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A STRUCTURAL STUDY INVOLVING PALINSPASTIC RESTORATION OF THE GATAGA JOINT VENTURE PROJECT AREA, NORTHEAST BRITISH COLUMBIA

GATAGA JOINT VENTURE
PROJECT M463

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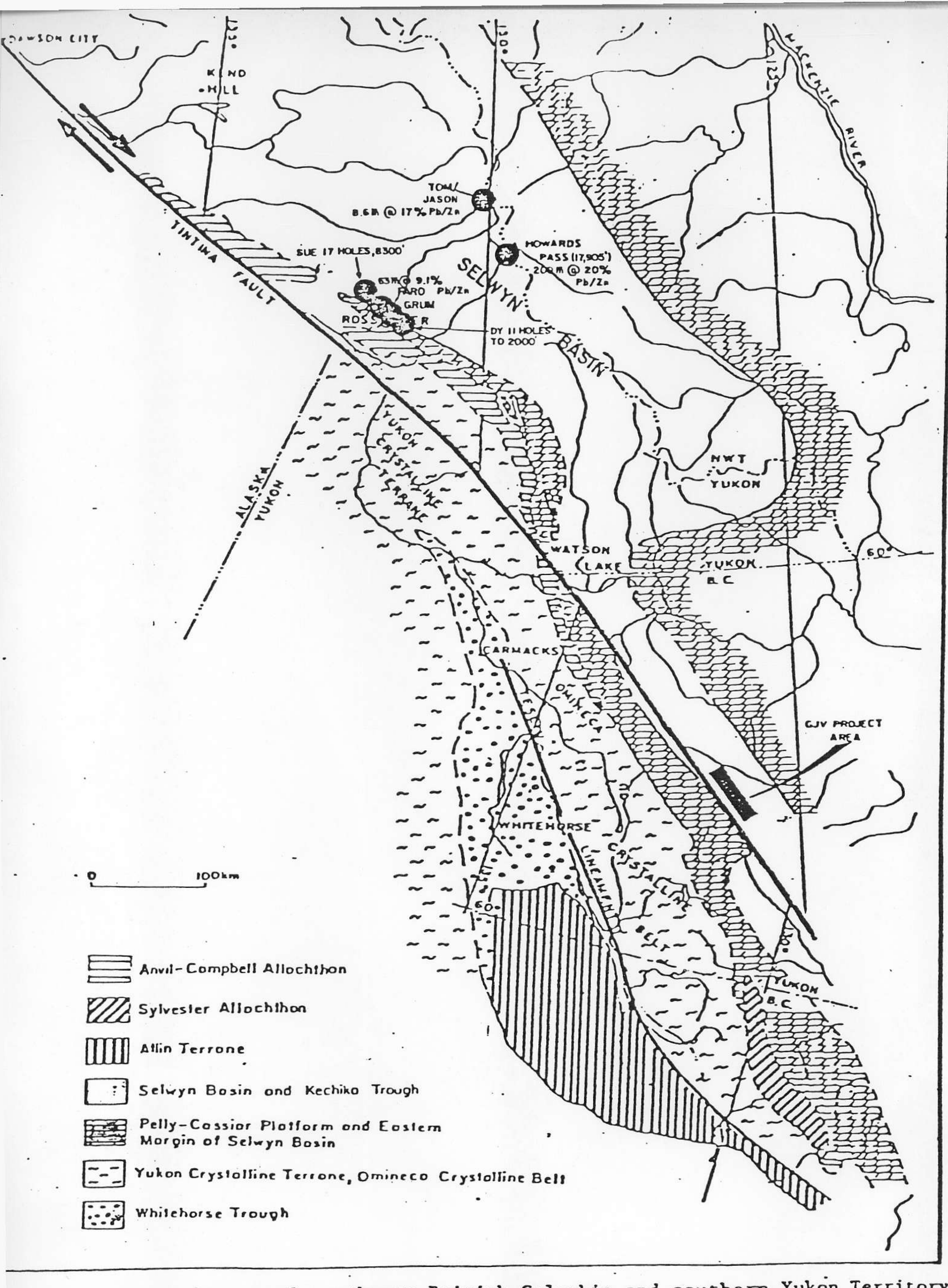
PURPOSE

The object of this study is to determine whether or not the major lineaments related to exhalative metal deposition within the Kechika Trough can be defined by a palinspastic reconstruction. A preliminary review of published and unpublished data relating to the Kechika Trough will serve as a basis for the attempted reconstruction.



ure 1. Tectonic map of northeast British Columbia and southern Yukon Territory after restoration of 450 km of right lateral movement on Tintina Fault (after Tempelman-Kluit, 1976).

1. INTRODUCTION

The area of interest is located within the Rocky Mountain (Foreland) thrust and fold belt of the Columbian Orogen and is underlain by Early Palaeozoic strata. The Kechika Trough is a structure bordered to the west by transcurrent faults of the Rocky Mountain Trench system and to the east by platform carbonates and Proterozoic rocks (Figure 1). The Trough trends northwest and may represent a southwesterly extension of the Selwyn Basin. Physiographically the Basin covers part of the Yukon and Liard plateaux, the Ogilvie Mountains, the Selwyn Mountains and the Pelly Mountains (Figure 3). The Basin existed from Late Proterozoic (early Cambrian?) to the end of the Middle Devonian. The concave northeastern edge of the Basin may have developed as a large embayment on the continental shelf of what was a stable, trailing edge of the craton. Prior to the Ordovician the Basin may have been open to the sea on its western edge, having the form of a gulf or large bay rather than a basin. Fault displacement along an early predecessor of the Rocky Mountain - Tintina trench system probably initiated closure of the Basin.

Within the Basin thick carbonate and sandstone formations along the eastern flank grade abruptly to the west along well defined hinge lines into fine grained and thinner sequences of clastic rocks and chert. The greatest sedimentation is seen adjacent to these hinge lines.

Sediments in the subject area consist of the Upper Devonian Gunsteel Formation which unconformably overlies the Middle Devonian Besa River Formation which in turn unconformably overlies the Middle Ordovician-Lower Devonian Road River Group (Fig.2). Tectonism and erosion prior to the deposition of the Besa River Formation resulted in a pronounced unconformity which truncates folded and faulted strata to the west and south of the Gataga area. The Besa River Formation appears to have been deposited rapidly indicating that tectonism persisted. Elsewhere these rocks overlie shales and clastic rocks of Windermere age, the "Grit Unit", probably derived from the craton. The base of the Grit Unit is not recognized within the Basin,

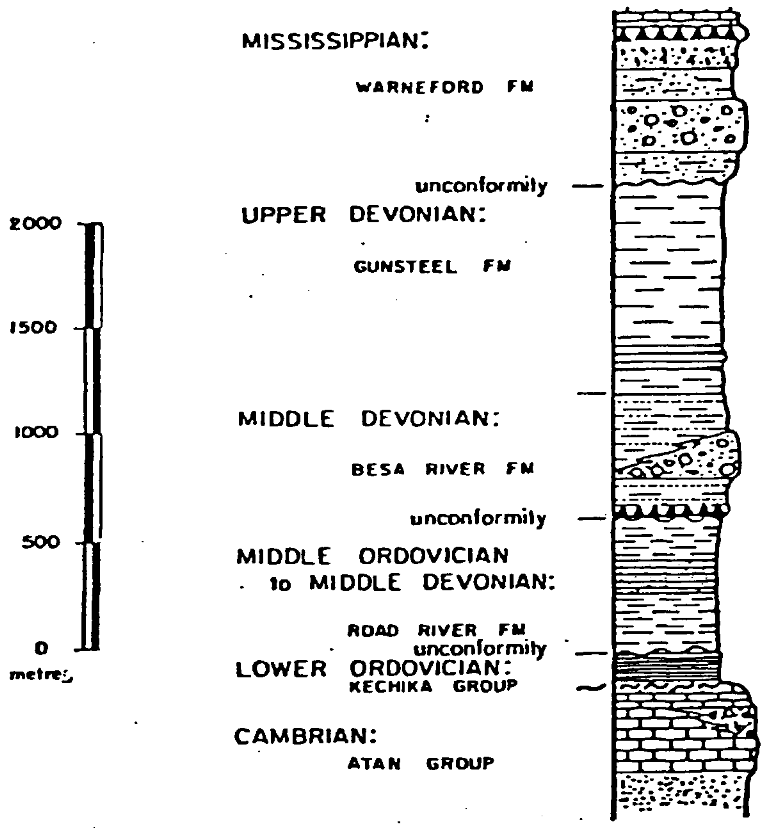


Figure 2. Regional stratigraphy Gataga Lakes area, northeast British Columbia. (from Gataga Joint Venture Final Report, 1980)

consequently, the earliest history of the rocks underlying the Basin is uncertain. Along the northern edge of the Ogilvie-Wernecke Mountains are windows that reveal rocks which may represent the underlying stratigraphy. These rocks are possibly of Aphebian age and consist of moderately metamorphosed and deformed shales, quartzites and carbonates cut by explosive breccias.

