70-68

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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A SUBDIVISION OF THE UPPER CRETACEOUS – LOWER TERTIARY SUSTUT GROUP, TOODOGGONE MAP-AREA, BRITISH COLUMBIA

(Report and 4 figures)

G. H. Eisbacher

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ABSTRACT

The Upper Cretaceous-Eocene Sustut Group within Toodoggone map-area of north-central British Columbia comprises continental clastic rocks and ash fall tuffs with a composite thickness of as much as 7,600 feet (2,310 m.). Two formations (Tango Creek Formation and Brothers Peak Formation) were mapped and correlated with known Sustut Group rocks in adjacent map-areas. Paleocurrent directions and modal analyses indicate progressive deformation within the basin framework during deposition of the Sustut Group. The existence of distinct clastic depositional fans may be significant in developing mineral exploration concepts.

A SUBDIVISION OF THE UPPER CRETACEOUS-LOWER TERTIARY SUSTUT GROUP, TOODOGGONE MAP-AREA, BRITISH COLUMBIA

INTRODUCTION

Widespread occurrences of Upper Cretaceous-Lower Tertiary continental clastic deposits and associated volcanics in northern British Columbia have been known for many years. However, Lord (1948, pp. 34-41) was the first geologist to map and describe in some detail the stratigraphy within a major outcrop belt of these rocks. He proposed the name Sustut Group for a sequence of Upper Cretaceous-Lower Tertiary clastic sediments and intercalated tuffs after Sustut River in McConnell Creek map-area. Stratiform deposits of equivalent age, made up predominantly of silicic to intermediate volcanics, have been named Sloko Group in northernmost British Columbia (Aitken, 1959, pp. 66-68; Souther, 1967), and Ootsa Group in north-central British Columbia (Duffell, 1959, pp. 67-73; Tipper, 1963).

In this report the term Sustut Group is extended to include all probable Upper Cretaceous-Lower Tertiary clastic sedimentary rocks and interlayered tuffs in north-central British Columbia. Previous reference to Upper Cretaceous-Lower Tertiary Sustut Group can be found in McConnell (1896, pp. 22, 23, 26, 28, 30, 35-37), Dolmage (1928, p. 29), Hedley and Holland (1941, pp. 42, 43), Lang (1942), Lord (1948, pp. 34-41), Armstrong (1949, pp. 65, 74), Roots (1954, pp. 190-192), Geological Survey of Canada (1957), Sutherland Brown (1960, pp. 36-38), Muller (1961), Gabrielse (1962a, b; 1963, pp. 94-96), Rutter and Taylor (1968), Muller and Tipper (1969), Eisbacher (1970, pp. 36, 37; 1971).

The stratigraphic age of Sustut Group rocks is mainly known from work on fossil plants by W. L. Fry, G. Rouse, and particularly through the thorough effort of W.A. Bell (Bell, 1965). A synthetic view of the depositional framework of Sustut Group rocks has been attempted by Souther and Armstrong (1966).

The ultimate objective of the present study is a basin analysis of the principal outcrop belts of the Sustut Group with special attention being focused on the structural evolution concomitant with and following the deposition of the Sustut Group.

This report contains a preliminary account of the stratigraphic subdivisions of Sustut Group rocks recognized during mapping in Toodoggone map-area, and implications for further study and economic utilization. It is based on field and office work carried out during 1969 and 1970.

A more complete presentation of stratigraphy, paleocurrent data, composition, tectonic framework, and deformation of the Sustut Group is planned for the near future.

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REGIONAL FRAMEWORK OF THE SUSTUT BASIN

The Sustut Basin represents a late orogenic continental successor basin to the eugeosynclinal domain of the north-central Canadian Cordillera.

The Sustut Group was deposited on or contains clasts of rocks ranging in age from Proterozoic to Late Jurassic. After its deposition in Late Cretaceous-Early Tertiary time the Sustut Group was deformed together with underlying older rock-units in Early to Middle Tertiary time. The area was then extensively peneplaned and locally covered by Pliocene to Recent basaltic volcanics (Lord, 1948; Souther, 1970). Remnants of this peneplane are presently found at an elevation of about 6,000 feet (2,000 m.).

