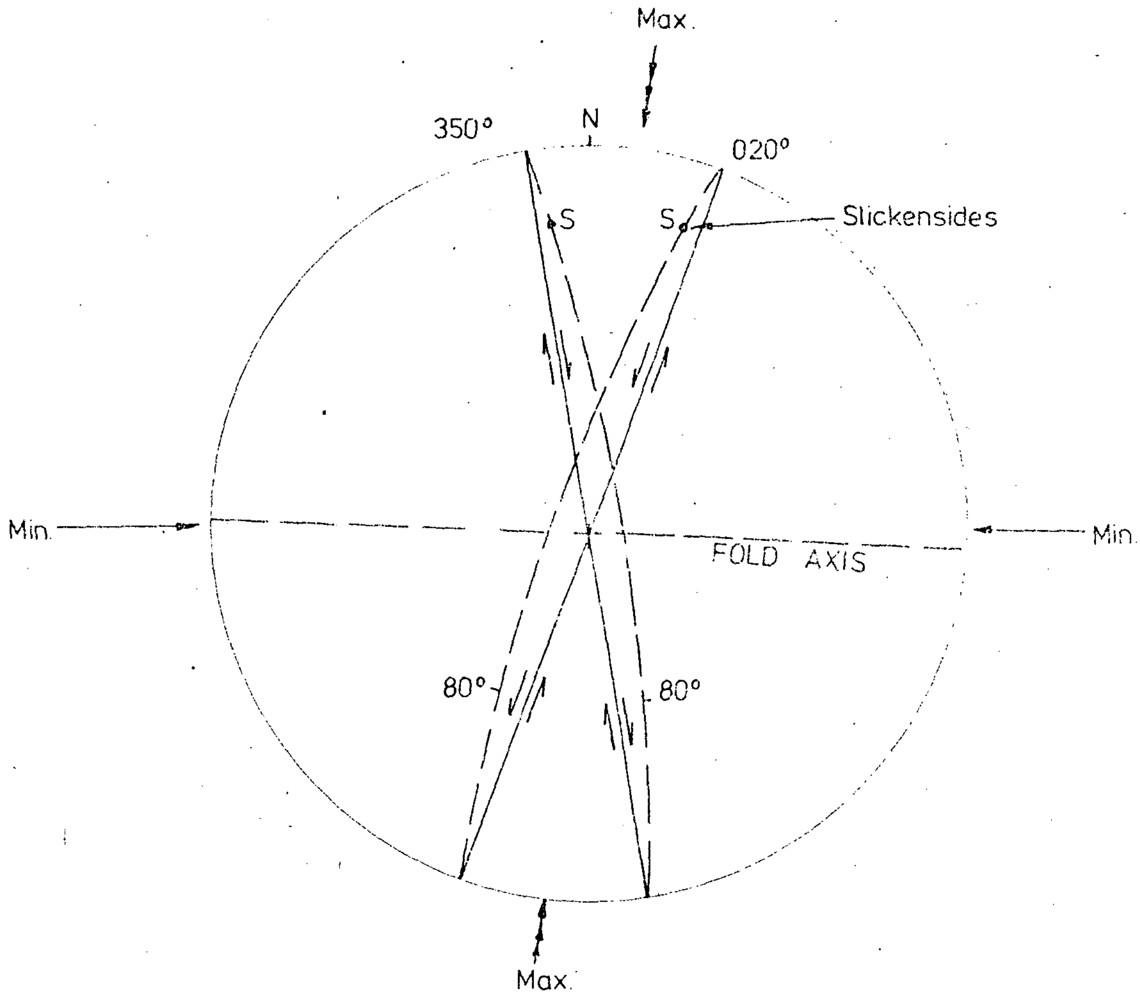
Kink bands are deformation bands of mesoscopic scale (fig. 16) occurring as narrow zones within which the S_f foliation has been rotated. Their development in Peko involves flexural slip with shear failure although cataclasis along the foliation is not marked (fig. 21b).