2. TIMING OF MINERALIZATION

Rifting, platform subsidence, and associated igneous activity in the Selwyn Basin occurred at the end of the Cambrian when the continent pulled away from the Pelly-Cassiar platform. A volcanic island arc formed on top of the carbonates to close off the seaward side and to create a true basin. This volcanism roughly coincided with the first stage of stratiform Pb-Zn mineralization in rocks of the Road River Formation (Middle Ordovician to Middle Devonian) e.g. the Anvil deposit, Howards Pass deposit.

The second stage of Pb-Zn mineralization. e.g. Tom-Jason deposit, Driftpile Creek deposit, is associated with the development of fault bounded basins and is time equivalent to Upper Devonian acid volcanism in the Pelly-Cassiar platform.

3. REGIONAL STRUCTURAL GEOLOGY

3.1 Introduction

The most recently published structural studies concerned primarily with the northern Rocky Mountains are those of Thompson (1979, 1981). A re-interpretation of earlier work, specifically that of Taylor and Stott (1973) is presented by Thompson, in which he visualizes the northern part of the Rocky Mountains as being essentially similar but orogenically less mature than the southern Rocky Mountains. The agreements forwarded by Thompson allow the RockyMountains to be seen as a continuum with local changes in structural style being accommodated along the length of the Belt by different structural mechanisms.

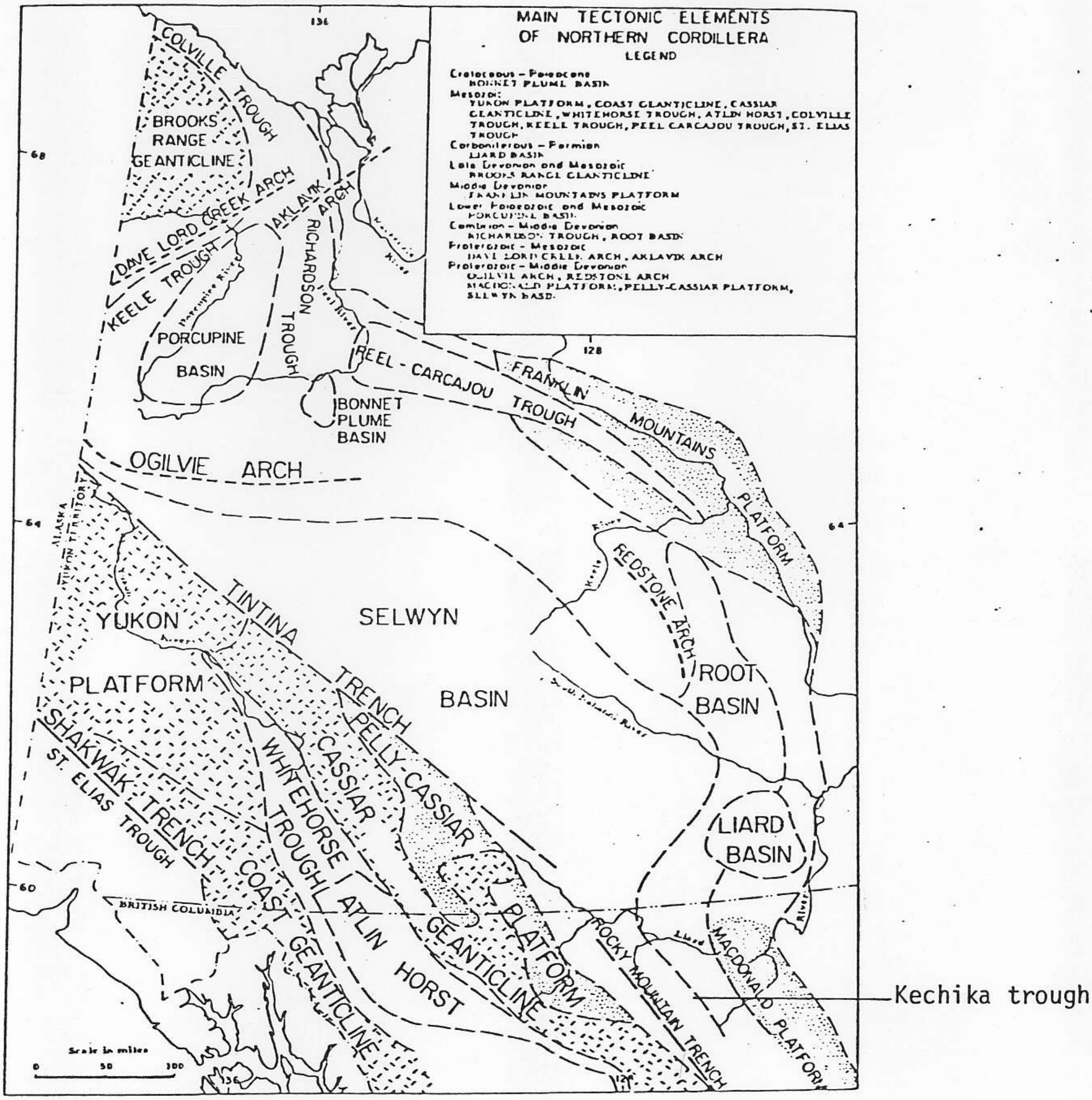


Figure 3. Main tectonic elements of Northern Cordillera (from Gabrielse, 196).

The Canadian Rockies are commonly described in terms of structural subprovinces (North and Henderson, 1954), a subprovince being characterized by distinctive stratigraphic, structural and topographic features separated by major thrusts or thrust systems. Within the southern Rockies four subprovinces have been defined: Foothills, Front Ranges, Main Ranges and Western Ranges. North of the Peace River (56° N) only two of these remain, the Foothills on the east and a composite Rocky Mountain subprovince on the west. The transition from one to the other may be via a small thrust or alternatively the Foothills subprovince may merge laterally with the Rocky Mountains. The large thrusts characteristic of the southern Rocky Mountains, e.g. the Lewis thrust and the McConnell thrust, which separate Proterozoic and Palaeozoic carbonates from a Foothills terrane of Cretaceous shales,do not persist as they are traced northwards. The thrusts that are present in the northern Rocky Mountains lack the lateral continuity of those to the south.

Thompson (1981) believes the lack of thrusts in the northern Rockies to be more apparent than real and that relative eastward movement of strata has been achieved on flat-lying thrusts, termed blind thrusts, that rarely intersect the surface topography. The Foothills subprovince of the northern Rockies is characterized by large amplitude box and chevron folds which expose predominantly Mesozoic strata, whereas large folds along the western edge involve Mississippian through Permian strata.

Lateral changes in the character of the Rocky Mountain miogeoclinal wedge have exerted a major influence upon the deformation style along the Belt (Figure 4). The northern part of the Rocky Mountains is lithologically characterized by a greater shale content, with the eastern margin of its Rocky Mountains subprovince containing major shale to carbonate facies transitions. Incompetent horizons that persist from the Rocky Mountains subprovince through the Foothills subprovince have acted as glide horizons into which thrusts either flatten with depth or verge upward into.