A short description of the principal rock units which constitute source and framework of Sustut sedimentation follows (see also Fig. 1a).

Proterozoic and lower Paleozoic miogeosynclinal rocks

A large portion of the Omineca Geanticline, which separates the Rocky Mountain Trench from the principal Sustut outcrop belt, is occupied by carbonates, quartzites, slates, phyllites and feldspathic grits of Proterozoic to early Paleozoic age. These sedimentary units are possibly more than 15,000 feet (5,000 m.) thick and have been extensively folded, thrust faulted, and metamorphosed in Late Mesozoic and possibly earlier time (Wheeler, 1966); they make up a substantial portion of the Wolverine metamorphic complex (Roots, 1954) and are in fault contact with younger eugeosynclinal rocks to the west.

Cache Creek Group

The Cache Creek Group of northern British Columbia is composed of a very thick eugeosynclinal succession of chert, slate, siltstone, limestone, basalt, and ultramafic rocks. The Cache Creek Group has a known age range from Early Mississippian to Late Permian and a thickness of 5,000 to 10,000 feet (1,500-3,000 m.) (Monger, pers. comm., 1970). The Cache Creek rocks are the oldest known record of eugeosynclinal deposition in north-central British Columbia.

Asitka Group

The Asitka Group occurs in the McConnell Creek area and contains silicic volcanics, chert, and minor carbonates of Pennsylvanian-Permain age and has a thickness of several thousands of feet (Lord, 1948).

Takla Group

The Takla Group comprises a very thick and laterally extensive succession of andesitic flows, fragmental volcanics, redbeds, and minor limestone. These rocks have been described from many areas in north-central British Columbia and in a restricted sense are considered to be mainly of Late Triassic age (Armstrong, 1949; Tipper, 1963; Souther, 1967).

Lower and Middle Triassic clastic sedimentary rocks so far have not yet been adequately named; they may in places exceed 2,000 feet (600 m.) in thickness (Souther, pers. comm., 1970).

Hazelton Group

The Hazelton Group incorporates volcanic and sedimentary rocks ranging in age from Early Jurassic (Sinemurian) to Late Jurassic (Kimmeridgian) age (Tipper, pers. comm., 1970). The Lower Jurassic rocks of the Hazelton Group have nowhere been found in stratigraphic continuity with Takla Group rocks. An erosional hiatus between Triassic and Lower Jurassic rocks such as described by Frebold and Tipper (1970) from Ashcroft map-area, south-central British Columbia, may also exist in north-central British Columbia.

Nomenclature of Hazelton rocks, particularly those units in and around the Upper Jurassic Bowser Basin is under review. The Bowser Basin constitutes an extensive area of marine clastic sedimentation with possible intercalations of fluvial deposits. The sedimentary rocks of Bowser Basin have previously been referred to as Bowser Group (Duffell and Souther, 1964, pp. 27-33), but sedimentary rocks of Late Jurassic age have been found interbedded with volcanic flows and tuffs along the margins of the basin (Tipper, pers. comm., 1970). Tipper therefore suggests that the sedimentary rocks of the Bowser Basin be retained in the Hazelton Group. A re-examination of faunas from the northern part of the Bowser Basin (Geol. Surv. Can., 1957) by J.A. Jeletzky, H. Frebold, and H.W. Tipper (pers. comm.) suggest an Oxfordian to Early Kimmeridgian age for most of the basin fill. Therefore in this report the Upper Jurassic sedimentary rocks of the Bowser Basin will be referred to informally as "Bowser" conglomerate, greywacke, or shale without fixing stratigraphic rank in terms of group or formation.

The stratigraphic status of Lower Cretaceous volcanics (Brian Boru Formation of Sutherland Brown, 1960) and of Lower Cretaceous sedimentary rocks in the lower Skeena Valley has not yet been finalized.