The use of kink bands as a tool in structural interpretation is in the early stage of development and papers within the last ten years deal mostly with laboratory experimentation rather than direct field application. From examination of kink band plane to foliation, and kink band plane to stress relationships, certain facts emerge. The plunge of the inferred second generation σ_1 axis is near vertical owing to the shallow dip of the kink band planes (Kleist) and secondly the presence of a single set, and absence of a conjugate set of kink band planes, is indicative of compression at 25° and 45° to the foliation (Turner and Wiess 1963). It was noted by Kleist that the maximum principal stress axis derived from kink bands may only reflect a local stress condition, however, the angular relationship between kink band planes and slaty cleavage identified by Goulevitch at Warrego bears close similarity with that at Peko and could indicate a regional stress condition. The planarity of the kink band planes, although examined in small domain, are thought to indicate the planes to be the youngest structural element present at Peko.

(v) Joints

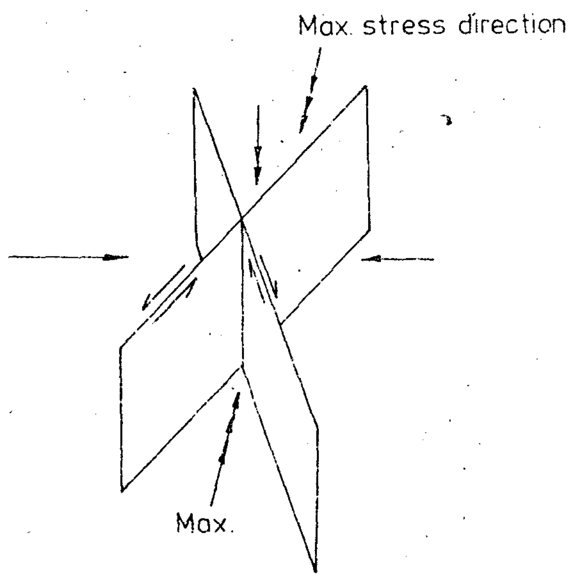
57 subparallel planar fractures were statistically examined from localities scattered throughout the Peko domain. Some were open whereas others were cemented with fillings of quartz or calcite. Joints formed by brittle rupture and are often related to flow structures reflecting response to residual stresses remaining in the tectonite after flow ceased. Poles to joints were plotted on equal-area nets (fig. 9) and possible relationships between joint orientation and mineralization were examined. Three families or mean joint directions were seen to occur, one family around N.34°E. strike and 75°N.W. dip, another N5°E strike and 80°E dip, and a third 090° strike and 35°S dip. The three sets when plotted did not form a small triangle of intersection suggesting that they did not form in the same stress system. The small circle defined is not in agreement with the bedding circle and the joint planes do not appear to bear a strong relationship to the fold pattern although longitudinal joints and steep cross joints on the fold limbs were observed. The plunge 58° → 302° and dip 66° → 360° of the ironstone, where well defined between the surface and 700' R.L., do not appear to bear a strong geometric relationship with joint planes at Peko.

45.



