THE STRUCTURAL GEOLOGY OF THE KOTANEELEE AND LA BICHE RANGES, NWT AND YUKON

A FIELD STUDY FOR:
HUSKY OIL OPERATIONS LTD

by
APU CONSULTING LTD

RESPECTFULLY SUBMITTED BY

Michael R. McDonough

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INTRODUCTION

The Kotaneelee Range is underlain by a 90 km long north-south oriented surface anticline, the Kotaneelee anticline, lying in map sheet NTS 95C, extending from south of the La Biche River, northward to Etanda Lakes (Douglas, 1976). The Kotaneelee anticline forms the northern extension of the producing Beaver River anticline in northernmost British Columbia. To the west, the La Biche Range is underlain by the La Biche anticline, which is separated from the Kotaneelee anticline by the broad, open structure of the La Biche syncline. The La Biche anticline is composed of a series of en echelon anticlinal structures extending northward from the Yukon-British Columbia border, northward to about 61°N.

APU CONSULTING LTD was contracted by Husky Oil during August of 1995 to conduct a program of 1:50,000 scale geological mapping of specific parts of the Kotaneelee and LaBiche ranges in order to assess the geometry of the surface structures as a precusor to a potential future seismic program. The field party consisted of geologist M.R. McDonough, with capable assistance from J.A. van Ham. Field visits by Husky personnel V. Allen and B. Olchowy greatly enhanced the mapping program. Base camp for the field mapping was in the town of Fort Liard, NWT. Access to the Kotaneelee and La Biche map areas was by helicopter. Outcrops along Beaver river were accessed by canoe. Helicopter charter services are available in Fort Liard.

About two weeks time was delegated to each map area. Detailed mapping in the Kotaneelee Range was done north of Kotaneelee gap, where the Kotaneelee River crosses the range. The Kotaneelee map area lies in NTS map-sheet 95C/9, and extends from a southeast corner of 60° 35'N, 124° 7.5'W, to a northwest corner of 60° 45'N, 124° 15'W. The La Biche map area lies in NTS map-sheet 95C/2, and extends from a southeast corner of 60°N, 124° 34'W to a northwest corner of 60° 15'N, 124° 52.5'W.

Named geographic features in the La Biche map area include Mount Merrill (405000E, 6767000N) and Mount Dickie (407000, 6779500N). Map data from outside of these two areas, particularly the geology of Cretaceous rocks in the Kotaneelee and La Biche synclines, is from Douglas (1976).

A pair of geological maps (Figures 1 and 2), and two series of cross-sections, constructed with apparent dip data projected into the sections using GEOSEC4.1, accompany this report. Cross sections labelled LB are from the La Biche Range, and those labelled KT are from the Kotaneelee Range. Numbers following these prefixes correspond to plunge domains found on the respective plunge-domain maps. Structural orientation data were measured in the field to allow definition of structural plunges, and were captured in a relational database (FIELDLOG). Location data (NAD27, UTM Zone 10) were acquired on a digitizing tablet; minimal reliance was placed on a Trimble hand-held GPS unit, as the signal provided by U.S. Military satellites was found to be scrambled about 50% of the time, inducing an error of 300-400 m.

Reconnaissance scale mapping by Douglas (1976) indicated that the Kotaneelee and La Biche ranges are characterized by single very large anticlinal structures having from 1-3 km of amplitude and about 10-15 km wavelength. The anticlines involve Devono-Mississippian strata of the Besa River and Mattson formations in thier cores, with the Permian Fantasque Formation outlining the flanks This stratigraphy is overlain by Lower Cretaceous strata in the adjacent synclines to the east and west Douglas (1976) mapped a number of thrust faults separating domains of steeply dipping strata from gently dipping strata These potential faults were critically evaluated in the field

STRATIGRAPHY

The Kotaneelee and La Biche ranges are underlain by strata of the Devono-Mississippian Besa River Formation, Mississippian Mattson Formation, and Permian Fantasque Formation. The Upper Paleozoic is unconformably overlain by Lower Cretaceous strata of the Garbutt, Scatter, Lepine, Sikanni, and Scully formations, and Upper Cretaceous Dunvegan Formation. Stratigraphic thicknesses shown in Figure 3 for the Mattson and Fantasque formations are from sections measured in the Kotaneelee Range by APU CONSULTING during the 1995 field season; the remainder are from published sections by the Geological Survey of Canada (Douglas and Norris, 1959; Stott, 1982). Triassic strata are inferred by Douglas (1976) to exist in the area of Beaver River, where it crosses the La Biche Range. Only one outcrop of potential Triassic rock was observed (location 403385E, 6675956N) southwest of Mount Dickie; these strata may actually form part of the Permian system

Besa River Formation

Only the uppermost 150 m of Besa River Formation is exposed in the core of the Kotaneelee Range, and perhaps as much as 250 m is exposed in the core of the La Biche anticline near Mount Merrill, based on thicknesses obtained from detailed cross-sections. In the core of the Kotaneelee anticline, the Besa River Formation comprises variably calcareous to non-calcareous, and locally dolomitic, dark grey to black shale, with minor interbedded siltstone, and lesser fine grained sandstone. Besa River strata in the core of the Kotaneelee anticline are cut at a high angle by a set of east striking veins of Fe-carbonate and quartz.

Mattson Formation

The Mattson Formation was assigned a Carboniferous-Permian age by Douglas (1976). It is divided into informal lower, middle and upper members totalling about 1560 m in thickness. Mattson members are highly facies dependent, having irregular thickness and distribution. The lower Mattson is recessive and comprises dark to medium grey shales with minor sandstone and siltstone. Locally, a basal sandstone unit of the lower Mattson sharply overlies the Besa River Formation. The middle Mattson is dominated by thick bedded, massive to high-angle planar cross-bedded, commonly bioturbated, fine grained to very fine grained sandstones with lesser interbedded siltstones. Sandstones are well to poorly cemented and friable, with quartz, dolomite, and less commonly siderite cement. The upper Mattson is largely recessive, comprising poorly cemented dolomitic siltstones, silty brown limestones, and minor coarse grained grainstone to rudstone limestones with abundant brachiopod (mostly Productids with minor Speriferids), bryozoan (both branching and fenestral), and crinoid ossicle debris. Fossil assemblages suggest a Missippian age for the upper Mattson. The upper Mattson is absent from the La Biche map-area, except for a minor exposure near Mount Dickie (Figure 2).

Fantasque Formation

The Permian Fantasque Formation is a largely recessive unit with a measured thickness of 112m. No obvious erosional surface exists to mark the Mattson-Fantasque boundary. Therefore, the base of the Fantasque was placed at the first appearance of bedded cherts. Defined as such, the lower 30 m of the Fantasque has medium to thick bedded siliceous siltstone with interbeds of thick bedded chert. This is overlain by massive beddea cherts with local accumulations of sponge spicules, and minor interbedded siltstone and shale. The base of the thick bedded cherts is marked by a horizon with abundant Fe concretions. This may mark the base of the Permian sequence, however, no erosional surfaces are evident. Relic sandstone features that cross-cut the bedding in the cherts appear similar to clastic-dykes, suggesting incomplete silicification of a former fine-grained clastic and/or calcareous sequence. The top of the Fantasque is locally marked by a 8-10m thick silicified breccia with very angular clasts of white chert in a matrix of dark grey silicified siltstone (Figure 4). The Fantasque is unconformably overlain by sandstone and shale of the Lower Cretaceous Garbutt Formation.

Garbutt Formation

The Lower Cretaceous Garbutt Formation overlies the black chert, silicified siltstones, and breccias of the Fantasque Formation with profound unconformity, locally with angularity. On the east edge of Kotaneelee gap, the lowermost 2 m of the Garbutt is composed of carbonaceous shales with clasts of white chert derived from the underlying Fantasque breccia. The shale is overlain by a basal sandstone of variable thickness, which in turn is overlain by dark weathering concretionary shales.

Scatter Formation

The Scatter Formation conformably overlies the Garbutt Formation. It is composed of distinctive olive green (probably glauconitic), medium brown weathering, medium to thick bedded, very fine grained sandstone to siltstone, with minor interbedded concretionary dark grey shale. Sandstones typically have low-angle cross stratification. The Scatter Formation forms prominent cliffs in areas of little to no outcrop on the flanks of the La Biche Range, particularly in the Fantasque syncline. It forms slightly more resistant ribs within the predominantly shaley Lower Cretaceous section in the Kotaneelee syncline.

Lepine Formation

The Lower Cretaceous Lepine Formation conformably overlies the Scatter Formation. It comprises dark grey to black concretionary shales with thinly interbedded, Fe-stained, orange weathering siltstone beds, and minor sandstones. Stott (1982) correlated the Lepine with the Buckinghorse Formation of northeastern British Columbia.

Sikanni Formation

In the Kotaneelee syncline, the Lower Cretaceous Sikanni Formation consists of rusty weathering thinly bedded, medium grey, greenish grey sitlstone with interbedded medium to dark grey shale.

Dunvegan Formation

The Upper Cretaceous Dunvegan Formation is shown to be in fault contact with the Lepine and Sikanni formations in the core of the Kotaneelee syncline. No evidence was found for this fault (see cross sections KT1 and KT4). The Dunvegan comprises thinly bedded light grey to brown silty shale with medium to thick interbeds of light brown very fine grained poorly cemented sandstone having abundant carbonaceous debris on bedding surfaces. Sandstone beds up to 1.5 m thick are trough cross bedded.