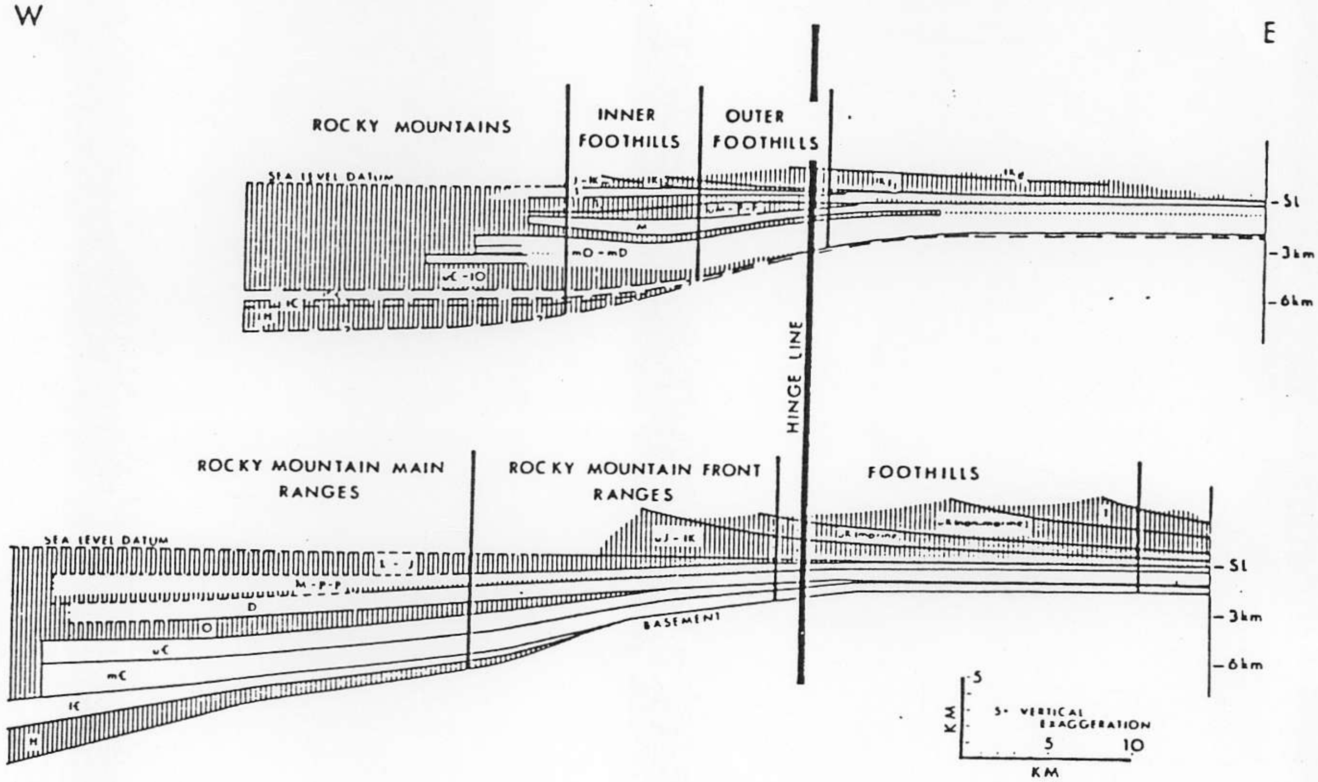


Figure 4. A comparison of palinspastic reconstructions of stratigraphic sections across the miogeocline for the Northern Rockies region and the southern Rockies (adapted from Price and Mountjoy, 1970, Figs. 2-3).

Vertical line pattern - incompetent units
Open area - more rigid quartzites and carbonates
Hinge line - approximate locus of accelerated thickening of lower and middle Paleozoic carbonate successions in each section.

(from Thompson, 1979)

Contained within thrust slices of folded strata a carbonate succession in the south may pass northwards along strike into a fine grained clastic succession. This oblique trend of major facies transitions relative to the structural grain is another important influence upon the structural style seen along the length of the Belt.

Probably the most important structural elements within the northern Rockies are the blind thrusts. Thompson (1979) believes that this particular type of thrust played a critical role in the development of the northern Rocky Mountains and is reponsible for some of the important differences in structural style between the northern and southern Rockies. Such thrusts are low angle features that require the presence of an overlying glide horizon/detachment zone into which they are able to merge upward and continue laterally without reaching the surface. Consequently, they are not exposed at the surface.

The displacement on a blind thrust, when transferred into the overlying beds, produces a complex set of disharmonic structures. Once displacement upon a blind thrust is initiated a second detachment within the over-riding sheet forms (Figure 5). Should there be any underlying competent units the incompetent strata will deform independently, such deformation being of a disharmonic type. When the amount of shortening on the blind thrust is not balanced by the shortening due to disharmonic folding a splay from the blind thrust will form to accommodate the inbalance. The displacement at depth across the blind thrust should be equalled by the amount of bed length shortening within the fold complex at the surface.

4. GATAGA AREA

4.1 Introduction

Available, detailed field data concerned with the region in and around the Gataga Joint Venture claim group and the Driftpile Creek

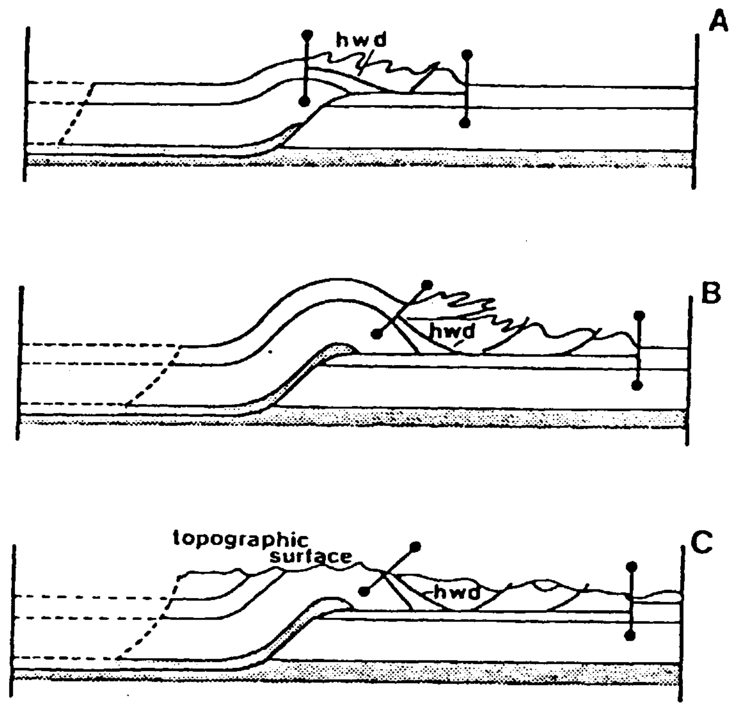


Figure 5. Diagrammatic representation of a blind thrust model (from Thompson, 1981).

hwd - hangingwall displaced

area is restricted to the Gataga Joint Venture Final Report 1980 (G.J.V.F.R. 1980) and the assessment reports of McIntyre (1980).

4.2 Local Stratigraphy

The stratigraphy (Figure 2) that is shown on the structural cross-sections (Figure 46, G.J.V.F.R. 1980) is contained within the Upper Devonian Gunsteel Formation, a generally fine grained and siliceous black shale, and the Besa River Formation. Only the upper part of the Besa River Formation is noted, this consists of siltstone and silty shale.

Pb-Zn mineralization is mainly confined within two layers, UH and TH_1, both of which occur in the lower part of the Gunsteel Shale Formation.

4.3 Local Structure

The Gataga Joint Venture area is structurally located within the Rocky Mountains subprovince of the northern Rocky Mountains thrust and fold belt. The dominant structural trend outlined by thrust faults and fold axial surface traces is northwest.