LOWER HEMISPHERE STEREOGRAPHIC PROJECTION

Fault plane geometry



ORIENTATION OF STRESS FIELDS

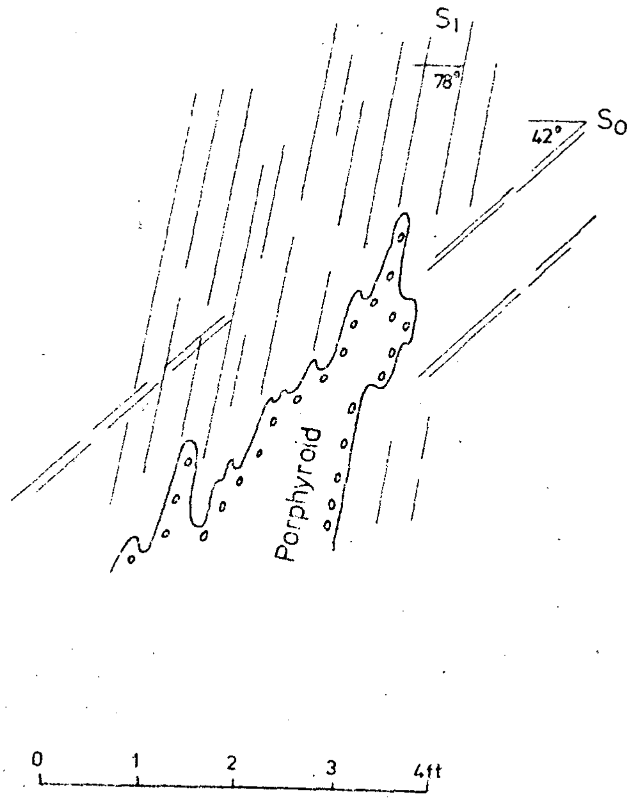
FIG. 19

(vi) Faults

Examination of the Main Peko Fault (a sheeted fault or shear zone), the 117 fault, and other faults of smaller magnitude define two sets striking 350° and 020° and dipping 80° respectively to the N.E. and S.W. Observed slickensides vary from 5° to 22° from the horizontal with dextral tear on the set striking N.W. and sinistral tear movement on the N.E. set (fig. 19). The faults are steep and form two sets closely corresponding to the two planes of maximum shear. The fault sets are symmetrical with respect to the axes of the related fold-system and appear to have resulted from the same act of compression. Their movement is post-mineralization and therefor cannot be considered as controls for mineralization in Peko, although movement appears to have caused some secondary mobilisation.

PORPHYROID

The prophyroidal rocks of Tennant Creek have been examined in considerable detail by Elliston (1963). Some comment is required of the textures observed in the porphyroid from samples obtained from openings and drill core at Peko. In hand specimen the porphyroid exhibits a foliation which is consistent with S_1 axial plane cleavage and not So. In thin section an iron stained serictic matrix can be seen to flow around phenocrysts of feldspar, quartz, (fig. 21c) and possible rock fragments. The quartz crystals are both euhedral and rounded with some displaying embayments (fig. 21d) and others marked secondary growth (fig. 21c). The crystals are usually single, in optical continuity with strain extinction, and predate the schistocity of the rock (Fander 1963). The feldspars range from microcline to albite are sometimes embayed and exhibit occasional bent lamallae (fig. 21b). They predate schistocity. Crystals are single in optical continuity with small inclusions. Zircon is present as detrital rounded grains. Pyrite predates schistocity and chalcopyrite follows shears (fig. 21c) which wrap around the quartz crystals. Intense brecciation, crushing, pull-apart, and cataclastic features are not well developed. Spiral chains were not observed, although tails of mica were present.