Omineca Intrusions

Plutonic complexes of great dimensions have invaded Takla-Hazelton rocks and older stratigraphic units of the Omineca Geanticline (Lord, 1948; Armstrong, 1949; Roots, 1954). By analogy with the Cassiar Intrusions to the northwest it seems probable that episodes of plutonic activity occurred throughout the interval between Late Triassic and Early Tertiary time but that most of the Omineca Intrusions were emplaced in Early to Mid-Cretaceous time (Gabrielse, 1967, Fig. 15, and Gabrielse, pers. comm., 1970).

STRATIGRAPHY

Mapping in the Toodoggone map-area has shown that the Sustut Group can be divided into two formations (Eisbacher, 1970). Although facies changes do occur, these subdivisions can be correlated with previously mapped Sustut Group rocks in the adjacent McConnell Creek map-area (Lord, 1948). The basis of the subdivision is the presence of white to greenish grey weathering silicic tuffs in the upper part of the Sustut Group. In the Toodoggone map-area the first occurrence of tuffs is accompanied by an equally abrupt appearance of poorly sorted cobble conglomerate. In the McConnell Creek area similar cobble conglomerates appear locally below the first occurrence of the silicic tuffs. Nonetheless, it was found useful in mapping structure within the Sustut Group to separate the upper tuffaceous light weathering part of the section from the darker weathering lower part. The names Tango Creek and Brothers Peak are proposed for the lower and upper formations of the Sustut Group, respectively.

Tango Creek Formation

Definition

The Tango Creek Formation constitutes the lower unit of the Sustut Group. The base of the Tango Creek Formation is the unconformable or disconformable contact with older rocks and is characterized by basal conglomerate or grit, overlain by interlayered sandstone, siltstone, and mudstone, and occasional conglomerate. In its upper part it consists mainly of dark grey carbonaceous mudstone. Its top is defined by the base of the Brothers Peak Formation (see below). In Toodoggone area the Tango Creek Formation overlies unconformably conglomerate, greywacke, and shale of the Bowser Basin to the southwest. The basal contact to the northeast has not yet been examined. Within the Toodoggone map-area the unconformity between Tango Creek Formation and the underlying Bowser Basin rocks is exposed at two localities: (a) 3 miles (4.8 km.) north of Kitchener Lake, and (b) 2 miles (3.2 km.) due east of the headwaters of Tango Creek, 6 miles (9.6 km.) southwest of Laslui Lake.

Distribution and contact relations

The Tango Creek Formation occupies a northwesterly trending belt about 5 miles (8 km.) wide between Laslui Lake and Thutade Lake. Along most of this belt the Tango Creek Formation has undergone intense folding and thrusting. Except for the two areas where an unconformity exists the Tango Creek Formation has been overridden by rocks of the Bowser Basin and its base cannot be seen.. The northeastern contact of this belt is marked by a monoclinal ridge (Kitchener Monocline) of basal Brothers Peak conglomerate. Towards the south the Tango Creek Formation can be traced into McConnell Creek area where it unconformably rests on Takla-Hazelton Group rocks (Eisbacher, 1971).

Figure 2. Unconformity between Bowser Basin rocks and Tango Creek Formation near Tango Creek, looking to the southeast (GSC Photo 201551).

