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Granduc

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STEWART COMPLEX

Northwest, British Columbia

By E. W. Grove

This study presents new data on the geology of this region, much of which is relevant to the tectonic evolution of the Western Cordillera and to the concept of metallogenesis in northwestern British Columbia.

Most of the writer's geological work in the Stewart Complex has been of a detailed nature, mainly involving the relationships between mineral deposits, geological structures, and lithology. The results, presented here are based on original work which involved the geological mapping of an area of about 3,500 square miles, most of which was completely unknown, or at the best poorly known. The writer's discussion of the economic geology of the area represents original contributions based on detailed studies of the major mineral deposits.

The Unuk River-Salmon River-Anyox map-area includes part of the eastern contact of the Coast Plutonic Complex with the west central margin of the successor Bowser Basin. Geologically, geographically and economically the country rocks of the area form a well defined entity that the writer has called the Stewart Complex. Sedimentary, volcanic and metamorphic rocks bordering the Coast Plutonic Complex, range in age from Middle Triassic to Quaternary. The detailed stratigraphy of the entire area is not completely known, principally because of the extensive icefields, poor accessibility, and the complex nature of the Mesozoic succession.

Within the Stewart Complex, Upper Triassic rocks are found only along the Iskut-Unuk River section. The Upper Triassic strata which include diagnostic fossil assemblages, are predominantly green epiclastic volcanic units. These include volcanic breccias, marbles, sandstones, and siltstones which form prominent horizons near the top of the sequence. The known Triassic succession in this area has an approximate thickness of at least 3,000 feet.

Triassic rocks are overlain in the area by the Jurassic Hazelton Group composed of sedimentary, volcanic and green epiclastic volcanic rocks. The contact with the Triassic rocks varies from place to place, generally exhibiting a disconformable to unconformable relationship. The Hazelton Group includes all the Jurassic rocks in the area. It is divisible into four major lithostratigraphic divisions represented by one Early Jurassic, two Middle Jurassic, and one Late Jurassic formation. The Lower Hazelton appears to be a predominantly volcaniclastic sequence marked by extensive pillow volcanic members as well as widespread thin marble lenses. The thick Triassic and Lower Jurassic Hazelton sequences are lithologically monotonous and similar and hence difficult to separate without structural and fossil information. The lower Middle Hazelton unit has been traced from the Unuk River to Alice Arm and forms one of the few easily recognizable stratigraphic units in the Stewart Complex, and may represent the most prominent Jurassic unit within the Bowser Basin. These rocks generally overlie the Lower Hazelton and Triassic with angular discordance. The lower Middle Jurassic unit, which has been named the Betty Creek Formation, consists of a thick succession of red and green epiclastic volcanics resting unconformably on Lower Jurassic and older rocks, and is in turn overlain by the Middle Jurassic Salmon River Formation.

In the Stewart Complex, the Betty Creek Formation is overlain conformably to disconformably by the mainly marine, thinly bedded Salmon River Formation which includes siltstones, greywackes and minor volcanic units. The Salmon River Formation is in turn overlain by the marine Nass Formation which forms the bulk of the surficial strata in the western Bowser Basin. Elsewhere in the Bowser Basin the Nass Formation and its equivalents are overlain by significant thicknesses of marine-continental sedimentary formations of Cretaceous or Tertiary age called the Skeena Group. These rocks have not been positively identified in the western part of the basin near Stewart.

Small Quaternary volcanic piles and flows are scattered throughout the Stewart Complex but are areally insignificant compared to those found in the northern part of the Bowser Basin.

Along the west side of the study area the structure is dominated by the Coast Plutonic Complex. The plutons of this extensive belt are known to include Middle Jurassic and Tertiary intrusions. Within the map-area granodiorite is the dominant rock type of the major intrusions which are flanked by numerous smaller satellite diapiric and tadpole-like plutons named the Skeena Intrusions. They include a large variety of rock types and appear to range in age from Late Triassic to Tertiary. Some of the most extensive dyke systems known in the western Cordillera are prominent features in the Stewart Complex and range in age from Jurassic to Tertiary.