SKETCH SHOWING RELATIONSHIP BETWEEN PORPHYROID S_0 AND S_1 8LEVEL J13 DRIVE

FIG. 20

SAMPLE 1648

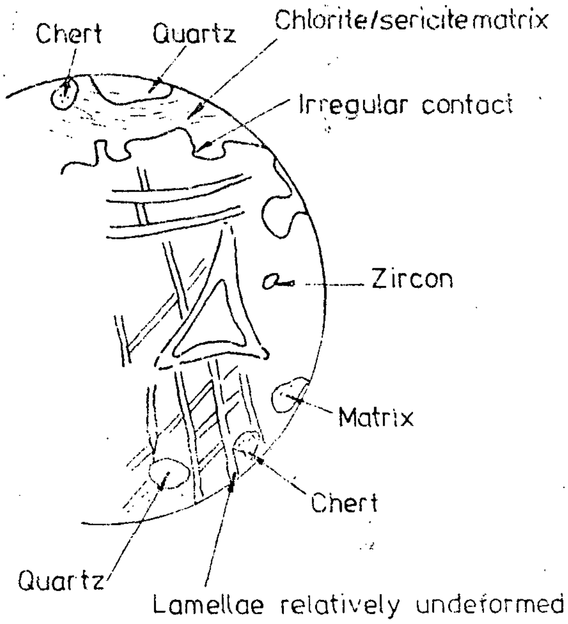


FIG. 21a

SAMPLE 1530

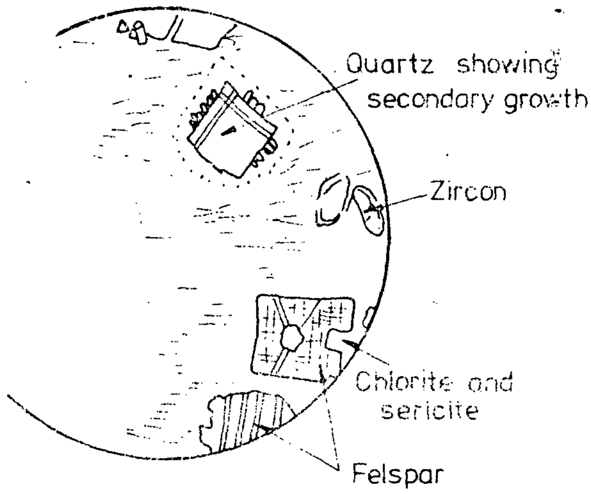


FIG. 21_c

SAMPLE 1655

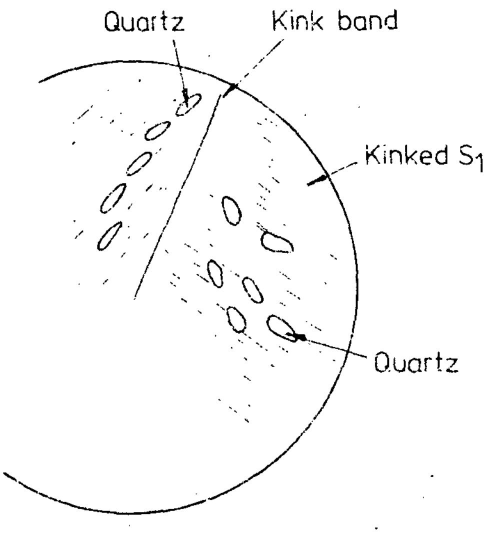


FIG. 21b

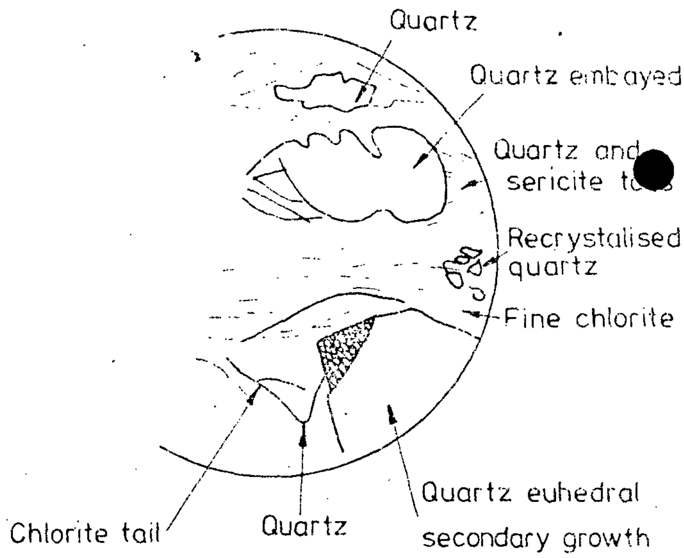


FIG. 21c

SCALE: 0·5mm $\frac{1}{2}$ diam.