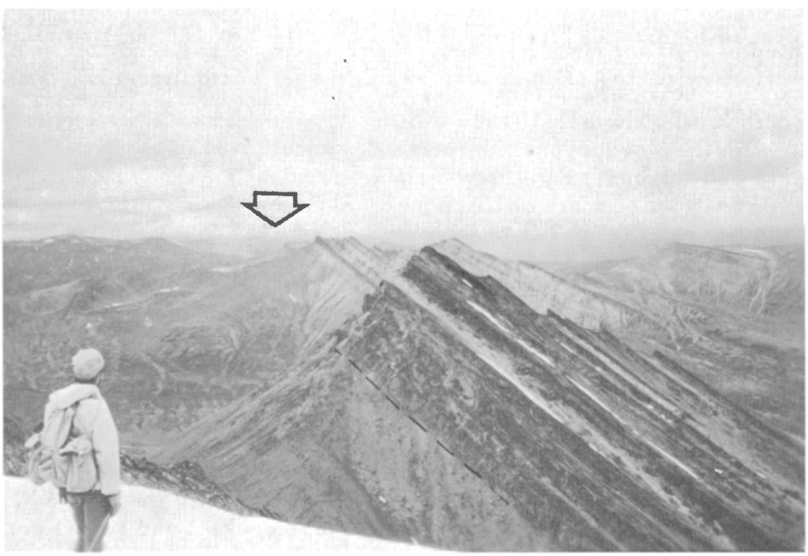


Figure 3. Base of Brothers Peak Formation at Brothers Peaks. View along trend of Kitchener Monocline to the northwest. Light bands of tuffs are interlayered with massive conglomerate units (GSC Photo 201551-C).

Type section

A structurally undisturbed, completely exposed section of the Tango Creek Formation has not been found between Laslui Lake and Thutade Lake, but a complete section, cut only by one minor thrust fault, is well exposed on the ridge due east of Tango Creek, 6 miles (9.6 km.) southeast of Laslui Lake (Fig. 1a). The simplicity of the structural break makes it possible to recognize the same stratigraphic intervals on both sides of the thrust and to connect the measured sections as shown on Figure 1c. In its type section the Tango Creek Formation overlies chert-pebble conglomerate of the Bowser Basin. The angular unconformity between the chert-pebble conglomerate and the basal Tango Creek grit-conglomerate grit is only a few degrees at the base of the type section but seems greater where other parts of the underlying structures are overlapped (Fig. 2). The basal conglomerate of the type section is very thin and contains mainly pebbles derived from volcanic rocks and chert. It is overlain by buff to light grey, commonly pink weathering, very coarse to fine-grained sandstones, which are internally cross-stratified or parallel laminated, generally grading into light brown siltstones and dark grey, green or red mudstones in a rhythmic pattern. A very conspicuous feature within the lower Tango Creek are intervals of pure, white quartz-cobble conglomerate which are internally channelled by numerous thin lenses of brown weathering quartzose sandstone. The bulk of the cobbles are rounded and are derived from pure crossbedded white to pinkish quartz arenites. The only possible source area for these cobbles is the belt of Lower Cambrian quartzites of the Cordilleran miogeosyncline. A sedimentological interpretation of these conglomerate intervals is attempted below.

The upper Tango Creek Formation consists of dark grey mudstones, interrupted by calcareous siltstones, concretions, occasional thick channels of concretionary pebbly sandstones, and thin coal seams (generally less than 10 cm. thick).

Thickness

In its type section the Tango Creek Formation is 4,400 feet (1,350 m.) thick (Fig. 1c). Sixteen miles (25.6 km.) due southeast from the type area a composite section of Tango Creek Formation of 4,000 feet (1,230 m.) was measured.

Age and correlation

Mapping in McConnell Creek map-area by the author established that part of the Sustut Group there can be correlated with the Tango Creek Formation of the Toodoggone area. From these rocks Lord (1948) collected a flora which was found by W.A. Bell to have a possible age range from Cenomanian to Turonian. The collections were made in the lower Tango Creek Formation.

On this basis a tentative Late Cretaceous age is suggested for the Tango Creek Formation of the Toodoggone map-area.

Brothers Peak Formation

Definition

The Brothers Peak Formation constitutes the upper unit of the Sustut Group. Its lower contact is defined as the base of the conglomerate or conglomeratic sandstone bed below the first tuff horizon. The boundary thus defined can be mapped in the Toodoggone and McConnell Creek map-areas over a distance of 100 miles (160 km.).

The Brothers Peak Formation makes up most of the flat-lying central part of the Sustut outcrop in the Toodoggone map-area. The basal Brothers Peak conglomerate forms a distinct hogback along a northwesterly trending monocline (Kitchener Monocline) which separates intensely deformed Tango Creek Formation from gently folded to flat-lying Brothers Peak to the northeast (Fig. 3). No distinct angular unconformity could be recognized between Tango Creek Formation and Brothers Peak Formation although vigorous channelling of conglomerate into underlying mudstones can be seen at several localities.