STRUCTURE OF THE KOTANEELEE RANGE

Structural style and geometry

The Kotaneelee anticline comprises a very large westerly vergent structure cored by Besa River and Mattson strata, having a strike length of greater than 90 km. In the northern Kotaneelee map-area, the Kotaneelee anticline is segmented into two anticlines that transfer shortening across a domain of flat lying bedding, forming a pseudo-syncline (Figure 1). The anticlines probably nucleated as separate fold structures with overlapping axial traces that grew into a larger amalgamated anticline. In general, the structure of the Kotaneelee anticline s characterized by dip domains with sharp anglular boundaries accommodating rapid dip changes. The southerly transect in the mapped area (section KT1; Figure 5), located at the latitude where the Kotaneelee River crosses the range (informally called Kotaneelee gap), is underlain by a westerly overturned structure with vertical to overturned Fantasque and upper Mattson strata. Overtruned strata are folded sharply into a gently east dipping orientation in the adjacent La Biche syncline. The overturned Fantasque strata contain easterly vergent overturned small scale folds which provide the most important clues to the overturned geometry of the west limb of the Kotaneelee anticline. These folds indicate an overturned forelimb (west limb) with upper Mattson strata overlying the Fantasque, without a faulted relationship. The geometry of the core in section KT1 at the level of the exposed Besa River Formation is very tight due to a small interlimb angle of less than 50°. About 1 km south of section KT1, a thrust fault truncates the west limb of the Kotaneelee anticline, placing upper Mattson strata on Garbutt sandstones (Figure 6). This fault dies out where it enters the Kotaneelee River valley (Figure 1). Thus, the prominent westerly vergence of the Kotaneelee anticline is accomplished with little to no thrusting; a small scale east vergent thrust with about 10 m displacement is a late feature that serves to steepen the east limb of the La Biche syncline (Figure 7).

Along Section KT2 (Figure 8), the Kotaneelee anticline attains a broader profile, with a wide domain of flat lying lower and middle Mattson strata exposed in the core (Figure 9), making more room for inclusion of the target Nahanni Formation in the core of the structure at depth. The calcareous strata of the upper Mattson thin dramatically to the west across the Kotaneelee Range (Figure 9), suggesting that the informal members of the Mattson are facies. Fantasque strata are not exposed at the surface on the west limb, but reappear to the west in the La Biche syncline (Douglas, 1976). The west limb remains nearly vertical to overturned in section KT2. Approximately 2 km north of section KT2, the west limb contains moderately west dipping middle Mattson strata, suggesting that the structure continues to broaden northward (Figure 10). Here, markedly disharmonic folds are found in thinly interbedded sandstones and shales of the middle Mattson (Figure 11), which are indicative of a detachment system

Northward, Section KT4 shows a lack of exposure of the Besa River at the surface, and a lack of Fantasque at the surface on the west limb (Figure 12) It also shows that the west limb is less steeply dipping than in KT2 at the level of the middle Mattson, which suggests further opening and broadening of the structure, allowing for Nahanni involvement at depth. However, only the upper part of the middle Mattson shows this opening, while the lower part remains steeply dipping to overturned, possibly limiting Nahanni involvement at depth (Figure 13). The highest structural level is exposed along the northerly Section KT6, which is very similar in geometry to KT4. The northern extent of this segment of the anticline is truncated by a transverse fold pair having a box syncline flanked by a northwest verging anticline (Figure 15). This fold pair transfers shortening to the next large anticlinal segment that continues northward toward Etanda Lakes.

Dip domains and corresponding equal area plots of bedding are given in Figure 16. The southern two transects across the Kotaneelee anticline (domains KT1 and KT10) are domains of very shallow south plunge of less than 1° S where the Besa River Formation is exposed in the core of the structure. In domain KT2, north of the main exposure of Besa River in the core, the plunge reverses to 5.1° N in repsonse to opening of the structure at the level of the middle Mattson. The northerly plunge continues uninterrupted through domains KT3, KT4, and KT5, with a plunge variation of 3.0 to 7.7° N. In domain KT6, the plunge reverses to the south, but is shallow and less than 1 ° S. North of there, the plunge in domain KT7 reverses again toward the north to a significant 356/13.5 ° N. The steep plunge domain of KT7 is truncated by the transverse structures of domain KT8, which have a plunge of 208/8.5° SW.

The plunge of the Kotaneelee anticline at the level of the Nahanni Formation probably reflects the northerly plunge on the northern part of the structure to the north of domain KT3. South of domain KT3, the tightening of the anticline and involvement of the Besa River Formation may indicate that the height of the Nahanni in the core is lower, suggesting a potential south plunge closing the structure to the south, inducing a four way closure at depth.

Depth to detachment

Depth to detachment calculations were done in GEOSEC4.1 using: 1) the standard excess area above regional dip method (e.g., Woodward et al., 1989; and 2) the area-depth method of Groshong and Epard (1994) relative to an arbitrary datum (Figures 17 to 20). The excess area method cannot reliably be applied to the Kotaneelee Range because the units do not return to a regional flat dip, which may indicate a dip on the detachment itself. Thus, the results from both methods are not comparable (Table 1). Values of E and W for the Groshong method refer to the east and west sides of a section where pin lines were drawn through the bases of synclines adjacent to the main anticlines. The resulting depth values should be considered as maxima. The deeper calculated levels on the east side of sections indicate an easterly dip on the detachment of from 4 to 9°E. Similar results for the LaBiche Range are corroborated by the regional detachment observed on seismic (see below). An easterly dip for the detachment is also consistent with the prominent westerly vergence of the Kotaneelee anticline.

Table 1 Depth to detachment calculations for Kotaneelee anticline

SECTION	UNIT	METHOD 1	METHOD 2	DIP OF DETACHMENT
KT1	Pf	NA	-4375m (W), -6418m (E)	8.9° E
KT2	Pf	NA	-5000m (W), -5659m (E)	3.8° E
KT4	Pf	NA	-4860m (W), -6493m (E)	6.7° E
KT6	Mu	NA	-4553m (W), 6467m (E)	7.8° E

STRUCTURE OF THE LA BICHE RANGE

Structural style and geometry

The structural geometry of the La Biche Range in the Mount Merrill area is one of a relatively simple, broad, open, west verging large-scale anticline outlined by strata of the middle Mattson and Fantasque formations. The west limb is moderately west-dipping to locally slightly overturned, and the east limb forms a shallowly dipping homocline (Figures 21, 22, and 23). Thus, due to the gentle dip of the east limb, the structure is somewhat open to the east, and does not have good lateral closure at the level of the Mattson and Fantsaque. In the southern most section (Figure 24; LB4) an additional south-plunging west-vergent fold pair is developed. A thrust fault was interpreted by Douglas (1976) to accommodate the steeply dipping strata on the intervening limb of this fold pair. New field investigations show no geometric need for a fault, which is corroborated by regional seismic (C. Laws, pers. comm., 1995). The additional fold pair at Beaver River induce a moderately dipping east limb for the main

La Biche anticline to the south of Beaver River which suggests a more complete closure of the structure here

The main La Biche anticline can be broken into four plunge domains (Figure 25) The southern domain (LB4) lies to the south of Beaver River, and plunges to 205/6.9° SW (trend/plunge) To the north of Beaver River, the plunge decreases to 211/4.8° SW (LB3), and reverses northward to 032/0.2° NE in domain LB2 In the Mount Dickie area the plunge of the main anticline increases to 037/5.3° NE (domain LB1). There, the west limb has the added complication of a subsidiary chevron style anticline with a sharp hinge zone plunging 344/7.6° NW, and a broad intervening syncline plunging 032/8.3° NE. Therefore, the La Biche anticline in the Mount Merrill area shows significant plunge reversal, however, the shallow dip on its east limb restricts its four-way closure capability. Section LB4 shows an additional subsidiary west verging syncline-anticline pair to the east of the La Biche anticline. These structures are plunging 189/6.0° S and 194/ 9.3° S, respectively. The folds of this pair plunge south, but die out toward the north (Figure 2), and therefore do not have a doubly plunging geometry.

Thrusting is virtually non-existant at the surface in the Mount Merrill area No thrust faults of any scale were identified in this part of the La Biche Range. Thrust faults shown on Douglas' (1976) map immediately west of the Mount Dickie anticline, and in the core of the subsidiary syncline along Beaver River separate domains of steeply dipping strata from shallowly dipping strata New field observations indicate that these geometries are more easily accommodated by folding. No break in stratigraphy was observable in either case, indicating that the geometry of the structures is satisfied without faulting

Depth to detachment

Depth to detachment calculations were done in GEOSEC4.1 using 1) the standard excess area above regional method (e.g., Woodward et al., 1989, and 2) the area-depth method of Groshong and Epard (1994) relative to an arbitrary datum. The results from both methods are in general agreement for sections LB3 and LB4 (Table 2). Values of E and W for the Groshong and Epard method refer to the east and west sides of a section where pin lines were drawn through the bases of synclines adjacent to the main anticlines (Figures 26-28). The resultant depth values should be considered as maxima. The calculated depth to detachment values from the Groshong and Epard method agree with the interpreted detachment level observed on seismic in the La Biche Range, located in anhydrites beneath the Nahanni Formation (C. Laws, pers. comm, 1995). The deeper calculated levels on the east side of sections LB2 and LB4 indicate an easterly dip on the detachment of from 1 to 6°, which agrees with the regional detachment observed on seismic. Results for Method 1 agree roughly with Method 2 for section LB4, but differ widely for section LB2. The excess area method will yield an average depth to a dipping detachment, and therefore cannot be used to determine the dip of a detachment.