Three different fold styles are described in the G.J.V.F.R. 1980:

a. upright to westerly verging open folds
b. overturned isoclinal folds
c. "smaller" isoclinal folds confined to the easterly dipping limbs of major folds.

Two major thrust faults are recognized, one of these strikes through the central part of the project area and places Ordovician, Silurian and Lower Devonian strata on top of Upper Devonian Gunsteel Formation. To the west of this thrust the exposure of Gunsteel Formation strata is limited by a parallel fault that places Ordovician and Silurian strata over the Gunsteel Formation shales. The erosion level west of this fault as far as the Rocky Mountain Trench is below the stratigraphic level of Upper Devonian strata.

Numerous cross-cutting northwest and northeast striking faults and shear zones are reported (G.J.V.F.R. 1980); the sense of movement on these being west side up. Most of these faults are shown as being vertical on the structural cross-sections (Figure 46, G.J.V.F.R. 1980).

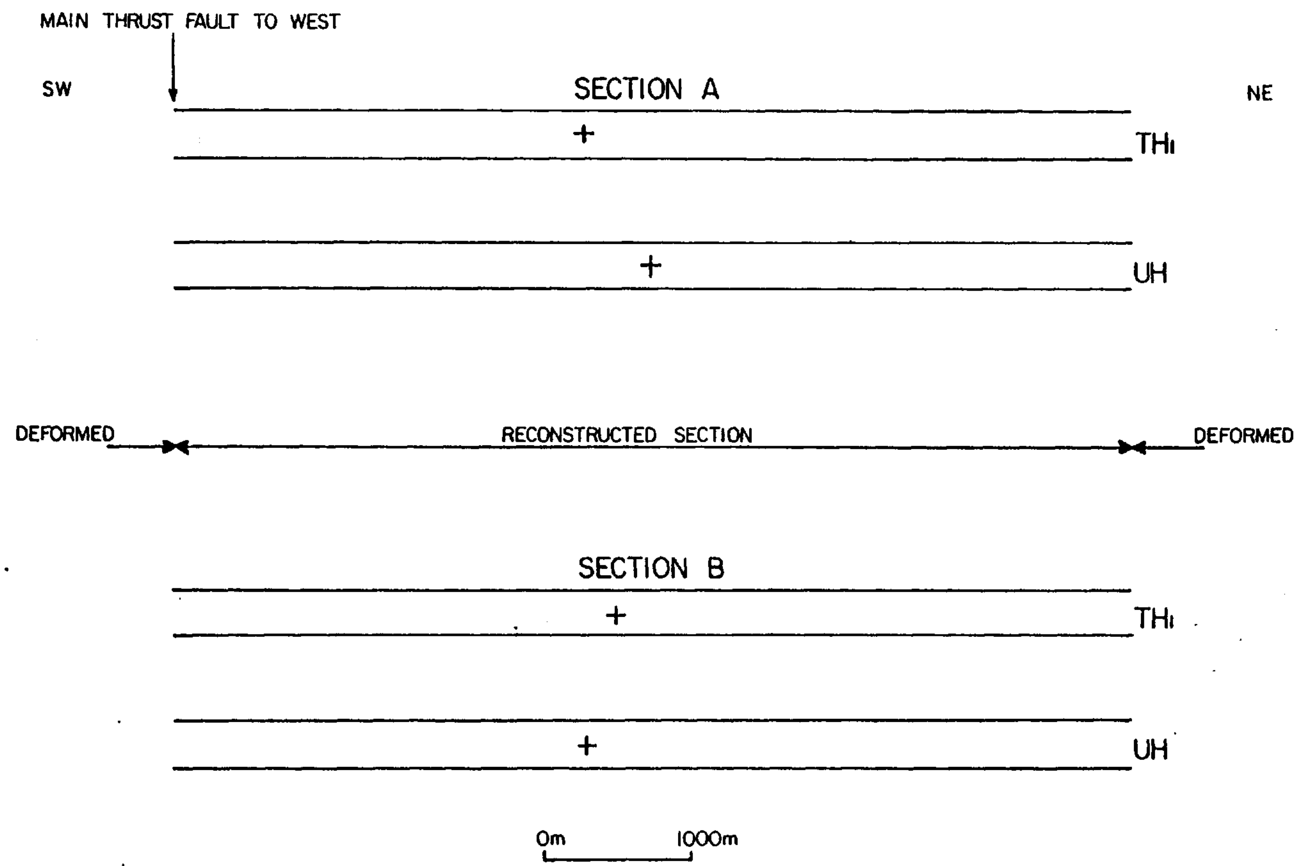
Cleavage surfaces strike at 120 to 140 degrees, dip varies from vertical to sixty degrees west. Cleavage bedding relationships indicate an average amount of plunge between ten and twenty degrees to either the northwest or southeast.

The northeast-southwest trending cross-section (Figure 6) is a re-interpreted version of Figure 6 (G.J.V.F.R. 1980) and outlines the major structural elements. The style of folding is disharmonic, axial surfaces dip steeply to both the northeast and southwest. The three fold styles referred to in the G.J.V.F.R.(1980) were probably produced during the same phase of deformation, the variety in style reflecting the disharmonic nature of the folding that has deformed the shales. In a succession of strata within which there is a distinct variation of competency from one bed to the next disharmonic folds will preferentially form in the incompetent layers whilst competent layers will fold flexurally and independently. Within the Gunsteel Formation the variation in competency between the layers is limited, the succession is primarily one of incompetent shales. In the southern Rockies tectonic thickening is associated with disharmonic folding. Cook (1975) presents evidence of thickening within the Chancellor Formation, which consists mainly of shales with some argillaceous limestones, by a factor of 2.5. In the southern Rockies the folds produced during the thrusting and folding event are orientated with their axial surfaces generally dipping in the same direction and at a similar angle as the adjacent thrusts.

DIAGRAMMATIC REPRESENTATION OF SECTIONS A & B PRIOR TO FOLDING

FIG. 11

FIG. 12



+ ZONE OF RELATIVELY HIGH Pb & Zn ASSAYS

The absence of such a relationship in the Gataga area emphasizes the disharmonic nature of the folding.

The penetrative cleavage recorded has a similar orientation to that of the major fold axial surfaces (Figure 6) and is interpreted to be genetically related to the folds.

The majority of the thrust faults shown (Figure 6) are imbricate structures with a minor amount of displacement recognized. The scale of thrust faulting that affects the section is minor when compared to the displacement recognized along thrust faults in the southern Rockies. The imbricate thrusts in the Gataga area are interpreted to be compensation mechanisms that were formed when the amount of shortening taken up by disharmonic folding lags behind that produced along underlying and unseen blind thrusts.

The northwest striking, steeply dipping faults are probably stress relaxation features related to northeastward extension following thrusting. In the southern Rockies such faults are well displayed and mark the last structural event (Early Tertiary) to affect the Foreland thrust and fold belt. Some of these faults pass into thrust faults at depth.

4.4 Palinspastic Reconstruction

Cross-sections A and B (Figure 46, G.J.V.F.R. 1980) were partially restored tb their original undeformed length by allowing for predominantly vertical movement along the steeply dipping normal and/or block faults (Figures 7 and 8), horizontal and vertical movement associated with a tilting factor along thrust faults (Figures 9 and 10) and measuring the distance along fold outlines (Figures 11 and 12). Structural thickening, a probable shortening effect, was not accounted for.