SAMPLE 1538

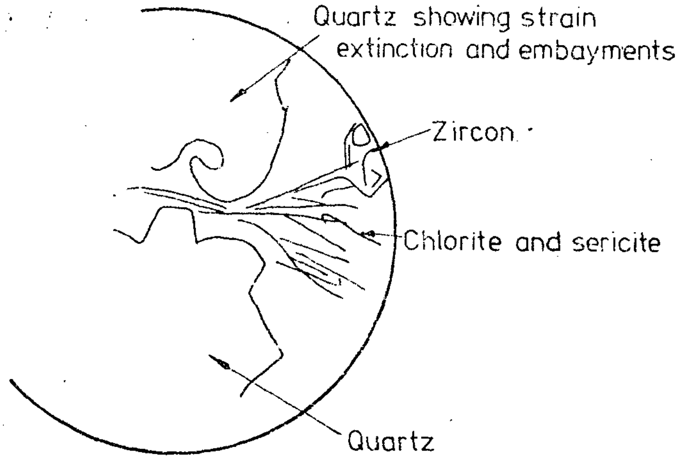


FIG. 21d

SAMPLE 1664

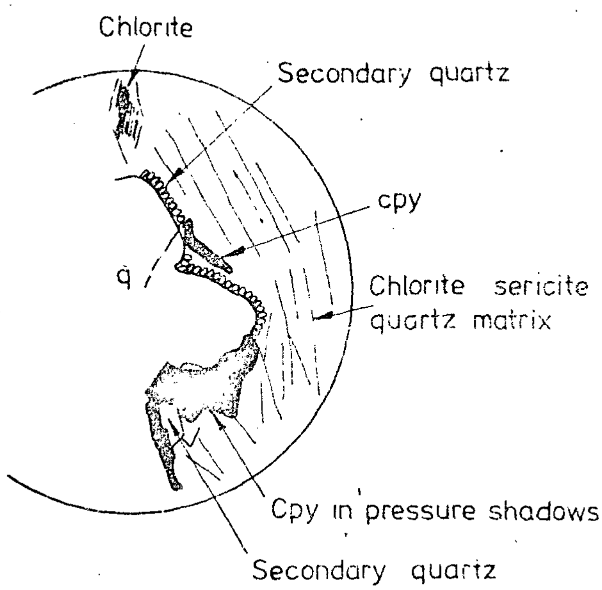


FIG. 21e

SAMPLE 1666

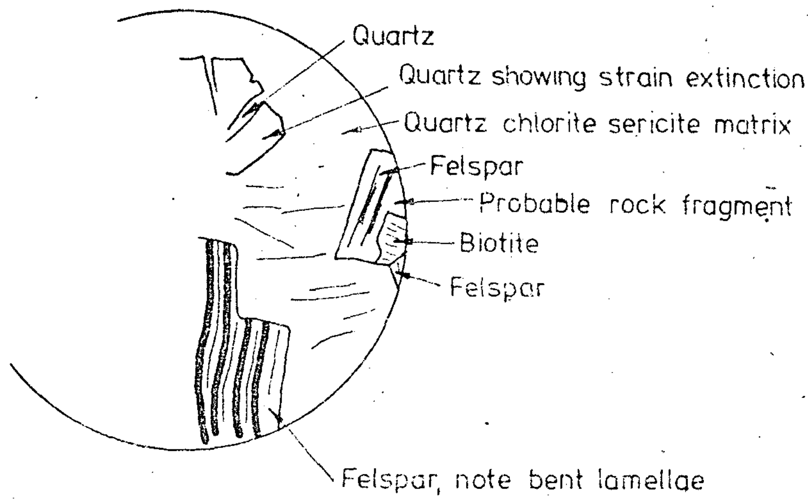
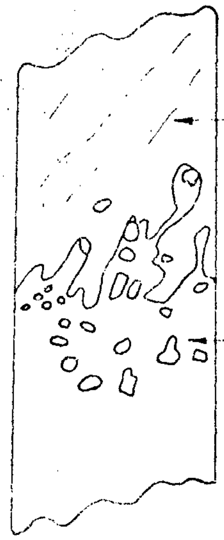


FIG. 21f

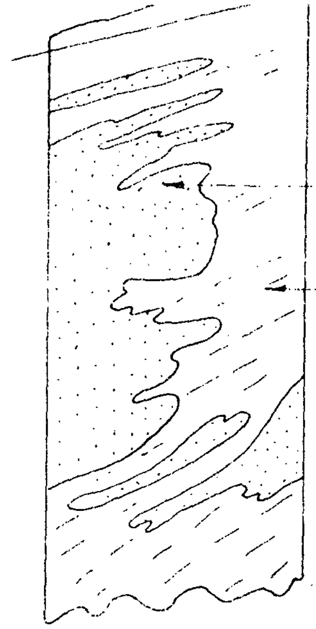
SCALE: 0·5mm $\frac{1}{2}$ diam.

SAMPLE 1605



Drill core from 8 level showing incipient isolation of grains.

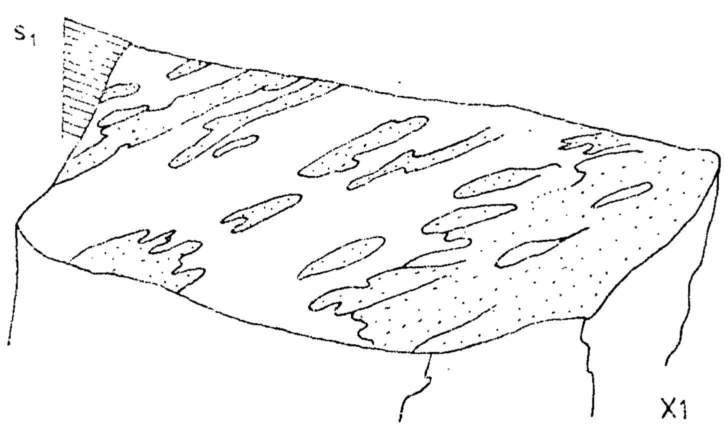
FIG. 22



Drill core East Peko, wisped sediment showing lobate and pinched texture approx. 50 ft. above porphyroid.