Table 2 Depth to detachment calculations for La Biche anticline

SECTION	UNIT	METHOD 1	METHOD 2	DIP OF DETACHMENT
LB2	Pf	-3172m	-6523m (W), -6913m (E)	0 9° E
	Mm	-3330m		
	Ml	-4054m		
LB3	Pf	NA	-6899m (W), -6903m (E)	0°
LB4	Pf	-6740m	-7140m (W), -8352m (E)	6 9° E
	Mm	-7105m		
	Ml	-7869m		

SUMMARY

The structural geometry of the Kotaneelee and La Biche ranges area is one of relatively simple westerly vergent anticlines controlled by detachment folds lying above a detachment calculated to lie at about -6000m to -8000m depth in the La Biche Range, and about -5600m to -6500 m for the Kotaneelee range. The calculated detachment for the Kotaneelee Range is estimated to have a 4 to 9° E dip, while the dip of the detachment beneath the La Biche Range is estimated to be 0 to 7 ° E. Only one significant thrust fault, having approximately 200 m of west-vergent displacement could be positively identified during 1:50,000 scale surface mapping. Thus, the probability of the generation of the anticlines by fault-bend folding is very small. The calculated dip of the respective detachments, and the prominent west vergent geometries of the Kotaneelee and La Biche structures, suggest that detachment folding and/or fault-propagation folding are plausible mechanisms for generating the observed structural geometries

Evidence for detachment structures underlying the Kotaneelee and La Biche ranges include the following: 1) the general lack of thrust faults observed in outcrop on either limb of both anticlines; 2) the presence of disharmonic folds on the west limb of the Kotaneelee anticline, and 3) high amplitude folding; 4) structurally-controlled topography; and 5) observation of a dipping detachment on seismic data from the Beaver River area of the La Biche Range (C. Laws, pers. comm., 1995). Subsurface mapping is required to distinguish between simple detachment and fault-propagation fold models. The estimated dip of detachment of up to 9° E favours a fault-propagation model.

Good potential exists for four-way closure on the Kotaneelee anticline if the tightening of the structure where the Besa River Formation is exposed requires a south plunge at the level of the Nahanni Formation. The north end of the Kotaneelee anticline has north plunges of up to 13° N, which occur where the structure has a fairly open core at the level of the middle and upper Mattson Formation, allowing significant room for Nahanni involvement. The plunge reversal on the La Biche anticline at Beaver River indicates good four-way closure potential, however, the shallow dip of the east limb of the anticline is somewhat restrictive.

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Figure Captions

Figure 1. Geological map (1:50,000 scale) for the Kotaneelee Range (95C/9).

Figure 2. Geological map (1:50,000 scale) for the La Biche Range in the Mount Merrill area (95C/2).

Figure 3. Measured stratigraphic section for the Mattson and Fantasque formations of the Kotaneelee Range. Upper mattson strata do not occurr in the La Biche Range. Measured thicknesses are 1565 m for the Mattson and 112 m for the Fantasque. Estimates of the thickness of the Besa River from cross section are a minimum of 150 m.

Figure 4. Field photograph of the upper part of the Fantasque Formation at Kotaneelee River showing bedded cherts overlain by a white marker of silicified breccia.

Figure 5. Structure section KT1.

Figure 6. Aerial view to the south of the west limb of Kotaneelee anticline. The light coloured strata in the foreground are gently dipping sandstones of the lower part of the Garbutt Formation, which are apparently cutoff by a thrust fault. This fault does not continue northward across Kotaneelee River.

Figure 7. Field photograph (view is to northwest) of a small displacement (10m maximum) easterly vergent thrust that steepens Fantasque strata on the east limb of the La Biche syncline (west limb of Kotaneelee anticline).

Figure 8. Structure section KT2.

Figure 9. Aerial view to the north of flat lying lower and middle Mattson strata in the core of the Kotaneelee anticline just north of Section KT2.

Figure 10. View to the north of the west limb of Kotaneelee anticline about 2 km north of Section KT2. Arrow shows location of Figure 11.

Figure 11. View to north of mesoscale disharmonic folds in a thinly bedded middle Mattson sandstone-shale multilayer.

Figure 12. Structure section KT4.

Figure 13. View north of the west limb of Kotaneelee anticline near Section KT4 showing a downward steepening of middle Mattson strata, indicating a downward tightening of the anticline.

Figure 14. Structure section KT6.

Figure 26. Graphical representation of the Groshong and Epard (1994) method depth to detachment calculations for Section LB2. Calculated depths are -6523m for the west, and -6913m for the east end of the section, yielding a 0.9°E dip for the detachment.

Figure 27. Graphical representation of the Groshong and Epard (1994) method depth to detachment calculations for Section LB3. Calculated depths are -6899m for the west, and -6903m for the east end of the section, indicating a horizontal detachment for this section.

Figure 28. Graphical representation of the Groshong and Epard (1994) method depth to detachment calculations for Section LB4. Calculated depths are -7140m for the west, and -8352m for the east end of the section, yielding a 6.9°E dip.

N. KOTANEELEE RANGE
UPPER PALEOZOIC SECTION

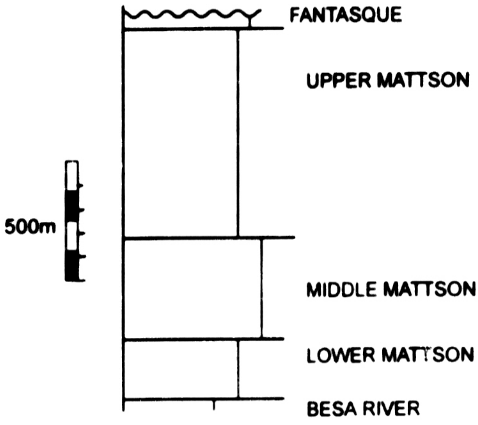
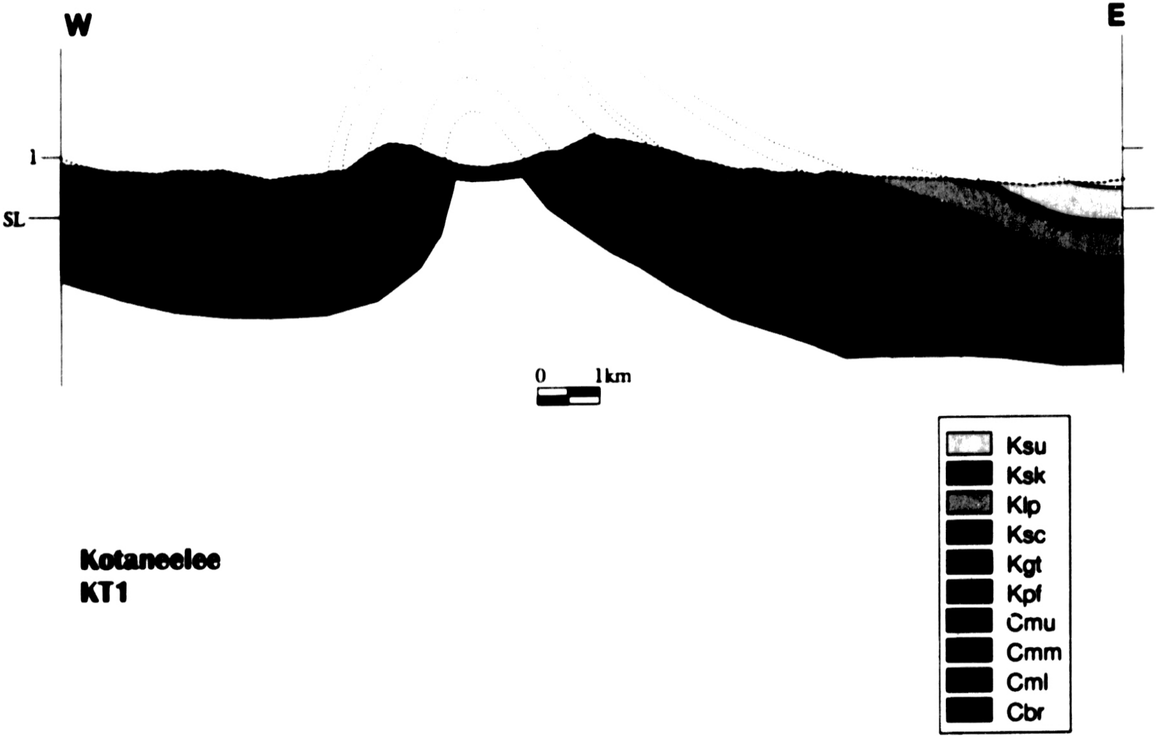