Type section

A structurally uninterrupted, completely exposed section of Brothers Peak Formation exists south of Brothers Lake where a type section was measured from Brothers Peak eastwards (Fig. 1a).

In the type section the basal Brothers Peak Formation consists of 1,150 feet of polymictic cobble conglomerate, conglomeratic sandstone, and silicic tuff sheets. The conglomerate is thick bedded, shows large scale crossbedding, and is generally poorly sorted. The basal surfaces of many conglomerate beds show flute-like ridges up to several centimetres in amplitude indicating that the clastic material was deposited on poorly consolidated tuffaceous muds and silts. Conglomerate clasts are predominantly derived from andesitic volcanics, siliceous argillite, chert, quartz veins, and granite and are generally subrounded. The silicic tuff horizons are composite sheets of parallel or crosslaminated very fine grained volcanoclastics, which probably represent airborne products of explosive volcanism. Composite sheets are as much as 20 metres thick, individual units commonly exceed 2 metres in thickness. In its upper part the Brothers Peak Formation is characterized by a succession of pebbly, concretionary sandstones, occasional conglomeratic sandstones, tuffaceous or carbonaceous mudstone, silicic tuff beds, and thin seams of coal.

Thickness

In the type section area the Brothers Peak Formation is 3,200 feet (960 m.) thick (Fig. 1c). Elsewhere the thickness could vary considerably due to thinning or thickening of the basal conglomerate. Near Thutade Lake the Brothers Peak Formation is approximately 1,500 feet (500 m.) thick.

Age and correlation

Lord (1948) made three collections of fossil plants in tuffs of Brothers Peak Formation near Thutade Lake. W.A. Bell suggested a Paleocene age for this flora.

Two samples of tuffs from the Brothers Peak Formation were submitted to the Geochronology Section of the Geological Survey for whole rock age determination. One of the samples (GSC K-Ar 1798) represents the lowest exposed tuff band near the bend of Thutade Lake (Mount Jorgensen section) and yielded an age of 53 ± 6 m.y. The second sample (GSC K-Ar 1797) was collected 1,475 feet above the base of the Brothers Peak Formation 3 miles south of Stikine River and 3 miles west of Chapea Lake, and yielded an age of 49 ± 5 m.y.

It is therefore suggested that the Brothers Peak Formation is mainly of Eocene age, although a Late Paleocene age is possible for the basal part.

SANDSTONE COMPOSITION

To gain an idea about detrital mode and possibly source areas of Sustut sandstones in the Toodoggone area, modal analysis was carried out for 40 thin sections. These sections can be identified as belonging to rocks of the lower or upper Tango Creek Formation, or the lower (conglomeratic) and upper Brothers Peak Formation.

Dickinson (1970) recently discussed classification of subquartzose sandstones and advised a flexible approach in the classification of sandstones which fit the classic concepts of arkose, greywacke, or lithic arenites. For the present preliminary interpretation three parameters were chosen as useful corner-points for triangular presentation: Q (quartz, quartzite fragments), F (feldspar), RM (volcanic and argillaceous rock fragments, chert, phyllosilicate matrix). The reason for grouping chert with the parameter RM rather than with Q, as is done conventionally, derives from the fact that within the basin framework of the Sustut Group chert is intricately associated with volcanic rocks (Cache Creek Group, Asitka Group), but not at all with highly quartzose Proterozoic and lower Paleozoic miogeosynclinal rocks of the Omineca Geanticline.

All sandstones analyzed are characterized by subangular to subrounded grains, and fall into the category of subquartzose (less than 75% Q), lithic to feldspatholithic sandstones. Thus they represent an original sand of low compositional stability and textural immaturity (Dott, 1964).