FIG. 23a

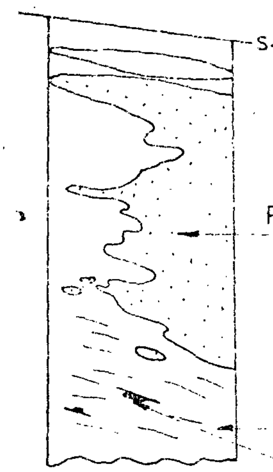
SAMPLE 1662



Fine grained brown sandstone/mudstone cut normal to S_1 within two feet of porphyroid Wisped pinched and streamed textures characteristic of escaping pore waters

FIG. 23b

SAMPLE 8/427/217



Drill core Peko wisped sediment

FIG. 23c

The foliation of the rock is due to axial plane cleavage, however, the ubiquitous development of intrusive dykes both on the small scale and large scale along S_f of the overlying sediments is consistent with deformation in the soft stage and not when the rock was hard and lithified (Spry 1963). The presence of tongue like projections along S_f, isolated clumps of porphyroid parallel with cleavage and close to the source bed, and concentrations of insoluble materials trailing out of the porphyroid beds accompanied by isolated porphyroid grains (fig.22) is in congruence with an unconsolidated state (Alterman 1973). The existence of a less compactable more permeable rock as a reservoir for fluids is demonstrated. That dewatering or escape of pore water occurred when the phyllosilicate particles were at some angle to the bedding caused by rotation away from parallelism with the strata is in evidence. The intrusion of dykes or tongues of porphyroid were probably facilitated by high pore fluid pressures which had prevented normal compaction of the porphyroidal rocks. The textural observations made in the porphyroidal rocks is best explained if dewatering coincident with S_f slaty cleavage is envisaged. The presence of tails, and lack of intense deformation during folding, can be explained if strain in the porphyroidal beds was absorbed by fluids, leaving them relatively uncompacted with little intergranular stress. The occurrence of volcanic rocks in the Tennant Creek field have been identified by Fander (1963), White (1963), Spry (1963) and Large (1971). This data and arguments supporting and disagreeing with this conclusion are presented in detail elsewhere and will not be repeated here. The presence of authigenic alumino-silicate minerals have been supported by Surdam and Parker (1972) who identified tuffaceous rocks as a highly reactive unit where reactions with waters produced authigenic minerals including potassium feldspar. That the porphyroidal rocks represent a volcanic episode, predominantly pyroclastic is in agreement with the observed facts although authigenic mineral growth in this environment is not precluded.

ENVIRONMENT AND MECHANISM OF DEFORMATION

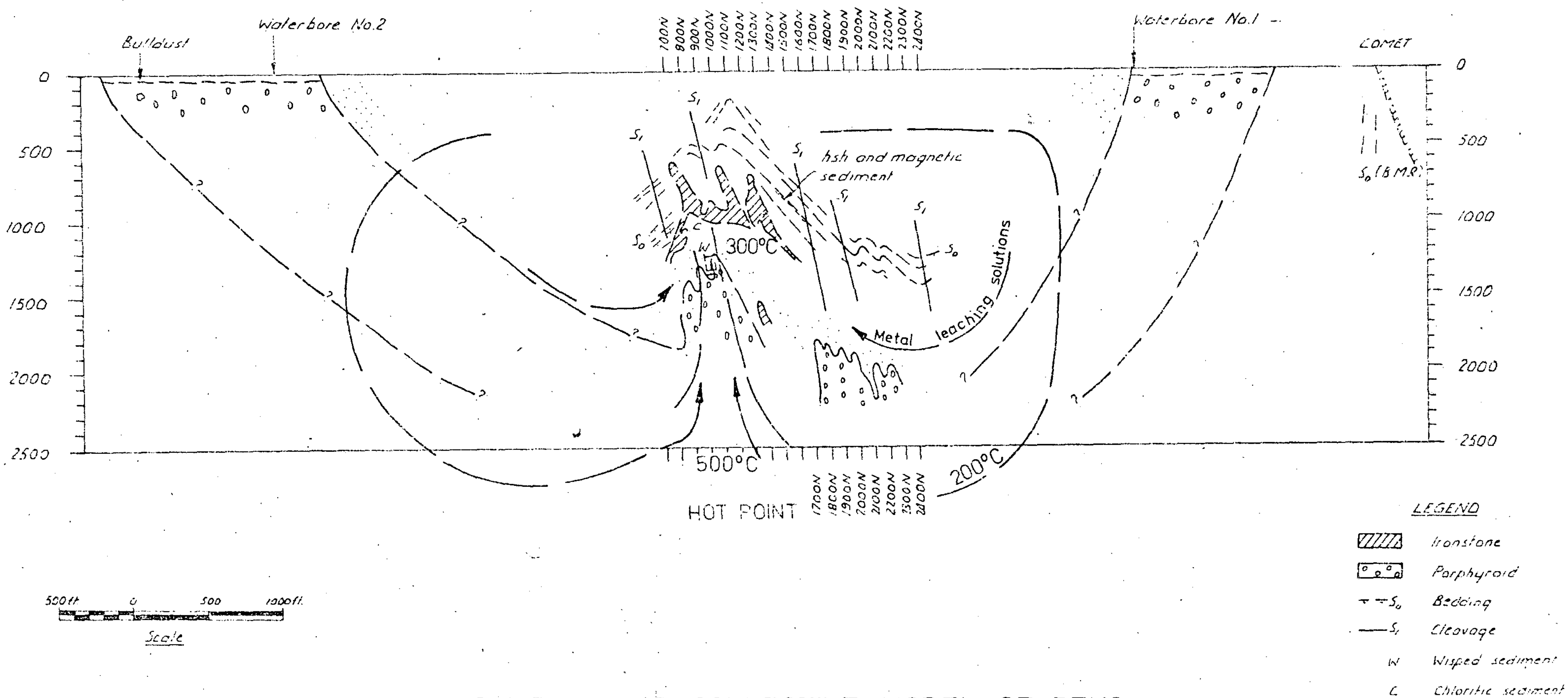
The various structural features described suggest different degrees of mobility during deformation. The close genetic relationship between pore fluids, slaty cleavage, folding, and mineralisation is evident.