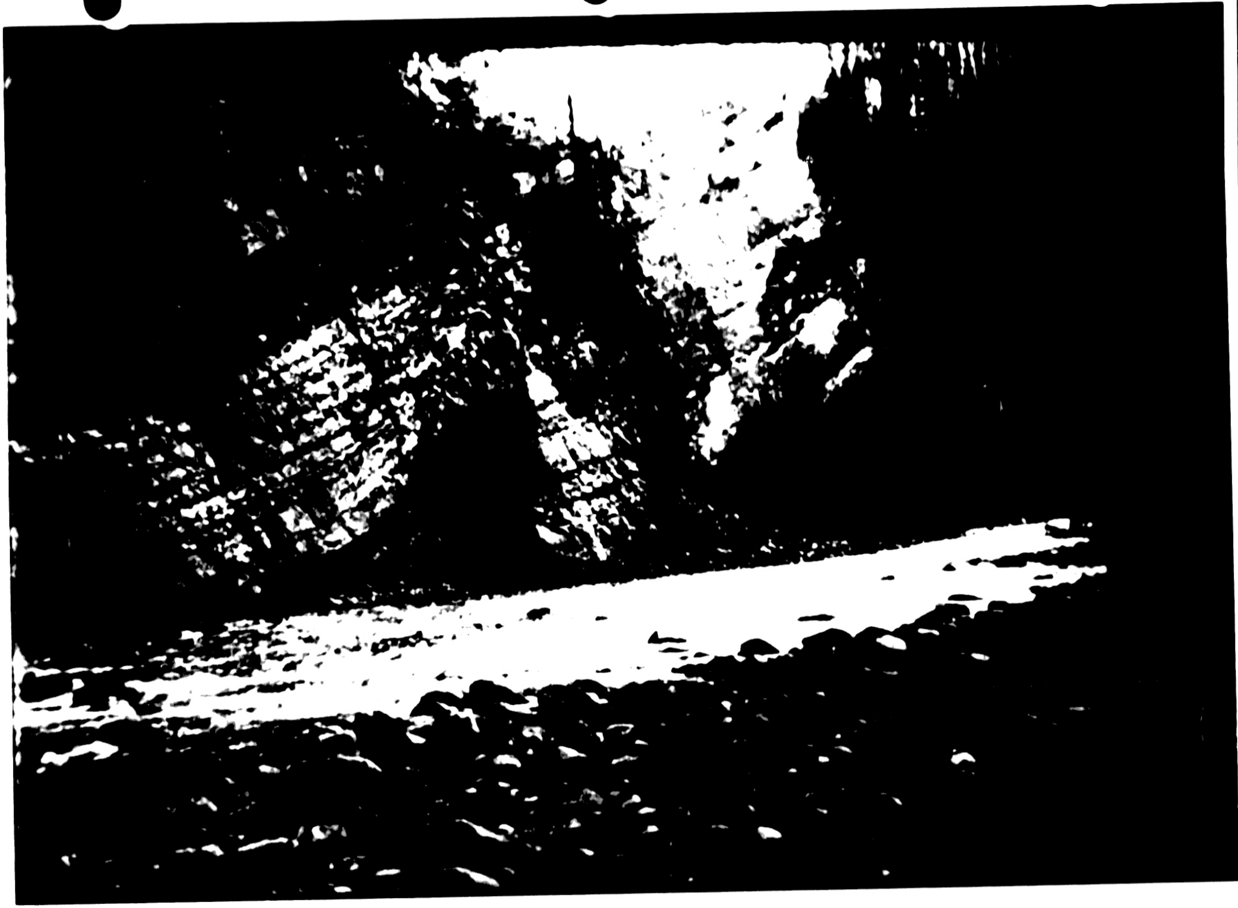
Figure 3

Figure 4



**Kotaneelee
KT1**

Figure 6



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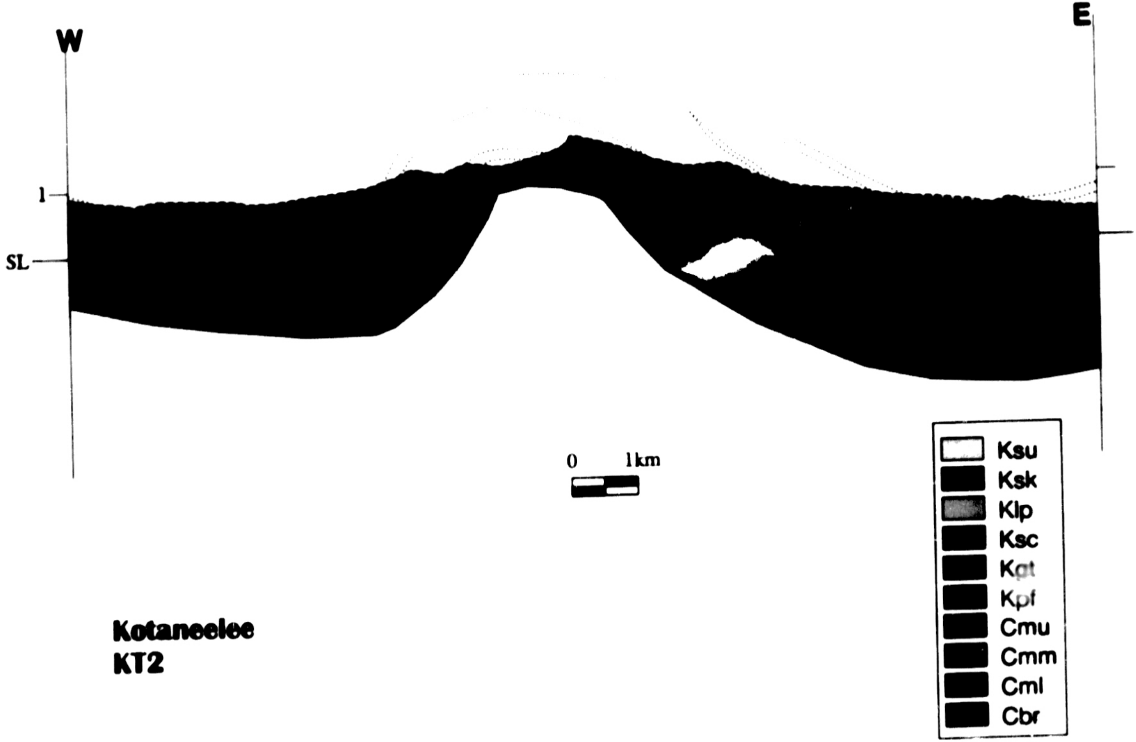
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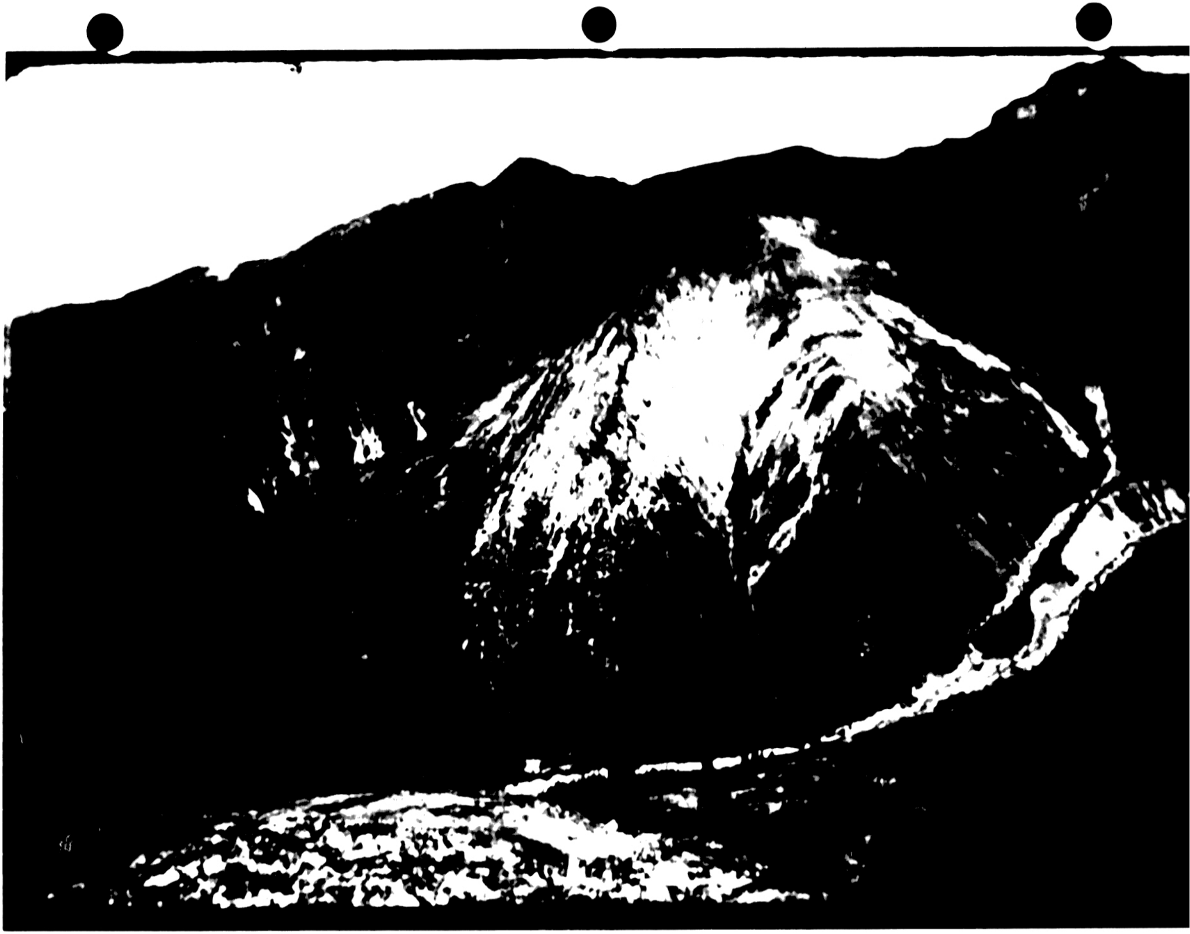
Figure 8

Figure 9



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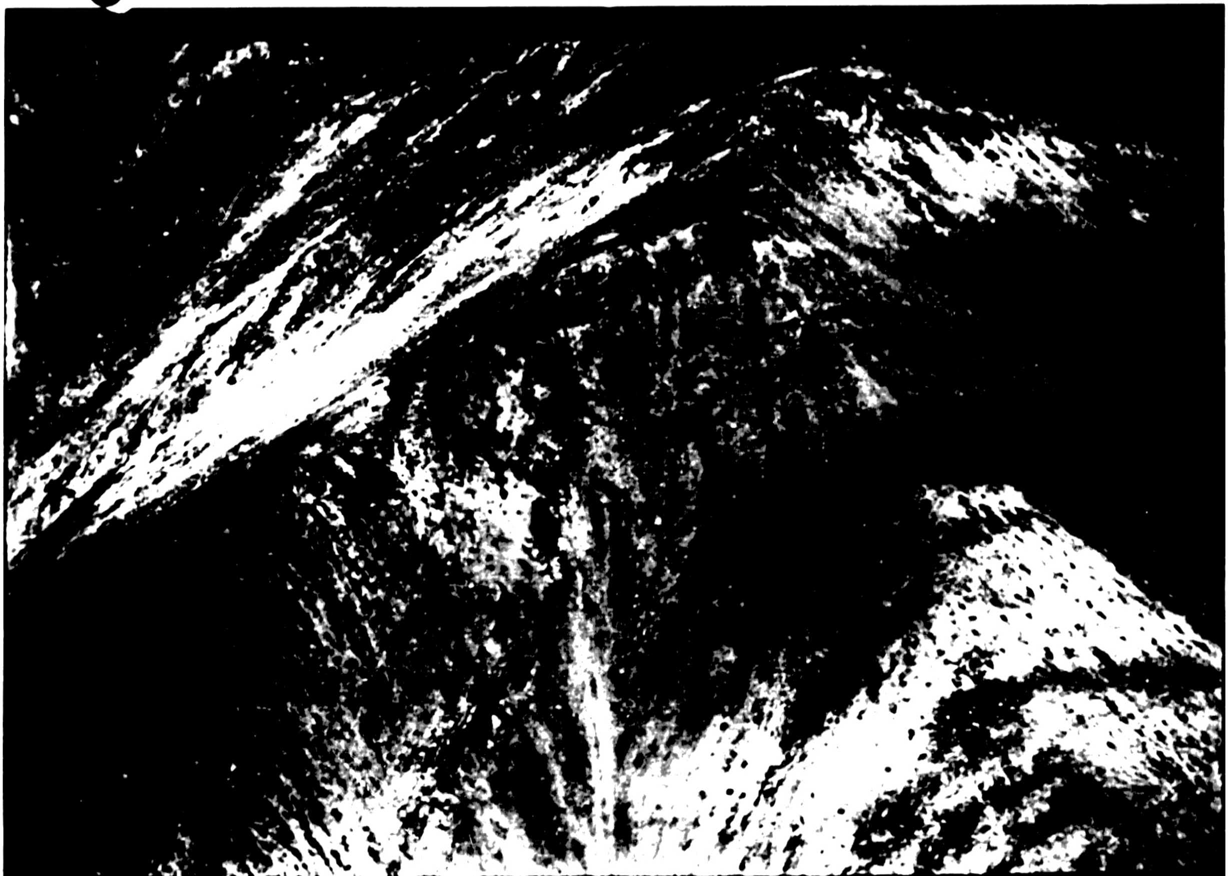