Along the undulating main contact of the Coast Plutonic Complex a number of prominent reentrants are marked by the presence of gneisses, migmatites, and some pegmatites.

Deformational metamorphism is important and is found expressed as cataclasite and shear zones largely restricted to competent Triassic and Lower Jurassic rocks. Extensive weathered alteration zones generally related to the shear zones are areally prominent. The Stewart Complex is one of several areas along the margin of the Bowser Basin that is noted for many sulphide mineral deposits and is responsible for a major part of the mineral production of the Western Canadian Cordillera.

Hazelton Group

The Hazelton Group in the Stewart Complex includes, in ascending order, the Unuk River Formation, the Betty Creek Formation, the Salmon River Formation, and the Nass Formation. The assemblage includes ubiquitous clastic sedimentary units intimately intercalated with volcanic flows, epiclastic volcanic rocks, pyroclastic rocks, and interbedded limestones. The rocks are predominantly andesitic or derived from andesitic flows. The Unuk River Formation is a thick accumulation of thick-bedded epiclastic volcanic conglomerates, sandstones, marine siltstones, pillow lavas, and carbonate lenses. The Unuk River Formation is overlain unconformably by three primarily sedimentary units. The Betty Creek Formation is a well bedded unit which comprises red and green volcanic breccias, conglomerates, and sandstone, and includes andesitic flows and pillow lavas. It is overlain with general conformity by a thin bedded, colour striped, marine siltstone and greywacke unit called the Salmon River Formation. The uppermost unit, the Nass Formation, is again a dominantly thin bedded, colour banded unit much like the Salmon River Formation upon which it rests disconformably. Very generally, the Hazelton Group can be described as a unit which includes a variety of discrete rock strata of different aspect, extent and uniformity. The most widespread characteristics, essentially universal to the assemblage, are the general intermediate or andesitic composition of the various units, the commonly fresh nature of the primary rock components, and the clastic texture of the sedimentary members. These features have been obscured in many places within the Stewart Complex by polyphase plutonism, metamorphism, alteration and widespread mineralization.

The evidence indicates that the Lower Jurassic of the Stewart Complex, in part represented by a great thickness and variety of volcanics, was in contrast to the rest of the Western Cordillera, an area of relative stability. It follows that the successor Bowser Basin, which the writer has suggested was initiated at the close of Late Triassic, received a significant supply of detritus throughout most of the Lower Jurassic epoch from the extensive volcanic highland situated along the Coast Geanticline.

The fossil collections from the Betty Creek Formation contain abundant triginoid pelecypods, as well as indeterminate fragments of other thick shelled pelecypods which indicate a near-shore environment. The presence of scattered, metamorphosed coaly material throughout the clastic section also indicates intermittent shallow, perhaps brackish marine conditions. The suggested configuration of isolated volcanic centres surrounded and buried in their own debris, indicates emergent shield-like volcanic areas shedding debris into broad shallow basins and occasionally venting pillow lavas along the margins from emergent or shallow submarine vents during the late stage eruptive phases.

The main Salmon River sequence appears to represent accumulation in a rapidly subsiding marine basin. Local concentrations of near-shore fossils, including fossil logs in the littoral deposits, suggests the presence of marine, brackish and fresh water units as part of a repeated transitional sequence. The presence of extensive rhyolite flows at the base of the formation suggest shallow or even emergent extrusion of the rhyolite member with concomitant sedimentation.

In this area the writer has subdivided the eastern margin of the Coast Plutonic Complex into a number of intrusive phases. These include: the Texas Creek pluton of probable Middle Jurassic age; the Hyder pluton and related bodies of Tertiary age; and an undivided group comprising part of the Central Gneiss Complex.