Some corrollary can be suggested in terms of dewatering from a compacting sediment pile of the Martinsburg formation of Pennsylvania (Alterman 1973) and deformation of Cretaceous trench deposits of Alaska (Moore 1973).

It is apparent that dewatering of the sediment pile occurred most prominantly where phyllosilicate particles are at some angle to the bedding (figs.2 and 5). The pelites which were dewatered early in the process of cleavage formation took up the strain by volume decrease with rotation, and where the slaty cleavage parallels bedding (fig. 5) pore fluids cannot escape across the interface. Once clay particles departed from parallelism with the strata avenues of escape of pore fluids became available parallel with the alignment of the clays. The escaping pore water carried with it clays, porphyroid, and insolubles to produce wisped lobate and pinched textures and tongue like projections (figs. 23a and b) As deformation continued a fold style was produced in the turbidites and pelites which can be related to slumping or gravity sliding in view of the basal décollements recorded elsewhere in the Tennant Creek area (Elliston 1963). The strain that produced flattening and elongation outside the porphyroid was absorbed by the pore fluids in the porphyroid to produce a weaker tectonic fabric emphasised by dewatering paths. The fold form was therefor dependent on lithology and the related strength of the rocks which varied with porocity and permeability. Deformation designated S_2 is neither prominant or penetrative and the key to recognition is the deformation of the pre-existing S_1 slaty cleavage into kink bands. S_2 occurred when the rocks were in a lithified state as demonstrated by the sharp kinking of the slate.

The position of ironstone pipes stratigraphically lower than the porphyroid sequence (Warrego, Golden Forty, New Comet) precludes the porphyroid as the sole source of mineralizing solutions. The dip and plunge of the ironstones suggest a close relationship with cleavage and folding, the presence and movement of pore fluids have been docuumented in the discussion above. That the leaching and subsequent deposition of metals by the same pore fluids is also a possibility and the dynamics have been discussed by Henley (1973). In terms of the dynamics of fluid flow in permeable media Henley outlined a convective ore-genesis model which could produce pipe-like bodies.

53.



SCHEMA FOR CONVECTIVE MODEL OF PEKO

(AFTER HENLEY)

FIG. 24

The fluid source is the ground water, the metal source is dispersed trace elements in the aquifer and the heat source could be high local geothermal gradients, not necessarily intrusions. With vigorousness of the convection (high Rayleigh numbers) the buoyancy-driven flow has the form of a jet, as the metalliferous brine passes through the jet and is subsequently cooled it eventually intersects the solubility curve resulting in deposition of metals or sulphides. Base metal zonation in the Tennant Creek field and the pipe-like bodies can be accounted for by this method. The porphyroid would allow the flow of solutions which could result in metal leaching and or deposition within the porphyroid itself. A possible convective model is tentatively suggested for Peko in fig. 24.

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