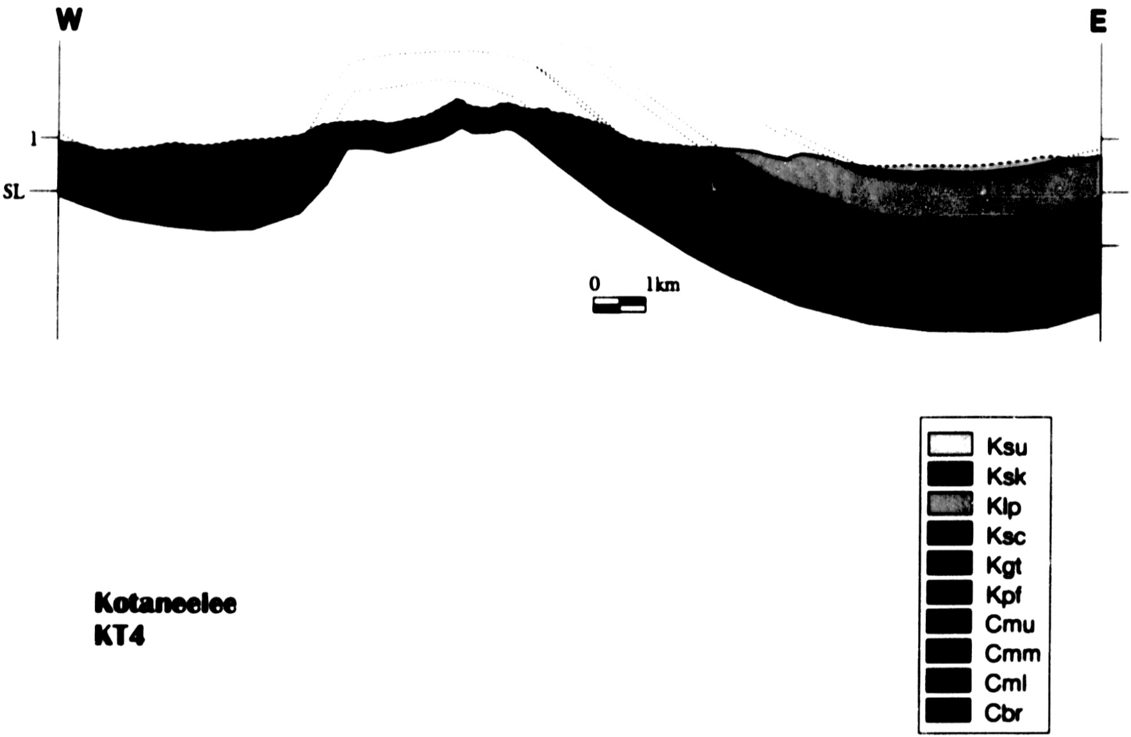
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Figure 12

Figure 13

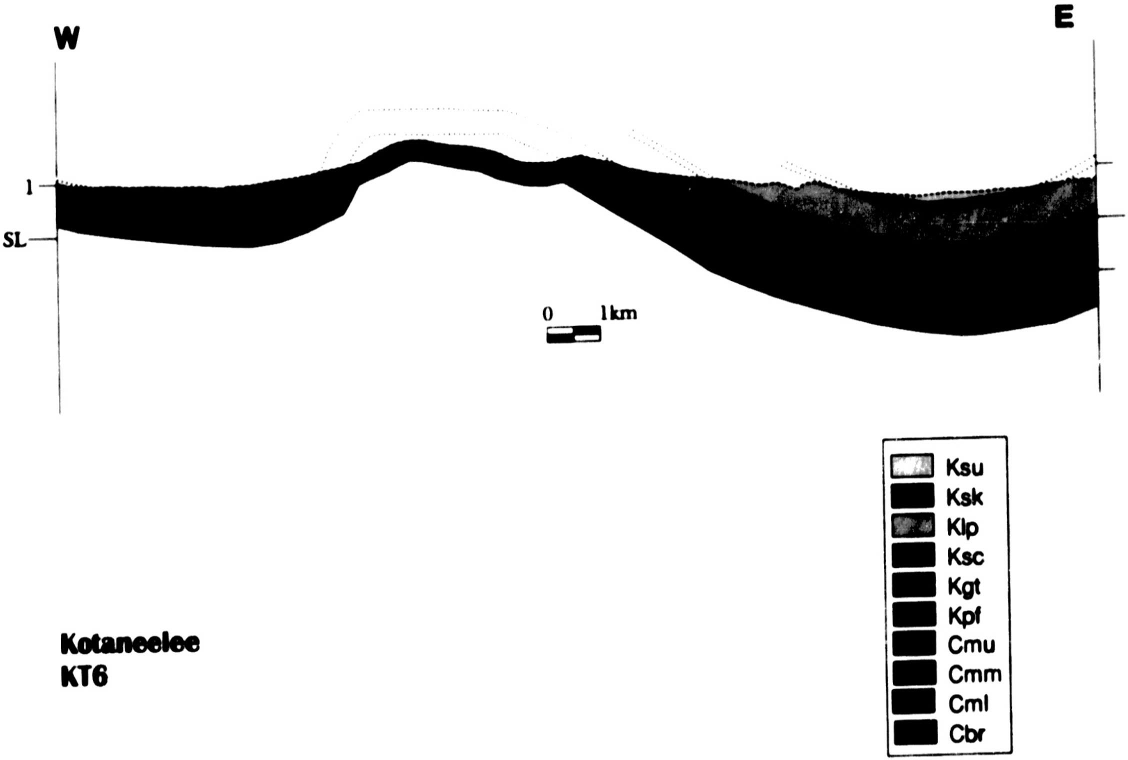
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Figure 14

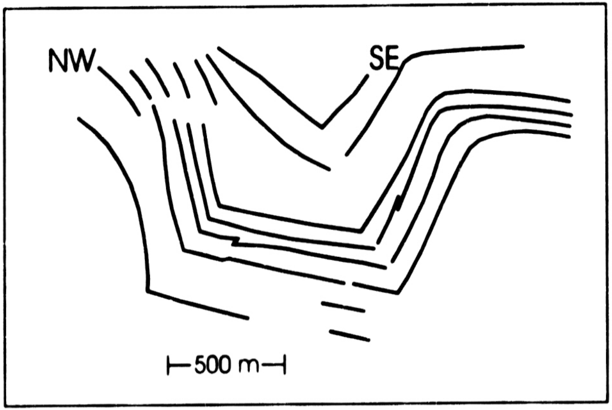
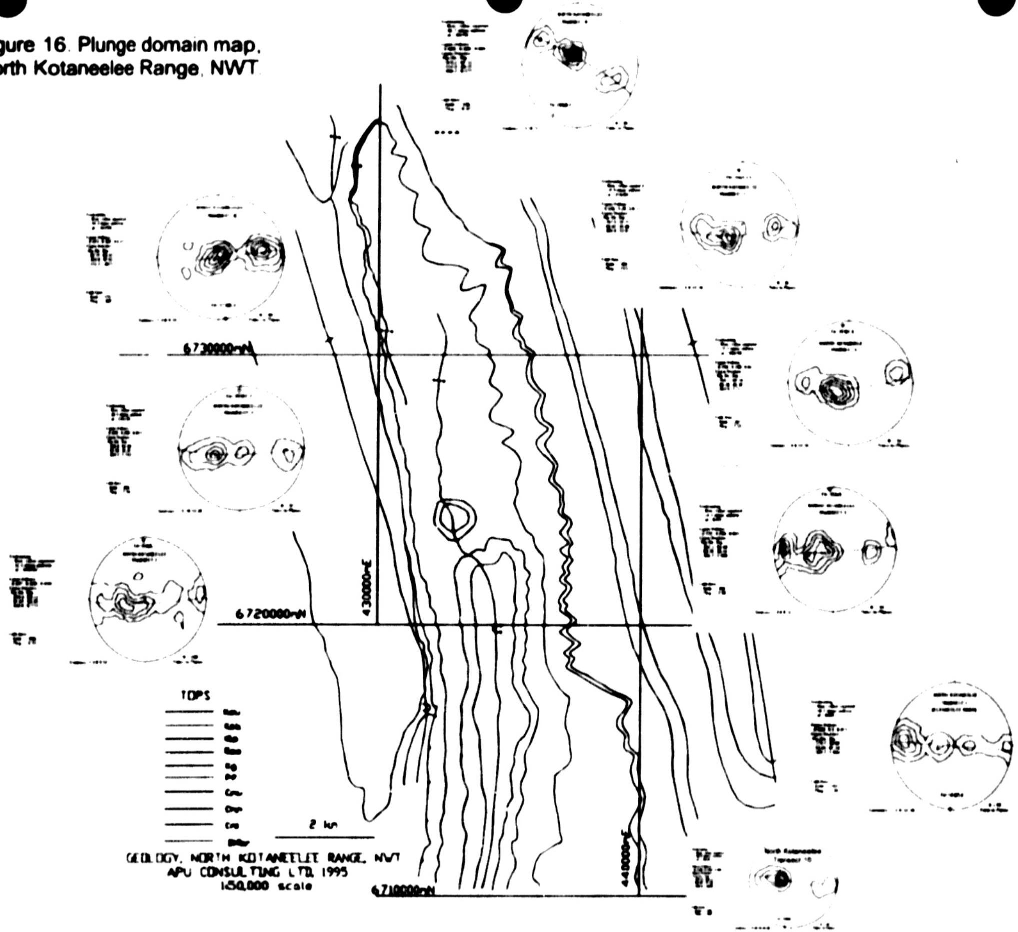
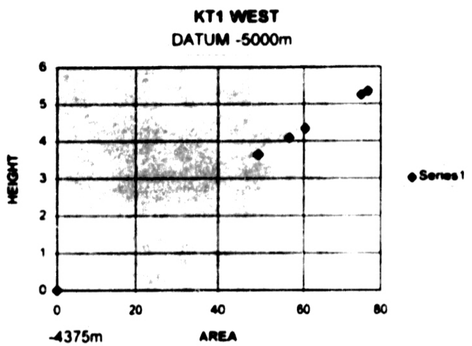