The triangular compositional plots for lower and upper Tango Creek Formation, lower and upper Brothers Peak Formation are shown in Figure 1b (B) alongside a generalized section of the Sustut Group in the Toodoggone area.

The most conspicuous feature in this diagram is the relative high quartz content of the lower Tango Creek Formation, and a relative increase of feldspar in the lower Brothers Peak compared with sandstones below and above. The variation in quartz content probably reflects a distinct drainage differentiation during the initial stages of uplift in the Omineca Geanticline. The most likely source for both the pure quartzite pebble conglomerate and the bulk of quartz grains in lower Tango Creek sandstones are Proterozoic and Lower Cambrian clastic sedimentary rocks of the Omineca Geanticline.

The relative increase of feldspar within the lower Brothers Peak Formation is probably due to the onset of volcanism.

The background of volcanic rock fragments, feldspar, and chert was supplied from areas occupied by the Omineca intrusions, the Takla-Hazelton volcanics, and Cache Creek chert.

The content of chert in the section varies from 0.7 to 20.6 per cent. Figure 1b (C) shows range and average of chert content for the chosen intervals. If differentiated according to stratigraphic level an interesting pattern emerges: the thick sandstone units that are interbedded with mudstone of the upper Tango Creek Formation mark the sudden appearance of chert as a significant detrital constituent.

The decrease in quartz and increase in chert probably reflects the elevation of the Cache Creek Group and/or Bowser Basin chert-pebble conglomerate to a significant level of erosion. At the same time the major source of quartz in the eastern part of the Omineca Geanticline must have been eliminated (see Fig. 1a). This change of source area is also reflected by a change of paleocurrents during deposition of the upper Tango Creek Formation (see below).

PALEOCURRENTS

Sandstones and conglomerates of the Sustut Group are commonly crossbedded and orientation of forests within cross-stratified units was recorded wherever possible. Some conglomerates also have imbricated pebble layers and imbrication planes were measured in those.

The crossbedding types found in Sustut Group rocks include tabular or trough cross stratification, and ripple drift cross lamination. Measurements from the area between Kitchener Lake and Laslui Lake (including the type sections of Tango Creek and Brothers Peak Formation) are plotted on Figure 1b (D) with respect to the stratigraphic level at which they occur. A vectorial mean has been derived from the paleocurrent rose by the technique described in Curray (1956).

It can be seen from Figure 1b that pronounced changes in the direction of paleocurrents took place during deposition of the Sustut Group in this area.

The mean vector of the paleocurrents in the lower Tango Creek Formation points to the south-southwest. This confirms direction of transport as indicated by quartzite pebble conglomerates which must have been eroded from Lower Cambrian quartzite terrain exposed to the northeast within the Omineca Geanticline. During the upper Tango Creek interval pebbly sandstones were deposited by currents which flowed to the northeast, an almost diametrically opposite direction. As pointed out above, this change is accompanied by a marked increase in the chert content of the sandstones. The highly tuffaceous lower Brothers Peak conglomerate was deposited by strong easterly directed currents. The upper Brothers Peak Formation indicates paleocurrents to the south-southeast, very similar to those in the lower Tango Creek.

These changes of paleocurrent trends in the vertical profile suggest that progradation of detrital deposition was caused by shifting centres of uplift within the basin framework.

More data must be collected to understand evolution and overlap of individual detrital fans within the Sustut Basin.

SIGNIFICANCE OF TUFFS IN THE BROTHERS PEAK FORMATION

A distinct belt of high level leucogranite-quartz monzonite bodies with K-Ar ages clustering about 40-50 m.y. has been reported by Hutchison (1970) for the northeastern border of the Coast Crystalline Complex. High level plutons of this type are known to be closely related spatially to volcanics of the Lower Tertiary Sloko Group (Souther, 1967).

Similar young plutons are known from the Cassiar Geanticline (Gabrielse, 1967).

These young acidic plutons within the Coast and Cassiar-Omineca Geanticline therefore appear to be a natural source for the extensive tuff sheets within the Brothers Peak Formation. An explosive nature of eruption may account for scarcity or absence of rhyolitic flows in this part of the Cordillera.