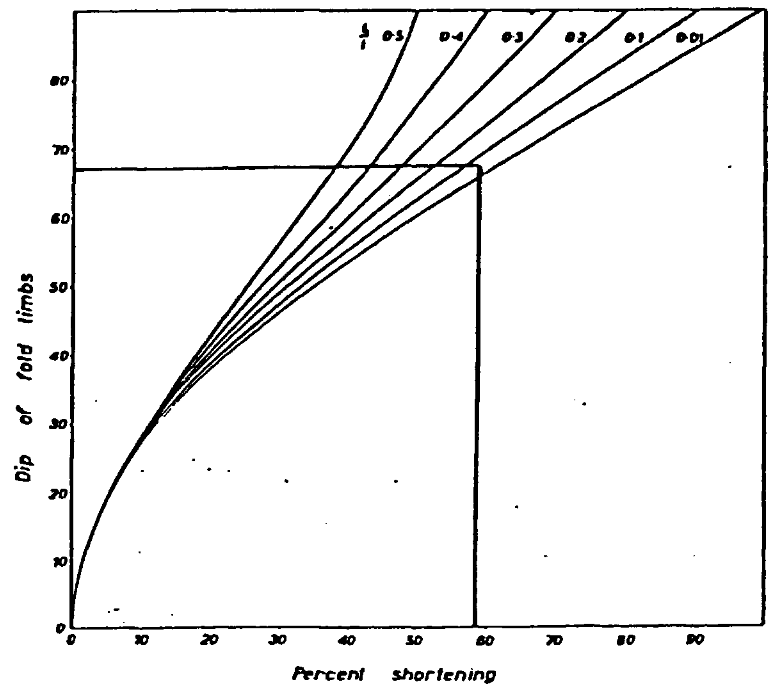


Figure 13. Variation of limb dip with percentage shortening. (from Ramsay, 1974)

Data from Gataga Joint Venture area plotted on graph.

A total shortening of 42% was determined across Section A, of this 34.5% is due to folding and 7.5% to thrust faulting. Across Section B the total shortening is 38%, 27% attributed to folding and 11% to thrust faulting.

4.5 Discussion of Results

Sections A and B exhibit a respective shortening of 42% and 38%. Ramsay (1974) in a study concerned with the development of chevron folds graphed the relationship between the dip of the fold limbs and the percentage shortening required. The deformation related to the production of chevron folds is a more penetrative one than is seen in the Gataga regien. When data from the Gataga region is plotted on the graph a percentage shortening of 57.5 is given (Figure 13). This figure is viewed as a maximum whereas the calculated 42% and 38% shortening, with no allowance made for thickening, are viewed as minimum estimates.

Thompson (1979) records an approximate shortening of 35% across a section 15 km to the northeast of the Gataga area. The section crosses the major facies change between carbonate platform and shale basin and is entirely within the Rocky Mountains subprovince of the northern Rockies. Again there was no correction made for shortening by thickening.

In both reconstructed sections the highest combined Pb + Zn assays in layers UH and TH_1 plot approximately above each other (Figures 11 and 12). The location of these superimposed high assays in relation to the front of the major thrust fault to the east is similar in both sections (Figure 14). One implication of the above is that the ore bodies located in UH and TH_1 in both sections are related to the same conduit, e.g. a steeply inclined fault (Figure 14). The host rock shales at this location are interpreted to have been deposited at least sixty kilometres to the west of the carbonate platform edge and were consequently well into the shale basin.

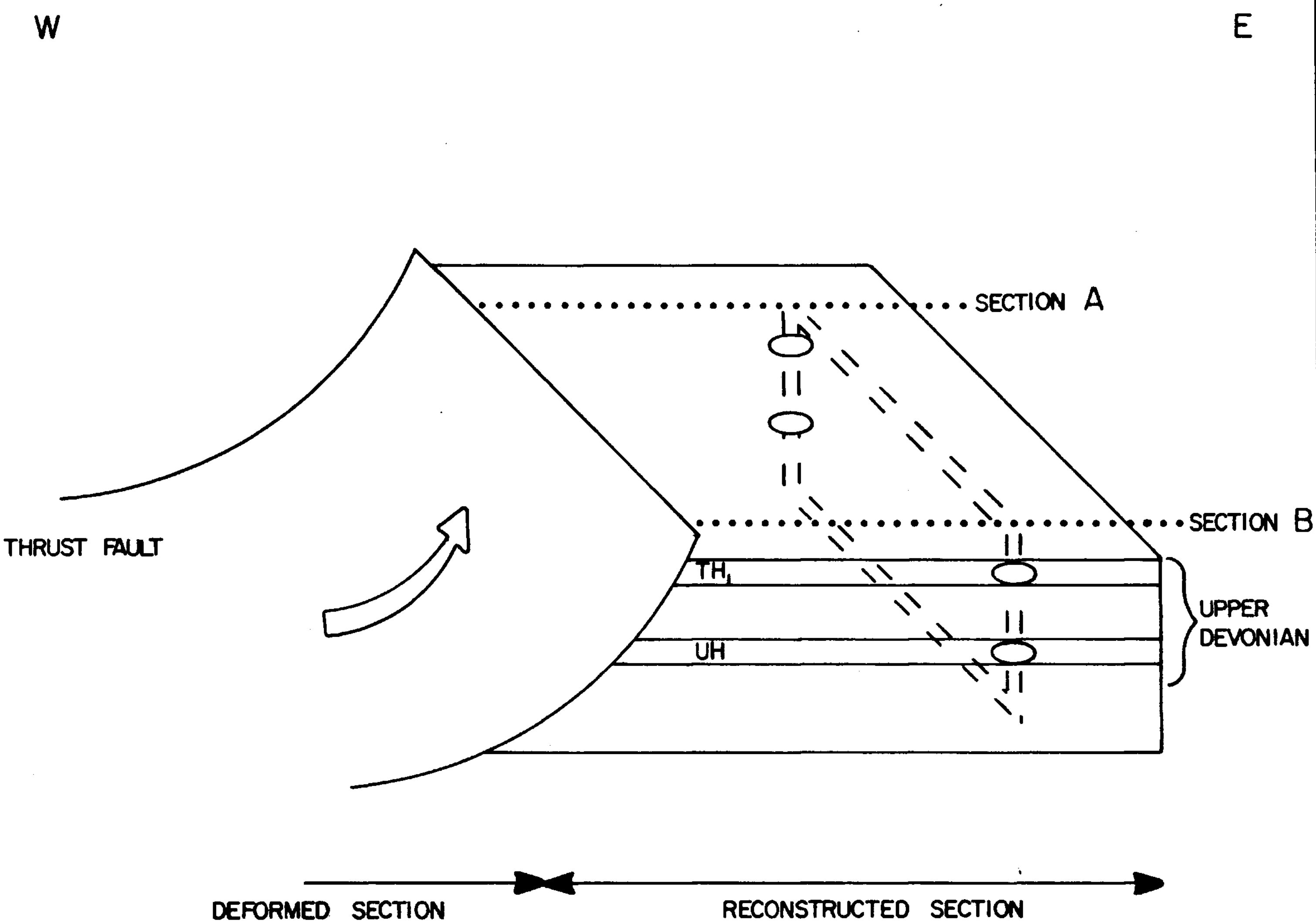


Figure 14. Interpretation of relationship between ore bodies and possible fault conduit.

Plane of possible fault conduit shown by dashed lines.

Instead of block faulting, and associated mineralization, being restricted to the carbonate platform edge a series of faults across the basin is envisioned. The likelihood of locating any of these faults at depth is remote due to the presence of the thrust faulted cover rocks. It is possible to trace the line of a fault within an individual thrust slice, however tracing it below the level of a major discontinuity, i.e. a blind thrust, would be very problematical.

5. RECOMMENDATIONS

The immediate application of this interpretation is within the Gataga Joint Venture area. An apparent trend of mineralization has been defined (Figure 15) and further work would prove or disprove the interpretation. The type of investigation recommended is one involving detailed structural mapping at both a local and regional scale. A better understanding of both the regional style of deformation and the orientation of major structures within the area would provide a firm basis for a detailed, local study of apparent trends of mineralization. The previous lack of a detailed, structural mapping programme is presently reflected in the level of understanding of the regional deformation style and the lack of control involved in any structural projection.