Figure 15

Figure 16. Plunge domain map, North Kotaneelee Range, NWT



KT1	Pf reference		DATUM	-5000
unit	area	west heigh	area	east height
	0	0	0	0
Pf	76 894	5 3379	76 894	3 3217
Mu	75 25	5 2379	75 25	3 2189
Mm	60 462	4 337	60 462	2 313
Ml	56 354	4 0867	56 354	2 0608
BR	48 967	3 6362	48 967	1 6068



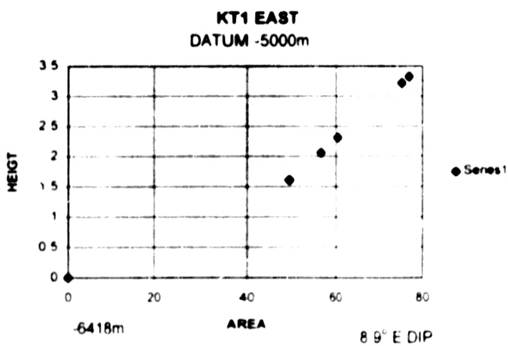
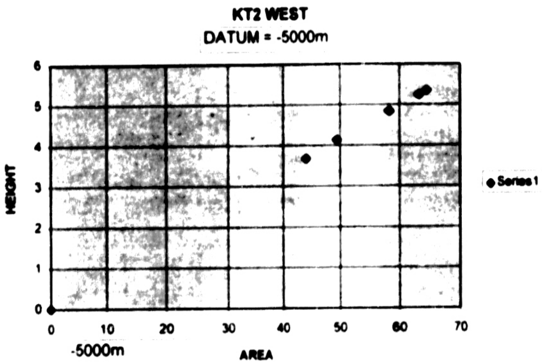


Figure 17

KT2	Pf reference		DATUM	-5000
unit	area	west heigh	area	east height
	0	0	0	0
Pf	64.314	5.3419	64.314	4.8036
Mu	63.13	5.2413	63.13	4.7036
Mm	58.393	4.8388	58.393	4.3036
Ml	49.507	4.132	49.507	3.5536
BR	44.173	3.6792	44.173	3.1036



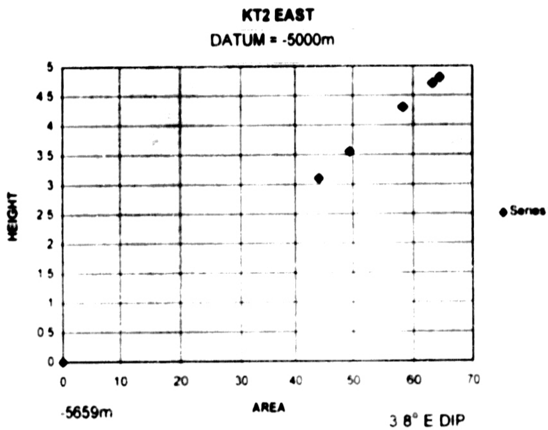
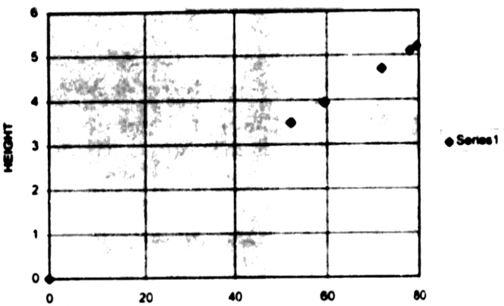


Figure 18

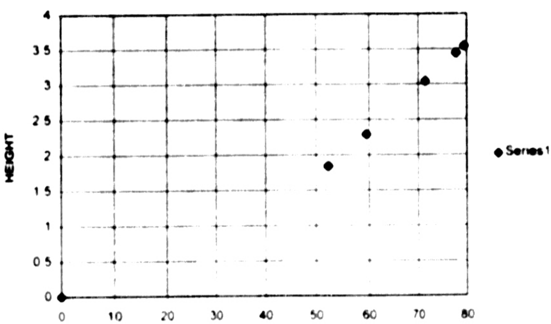
KT4	Pf reference		DATUM		-5000
unit	area	west heigh	area	east height	
	0	0	0	0	
Pf	79 518	5 1945	79 518	3 5399	
Mu	77 918	5 0943	77 918	3 4399	
Mm	71 518	4 6934	71 518	3 0398	
Ml	59 535	3 9416	59 535	2 2897	
BR	52 364	3 4905	52 364	1 8396	

KT4 WEEST
DATUM -5000m



-4860m

KT4 EAST
DATUM -5000m

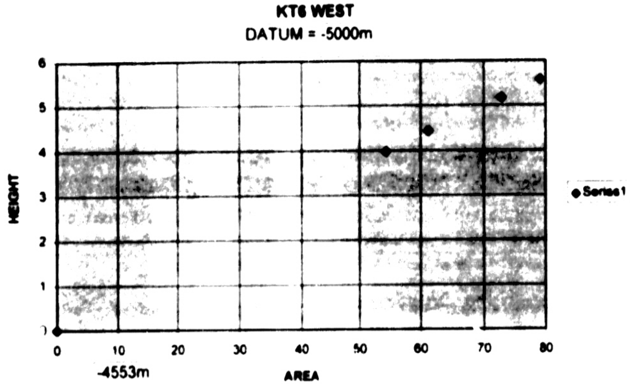


-6493m

6 7° E DIP

Figure 19

KT6	Mu reference		DATUM	-5000
unit	area	west heigh	area	east height
	0	0	0	0
Mu	79 042	5 5704	79 042	3 6794
Mm	72 847	5 1682	72 847	3 2785
Ml	61 246	4 4315	61 246	2 5268
BR	54 303	3 979	54 303	2 0758