The chemical composition of three tuff samples from the Brothers Peak Formation is shown in Table 1.

TABLE 1*

	1**	2**	3***
SiO_2	73.0	69.5	69.1
Al_2O_3	12.1	13.7	14.3
Fe_2O_3	0.1	0.9	0.6
FeO	0.9	1.0	1.0
CaO	1.8	2.7	3.2
MgO	1.0	0.5	1.1
Na_2O	0.8	1.1	1.7
K_2O	3.1	3.4	2.5
H_2O	5.7	6.0	6.1
TiO_2	0.25	0.25	0.24
P_2O_5	0.02	0.05	0.06
MnO	0.03	0.02	0.03
Total	98.9	99.3	100.0

* Analysis by Analytical Chemistry Section, Geological Survey of Canada.
** Tuffs exposed south of Stikine River at 57°19'N, 127°40'W.
*** Tuffs exposed at the knee of Thutade Lake at 56°54'N, 126°56'W.

ENVIRONMENT OF DEPOSITION

Any vertical profile in sedimentary rocks can be interpreted as a lateral succession of depositional environments (Visher, 1965b). Such an interpretation is attempted for the type area of the Tango Creek Formation and the Brothers Peak Formation; observations made in neighbouring areas have been considered for this purpose. The sections illustrated in Figure 1c can be interpreted on the basis of (a) repetition of sedimentary units, (b) grain size, (c) sedimentary structures, (d) geometry of sandstone bodies and (e) carbonaceous material.

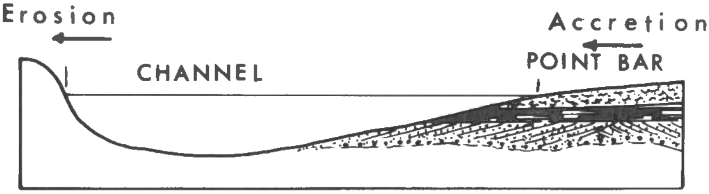
Tango Creek Formation

The basal Tango Creek Formation is characterized by lenses or tabular bodies of conglomerate of limited lateral extent. Accordingly, clast composition varies widely. The thickness of this basal member rarely exceeds 150 feet (50 m.) and commonly is represented by a thin grit horizon or is absent altogether. Internal channelling, crossbedding, and a lack of lateral persistence of individual conglomerate and sandstone bodies suggest an environment of high gradient braided streams flowing in valleys with relief probably not exceeding 150 feet. The distinct clast composition of this basal member suggests that the fluvial gravels were deposited on a pediment not far from the source area. The individual streams emerging from the source area must have coalesced farther downstream, progressively losing their distinctive bedload.

The section above the base contains many repetitions of grit, coarse- to medium-grained crossbedded sandstones, parallel laminated fine-grained sandstones, siltstones, and green, red, or dark grey mudstones. Many of the sandstone beds are laterally quite extensive and contain concretions. The sandstones are interpreted as point bar deposits of laterally accreting, meandering streams which flowed on an open alluvial plain; fine-grained sandstones and siltstones contain abundant plant fragments and probably represent overbank deposits of the same river system.

This part of the section is occasionally interrupted by pure quartz-pebble conglomerates which are exotic within the succession of fining-upward sandstone cycles with respect to the large grain size and internal stratification characteristics. These units are intensely channelled and cobble lenses are rapidly replaced by sandstone stringers both laterally and vertically. The cobble conglomerates are commonly imbricated indicating transport of cobbles by rolling between longitudinal gravel bars. The conglomerate units rarely exceed 100 feet (30 m.) in thickness, and probably represent times of uplift in the source area with progradation of high gradient braided streams onto the low gradient alluvial plain. Previously developed models for recent low gradient meandering streams (Visher, 1965a; Allen, 1965) and high gradient braided streams (Williams and Rust, 1969) seem to strengthen the explanation given above (see Fig. 4).