In recommending any detailed fieldwork within the Gataga Joint Venture area the following adverse factors have to be considered:

1. Bedding (compositional layering) is difficult to distinguish.

2. The sense of bedding is difficult to determine. In the available literature there were no references given as to the criteria used to determine this. When mapping in a terrane of shales that have been isoclinally folded and overturned the sense of bedding is especially important.

3. There is a lack of distinctive and recognizable marker horizons.

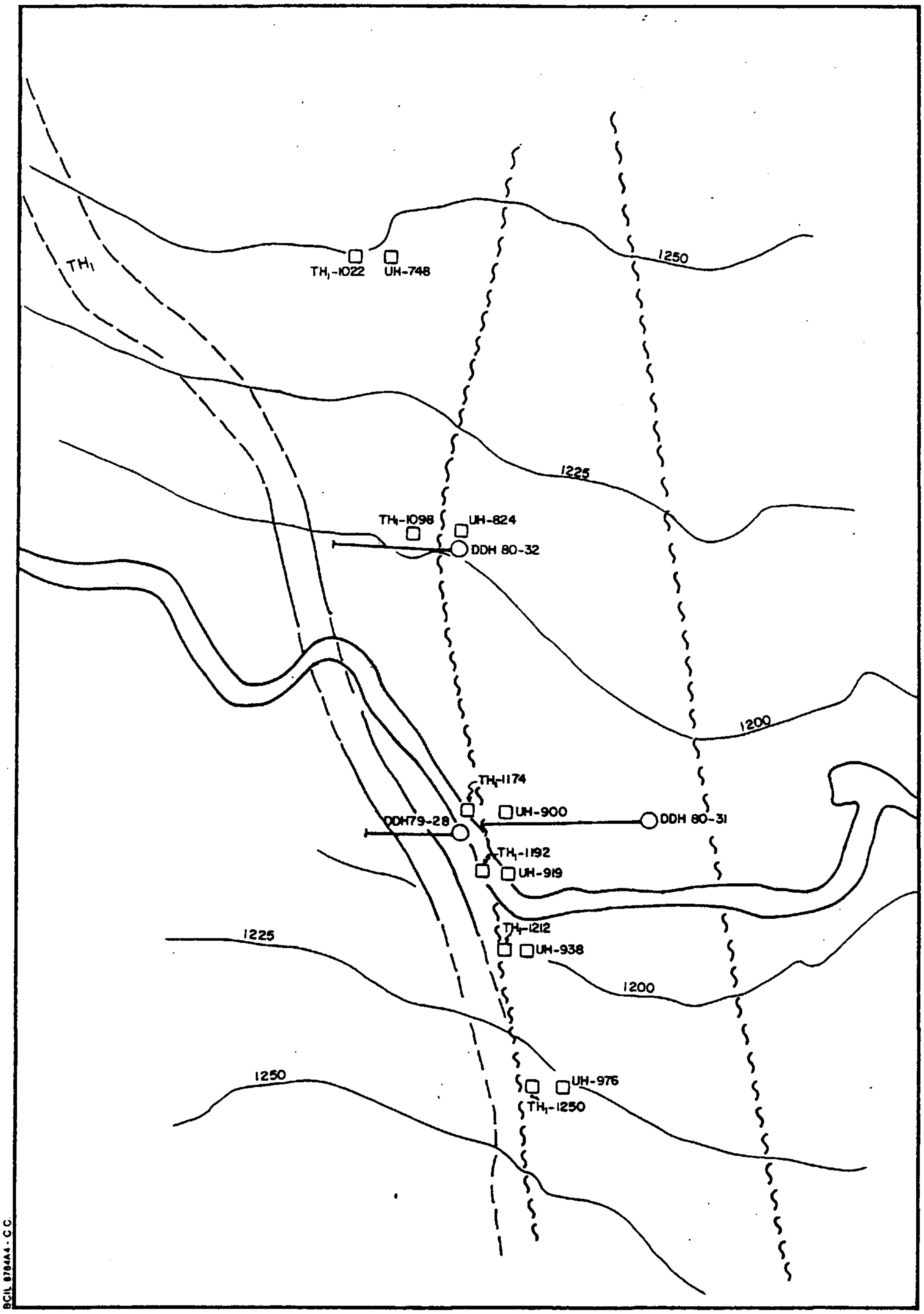


Figure 15. An apparent trend of Pb-Zn mineralization is outlined by open squares. Numbers given for Th_1 and UH refer to elevation of projected ore body. Control of projection is by use of data from DDH's 79-28, 80-31 and 80-32.

4. The imbricate thrust faults are not laterally persistent.

5. Axial surfaces cannot be traced laterally, nor may they be projected up or down dip, for any appreciable distance.

6. The shales in outcrop are heavily weathered, the weathering profile can attain a depth of two metres.

These factors combine to make the thrust faulted, complexly folded and deeply weathered Devonian shales a difficult succession to map. Once surface exposures of mineralization have been investigated, along with any geochemical anomalies, the investment required in attempting to delineate subsurface trends may be prohibitive and unrewarding.

In conclusion it would be worthwhile to conduct two structural mapping programmes within the Gataga Joint Venture area. The initial approach would be at a regional scale, information obtained would aid in the recognition and projection of structural trends at a local scale.