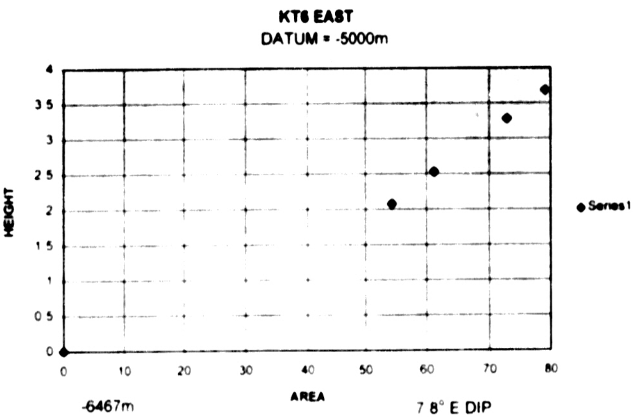


Figure 20

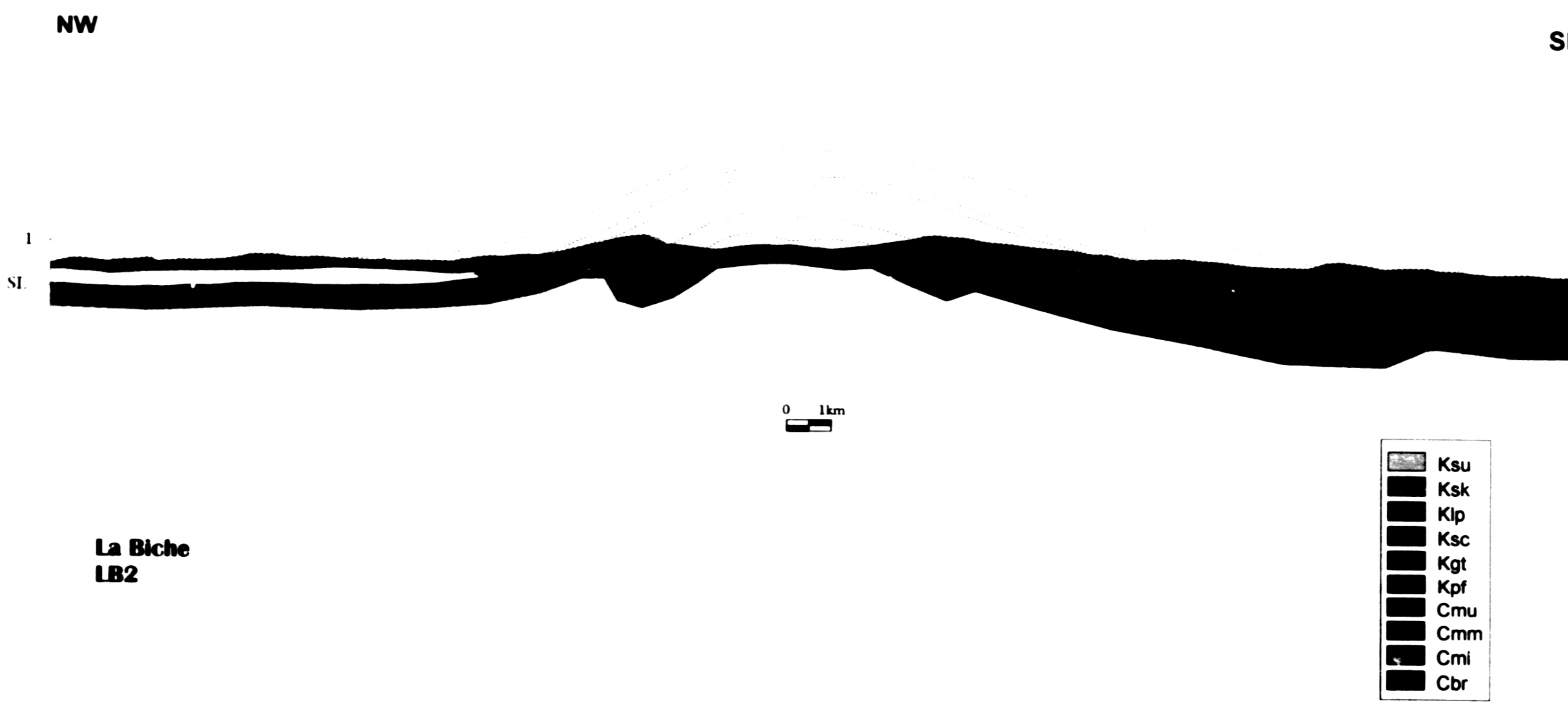

NW
SE
1
SL
0 1km
Ksu
Ksk
Klp
Ksc
Kgt
Kpf
Cmu
Cmm
Cmi
Cbr
La Biche
LB2

Figure 21

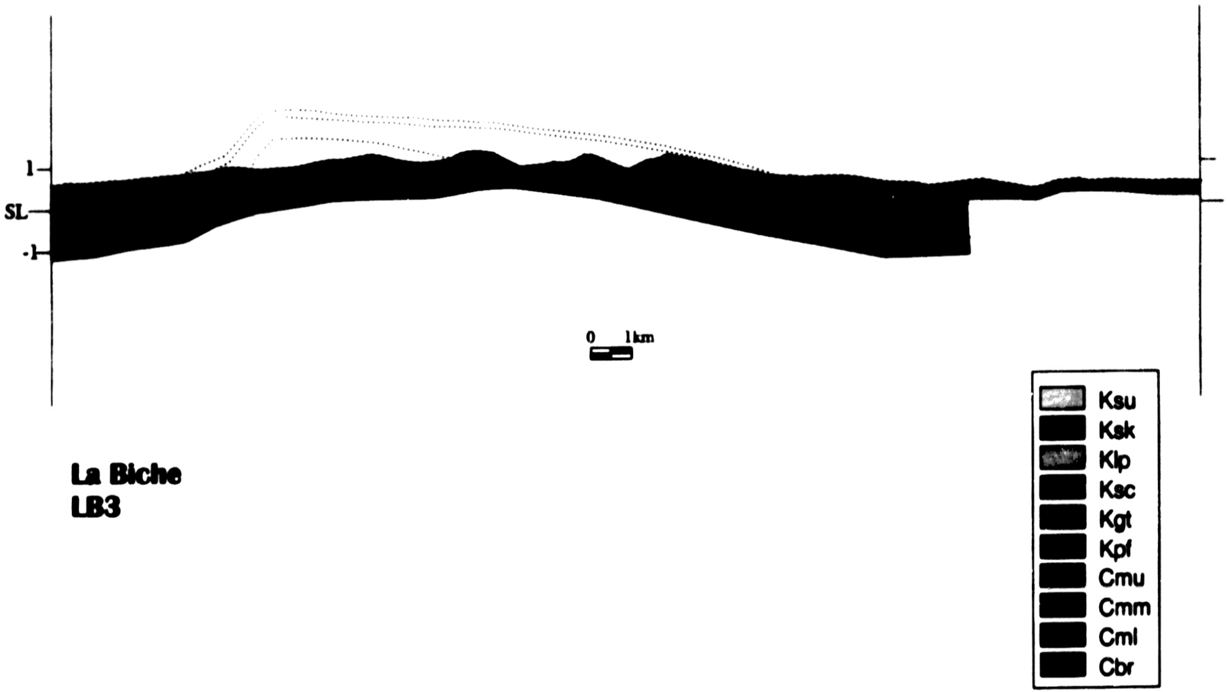


Figure 22

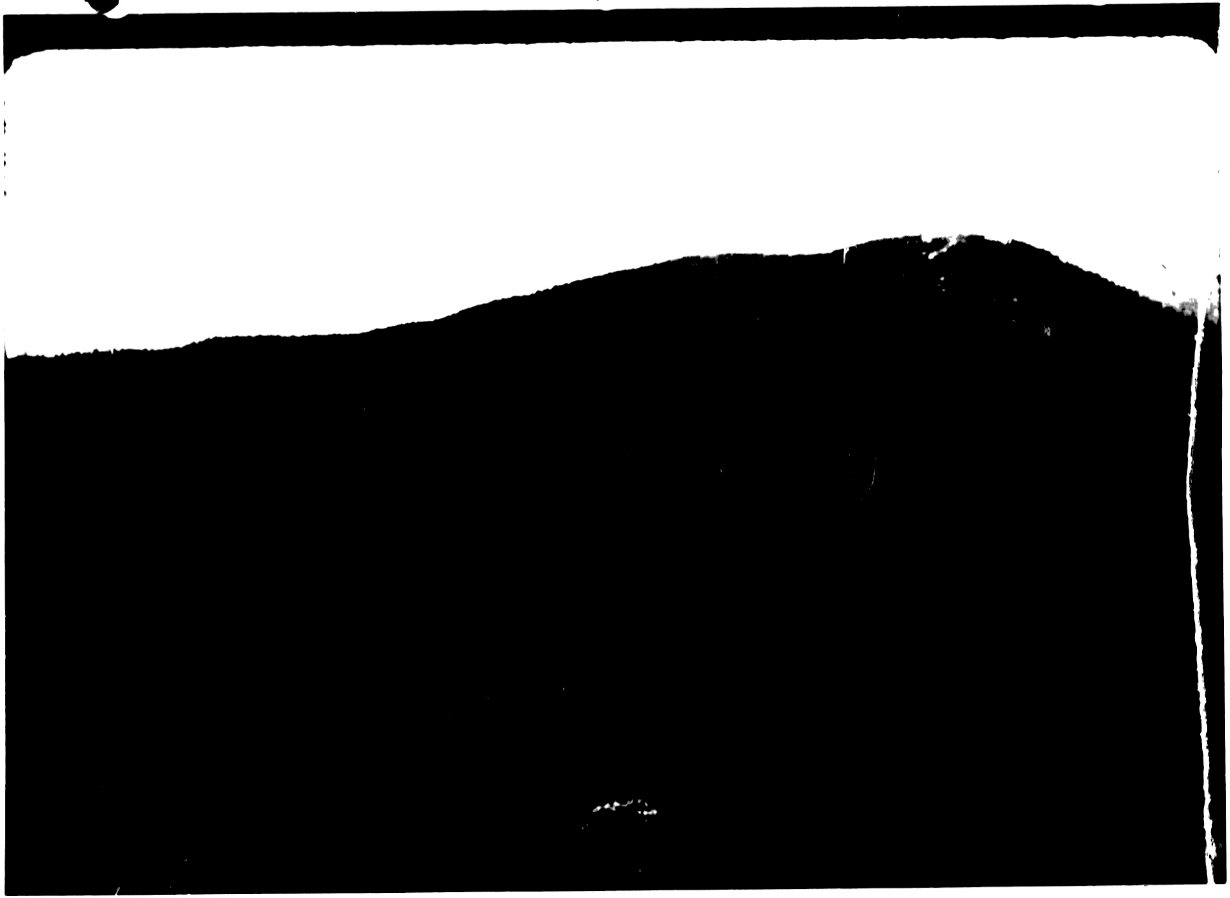


Figure 23

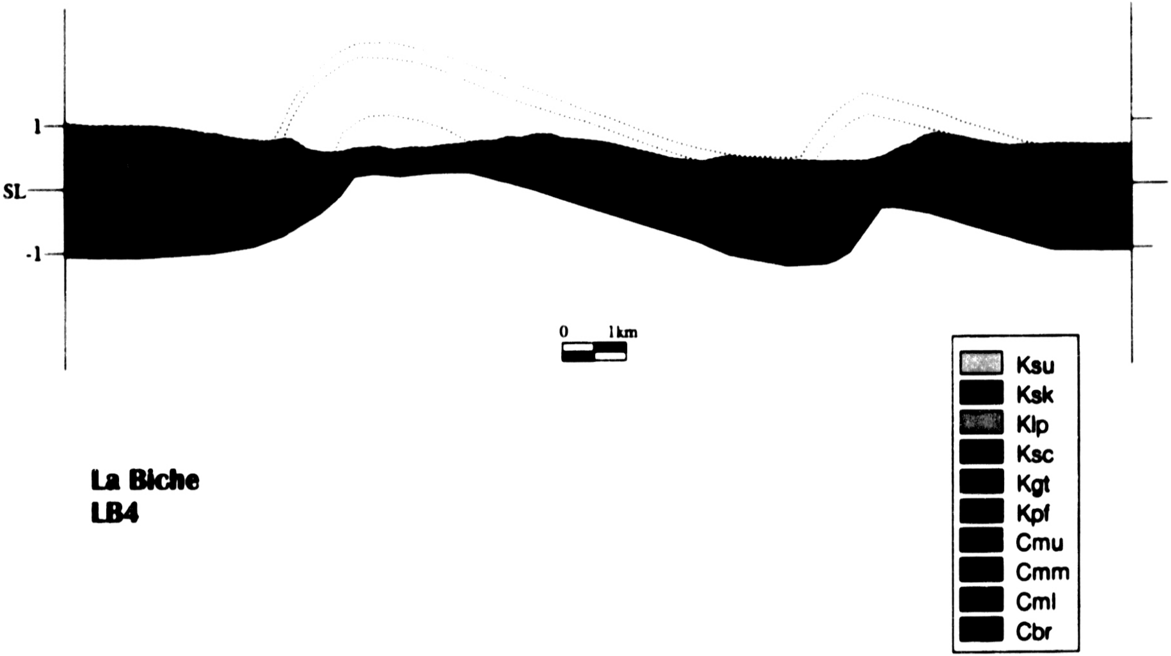


Figure 24

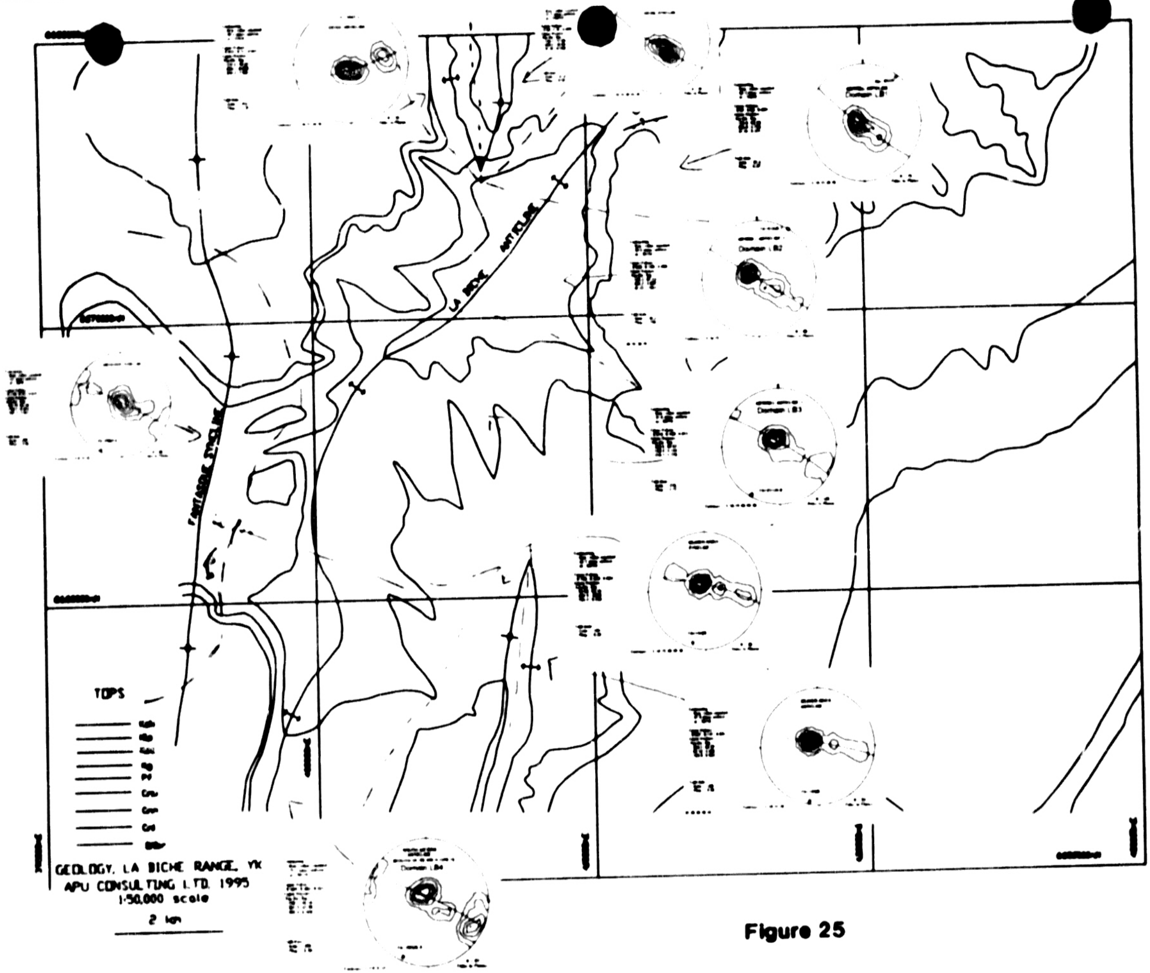
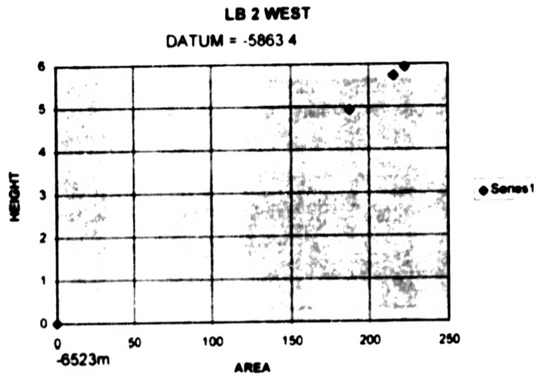

LA BICHE ANTICLINE
FANTASQUE SYNCLINE
TOPS
GEOLOGY, LA BICHE RANGE, YK
APU CONSULTING LTD. 1995
1:50,000 scale
2 km

Figure 25

LB2	Pf reference		DATUM	-5863 4
unit	area	west heigh	area	east height
	0	0	0	0
Pf	222 7136	5 9298	222 7136	5 1211
Mm	215 7115	5 7266	215 7115	4 9211