The uppermost member of the Tango Creek Formation is characterized by dark grey to black carbonaceous mudstones with concretionary layers, brownish weathering calcareous siltstones, and thick beds of pebbly sandstones with conspicuous planar crossbedding. It seems that during this phase



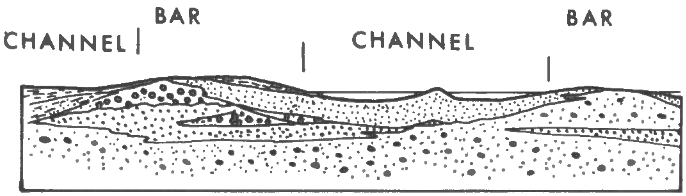


Figure 4. Facies models for recent low-gradient meandering streams and high-gradient braided streams (after Visher, 1965a; Williams and Rust, 1969).

of deposition drainage had become very sluggish and swamps or small lakes were common features of the alluvial plain; incoming rivers quickly deposited their sediment load in lateral bars and small deltas.

Brothers Peak Formation

The sudden appearance of the conglomeratic member of the Brothers Peak Formation and similar conglomerates in the upper parts of the Tango Creek Formation near Thutade Lake indicates that tectonic movements intensified within source area and basin. Massive bedding, poor rounding and sorting suggest an environment of alluvial fans spreading from nearby source areas into swamps and lakes. These standing bodies of water allowed the preservation of numerous sheets of airborne tuffs within an environment of vigorous alluvial fan deposition. Many of the tuffs show ripple lamination, indicating that weak currents were unable to carry the load of suspended tuffaceous material which was being added rapidly from the air (McKee, 1965).

Continued erosion in the source area caused a recession of the alluvial fan heads, accompanied by a progressive reduction of grain size in the vertical profile (Fig. 1c). Swamps and small lakes were filled by prograding streams and ash falls. The sandstone lenses of the upper Brothers Peak Formation show very limited lateral extent, probably because of temporary choking and frequent relocation of stream beds during heavy ash falls.

TECTONIC INTERPRETATION OF THE SEDIMENTARY HISTORY

Uplift within the Omineca Geanticline in Cretaceous time exposed a plutonic terrain and quartz veins related to the Omineca intrusions, silicic volcanics and chert of the Asitka Group, andesite and siliceous argillite of the Takla Group, chert of the Cache Creek Group, and quartzite of the Lower

Cambrian miogeosynclinal sedimentary succession. These rocks and rocks of the Upper Jurassic Bowser Basin are now partly covered by Sustut Group but had been deformed previous to deposition of the Sustut Group (Eisbacher, 1971). During sedimentation of the Sustut Group, folds and faults continued to grow but along slightly different trends, thus constricting parts of the basin. Uplift and deformation outlasted deposition and terminated sedimentation of the Sustut Group. Thus initial widening of the basin by sourceward erosion was followed by progressive constriction of the drainage along the basin margin. This evolutionary pattern is known from graben type deposits such as those of the Rhinegraben (Illies, 1967), and the Baikal Graben (Florensov, 1969), and could be partly due to the effect of sedimentary loading.

ECONOMIC POTENTIAL

The importance of fluviatile sandstones as host-rocks for uranium mineralization has been widely recognized (Harshman, 1968). The prerequisite for this type of deposit is a favourable source rock (granite of silicic tuff) from which uranium is leached and transported in groundwater solution down the regional dip. Deposition seems to be controlled by the intricacies of permeability barriers in sandstone-mudstone successions and the presence of organic matter in the form of plant debris. With these points in mind it seems that the central, flat-lying part of the Sustut Basin could be a favourable area for uranium exploration.

The coal seams observed in Sustut Group rocks of the Toodoggone map-area are very thin and probably not economic.

The succession of distinct detrital fans within the Sustut Basin, as inferred from paleocurrent directions and modal analyses, indicates stripping of different source areas at different times. It is therefore possible that individual fans also contain distinctly enriched suites of economically important minerals (e.g. gold, silver, copper, platinum, tungsten, tin).

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