D. Shaw, Ph.D.
May, 1981

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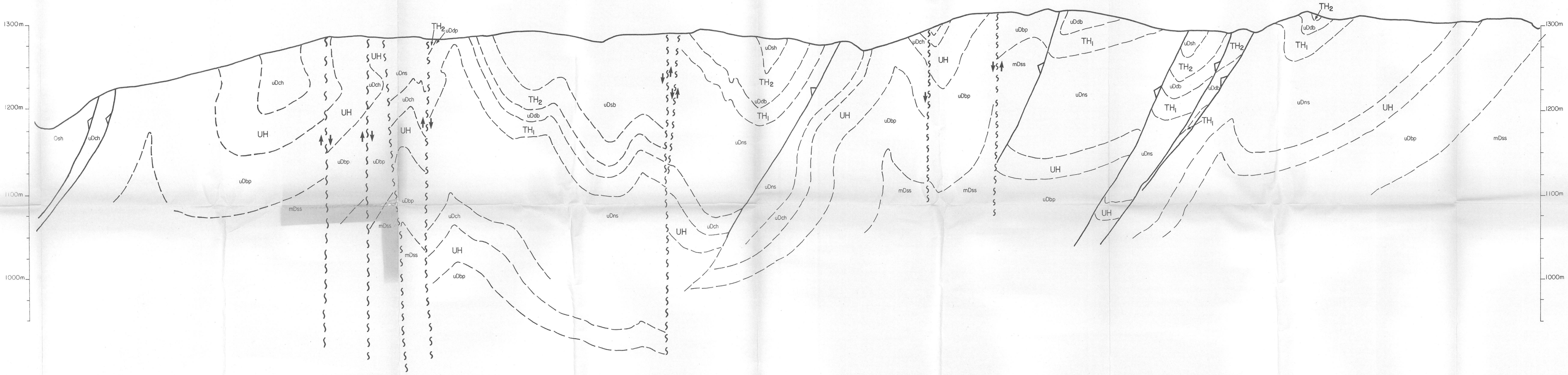
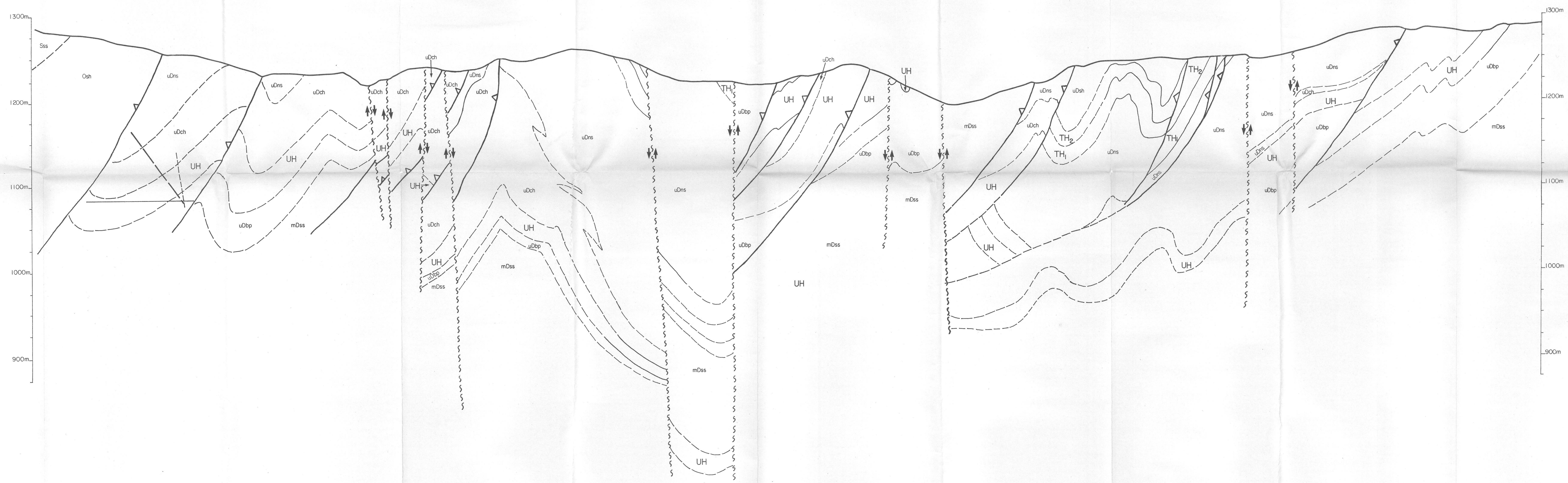
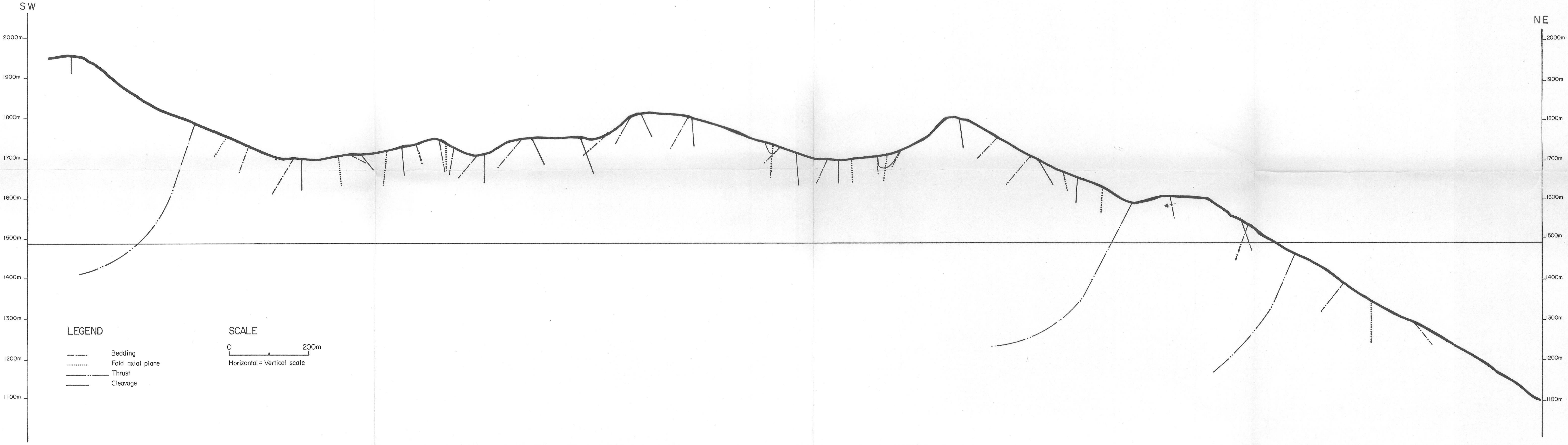
SECTION A



SECTION B



RE-INTERPRETED VERSION OF FIGURE 6
FROM G.J.V.F.R., 1980.