Ml	187 6986	4 9265	187 6986	4 1211



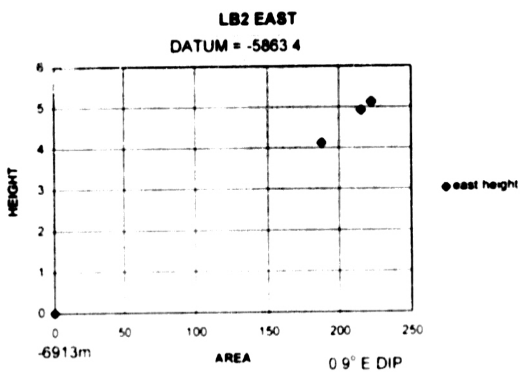
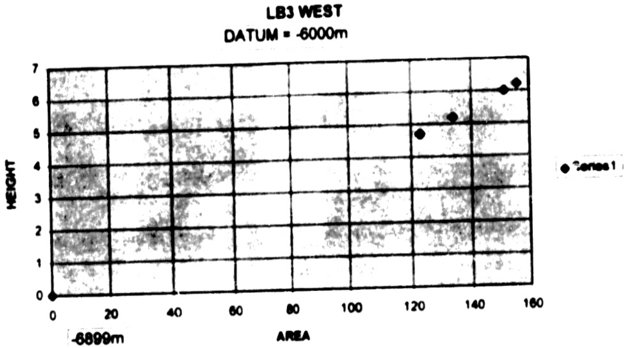


Figure 26

LB3	Pf reference		DATUM	-6000
unit	area	west heigh	area	east height
	0	0	0	0
Pf	155 839	6 2004	155 839	6 1889
Mm	151 452	5 9998	151 452	5 9888
Ml	133 906	5 1973	133 906	5 1885
BR	122 948	4 6957	122 948	4 6862



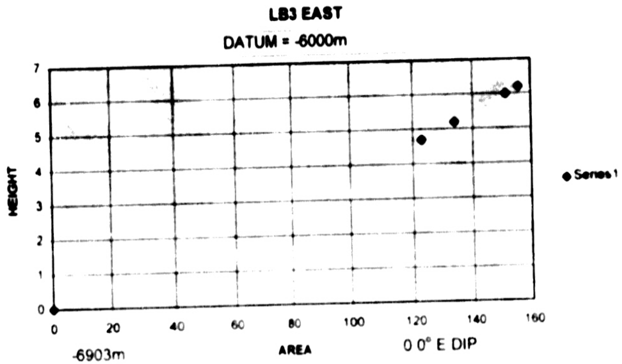
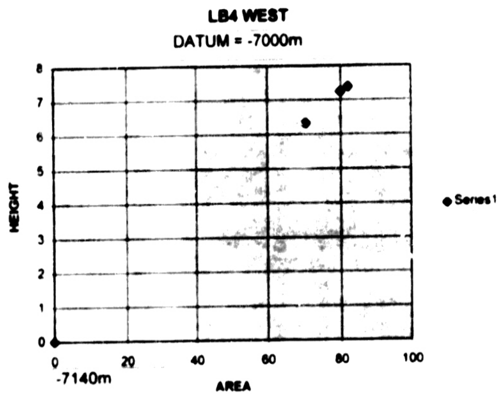


Figure 27

LB4	Pf reference		DATUM		-7000	
unit	area	west heigh	area		east height	
	0	0	0		0	
Pf	82 11	7 3734	82 11		7 4434	
Mm	80 003	7 2377	80 003		7 1834	
Ml	70 414	6 322	70 414		6 2074	



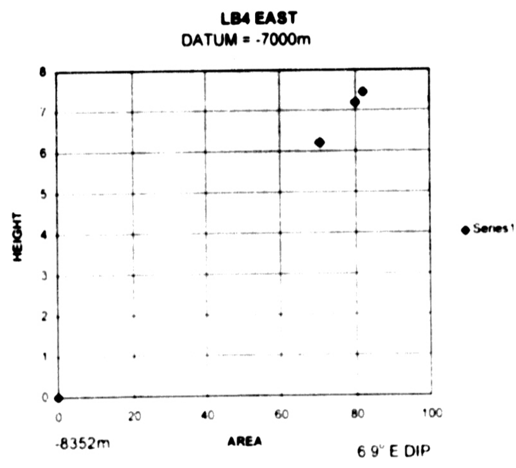


Figure 28