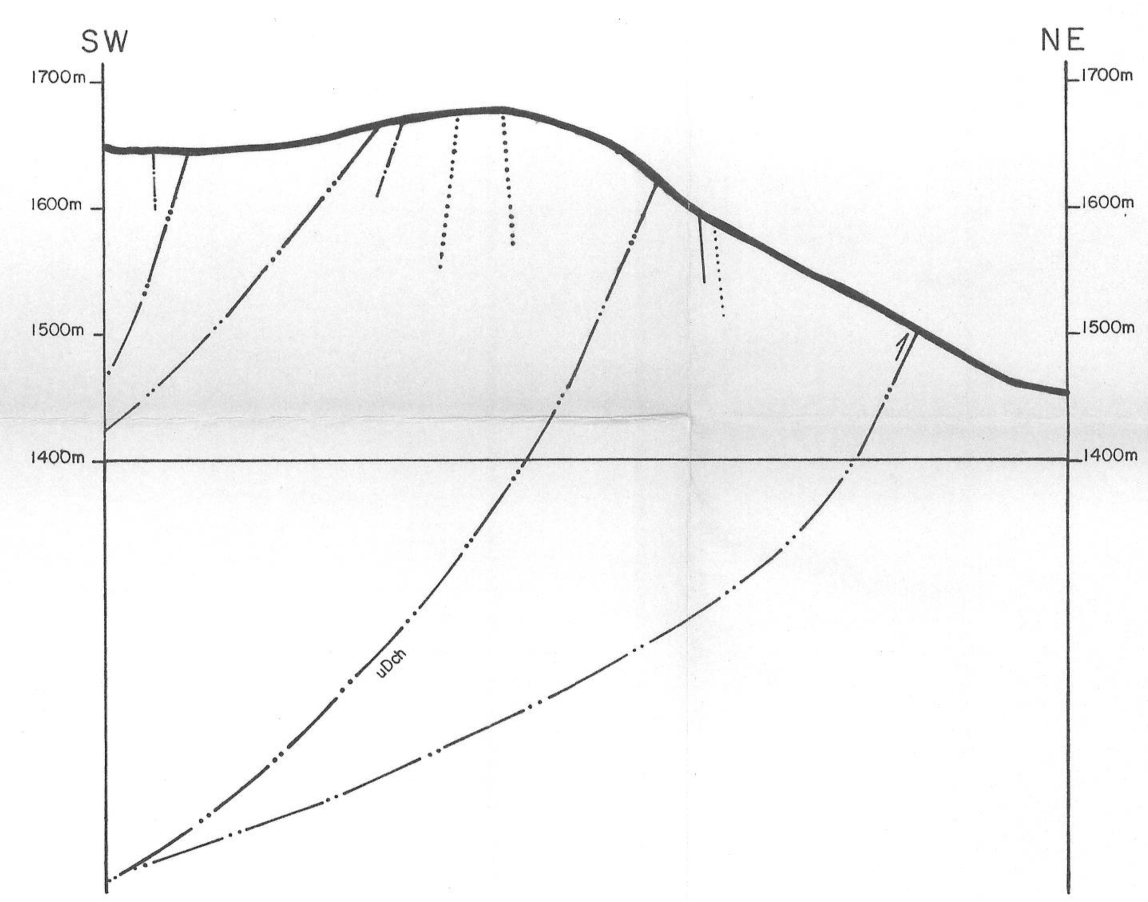


FIG. 6

SECTION A PRIOR TO NORMAL/BLOCK FAULTING

FIG. 7

SECTION B

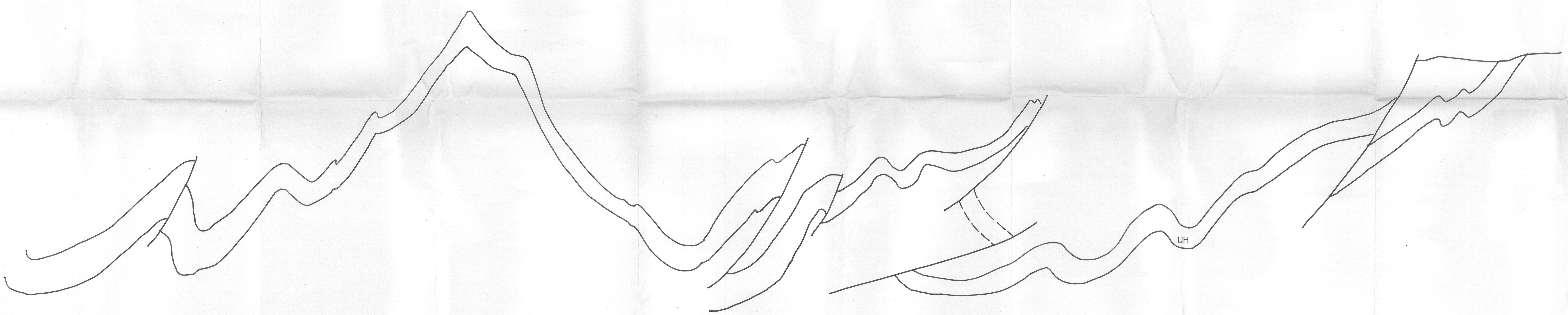


FIG. 8

SECTION A PRIOR TO THRUST FAULTING

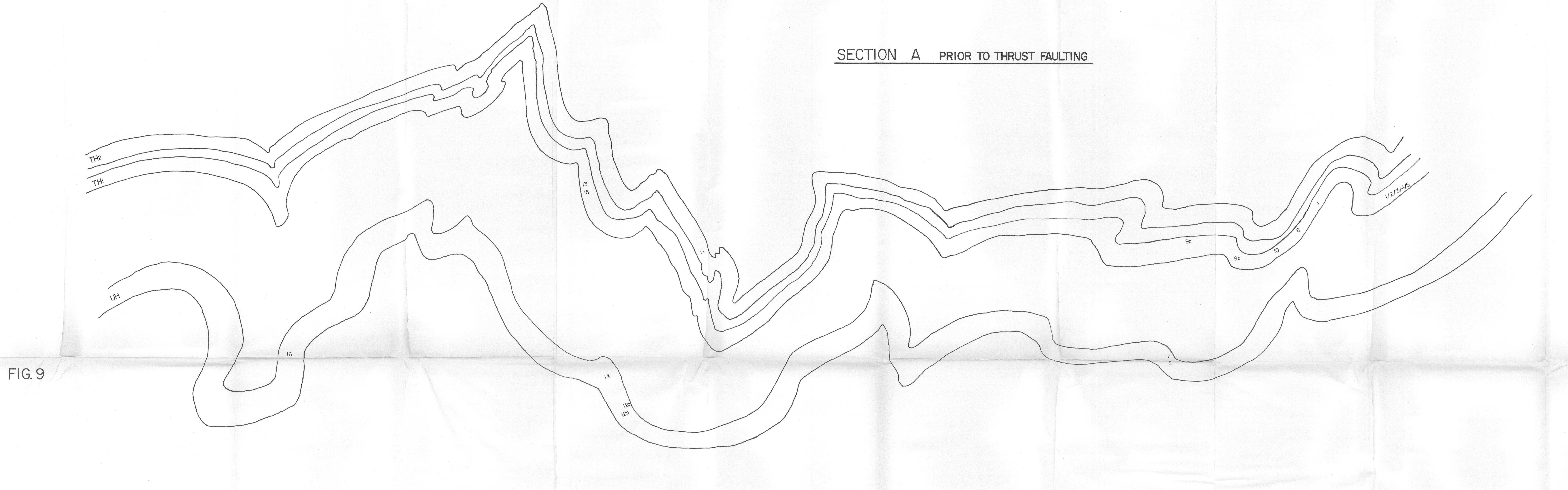


FIG. 9

SECTION B PRIOR TO THRUST FAULTING

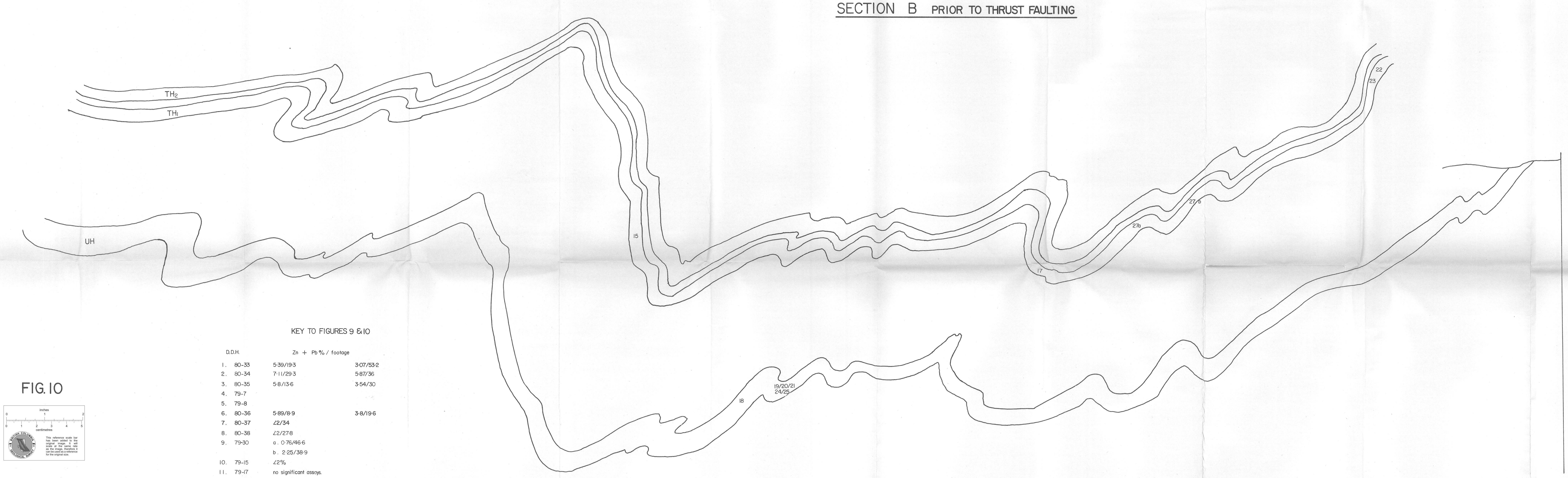


FIG. 10

KEY TO FIGURES 9 & 10

D.D.H.		Zn + Pb % / footage			
1.	80-33	5·39/19·3	3·07/53·2		
2.	80-34	7·11/29·3	5·87/36		
3.	80-35	5·8/13·6	3·54/30		
4.	79-7				
5.	79-8				
6.	80-36	5·89/8·9	3·8/19·6		
7.	80-37	<2/34			
8.	80-38	<2/27·8			
9.	79-30	a. 0·76/46·6			
		b. 2·25/38·9			
10.	79-15	<2%			
11.	79-17	no significant assays.			
12.	79-16	a. <2%			
		b. 2·75/57			
13.	80-32	5·37/17·9	15·72/32·6		
14.	80-31	14·2/10	11·7/28·5	15·1/11·7	
15.	79-28	4·9/50	17·8/10·5		
16.	79-18	3·79/60	7·45/11·2	7·49/13·1	
17.	79-14	4·11/8			
18.	79-10	6·65/17·6			
19.	78-02	1·46/45·8			
20.	78-03	1·21/38·5	1·28/52·5		
21.	78-01	2·06/52·5			
22.	78-25	no significant assays.			
23.	79-26	2·91/30·0	2·85/100·5	2·96/30·9	3·56/9·7
24.	78-04	2·22/133·3			
25.	78-05	3·25/42	2·2/167		
26.	78-06	a. 1·47/48			
		b 1·68/80			
27.	79-13	a. 2·5/20			
		b. 2·5/18·2			