The evidence presented here clearly shows that the eastern margin of the Coast Plutonic Complex includes dykes, stocks, and batholiths of probable Middle Jurassic age. These plutons are generally granodiorite in composition and include gradational phases of quartz diorite, and are commonly similar in general aspect to the more extensive Tertiary plutons.

Central Gneiss Complex

Metamorphic rocks are concentrated in three areas, at the margin of the Stewart Complex, along the east contact of the Tertiary Hyder pluton, and west of the complex in the relatively unknown Alaska section. The bulk of the metamorphic rocks in association with the Tertiary plutons constitute the eastern margin of the Coast Plutonic Complex. Within the complex the metamorphic rocks include mixed, banded gneiss, migmatite and minor gneissic plutonic rocks.

The writer has mapped and studied one of the most extensive concentrations of satellite plutons known along the eastern margin of the Coast Plutonic Complex. The length of the belt between Alice Arm and the Iskut River is about 110 miles, and the width, which varies from 10 to 25 miles, has its maximum in the Unuk River area, and the minimum at Alice Arm. The satellite belt parallels the margin of the north-northwesterly margin of the Coast Plutonic Complex transecting the northerly grain of the country rocks. Many of the individual plutons are semi-concordant, whereas major dyke swarms trend northwesterly and northeasterly and are strongly discordant with the local fabric. The plutons which range in age from Late Triassic to Late Tertiary have a wide range of rock compositions, from gabbro through syenite, diorite, quartz diorite, granodiorite, to quartz monzonite.

One of the outstanding geologic features of the Stewart Complex is the extensive array of dykes and dyke swarms. In order to present this vast assemblage of plutons, the writer has grouped the dykes on the basis of comparable composition, texture, and relative age. Many of the dykes are grouped naturally as swarms which exhibit certain characteristics presumed to be typical of the swarm. The dykes and dyke swarms show dominant northwesterly and northeasterly trends, and several of the groups appear to follow at least two directions. The number of dykes in the area is unknown but they probably form up to 10 per cent of the rock in the area, but of more importance is the apparent localization of dyke swarms in mineralized areas and the presence of mineral deposits in dykes.

Cataclasites and Schists

Four major cataclasite zones have been mapped in the Stewart Complex. These include the South Unuk, Cascade Creek, Bear River, and Maple Bay zones which all trend northerly across Lower Jurassic country rocks, and are partially obscured by overlying Middle Jurassic strata, and have been partially destroyed by Tertiary intrusions. These zones have been recognized by the writer, and are briefly described here as a group for the first time. All of these zones include significant mineral deposits, and are important to the understanding of tectonics and metallogenesis in the Stewart Complex. The most extensive of these zones, the Unuk River, includes the massive sulphide deposits of the Granduc mine.

The extensive and important cataclasites, mylonites, and schists have been derived from pre-existing sedimentary and volcanic country rocks. Abundant relict textures still evident in spite of dynamothermal metamorphism leave little doubt as to their origin. Surface weathering and limited recrystallization have locally obscured the diagnostic features and have led, in the past, to various erroneous identifications which have stressed a simple sedimentary or volcanic origin and have disregarded metamorphism.

The differential movements that produced the cataclasite zones appear to have been related to a single pre-, or early Middle Jurassic tectonic event. Temporal and spatial relations between the Cascade Creek zone and the Middle Jurassic (or older) Texas Creek pluton as well as the marked northerly alignment of pre-Middle Jurassic satellite plutons suggests that deformation preceded extensive plutonism.

The relative position of the idealized tectonic elements involved in the general area include the Wrangell-Revillagigedo Metamorphic Belt, the Coast Plutonic Complex, and the Bowser Basin. The Bear River Uplift involves part of the Whitehorse Trough as well as part of the Bowser Basin and includes such minor elements as the Stewart Complex, Oweegee Dome, and Ritchie Anticline. The terms Bear River Uplift, Stewart Complex, and Meziadin Hinge have been introduced by the writer in order to describe these structural elements within the larger concept of the regional framework.

The Stewart Complex is bounded on the west by the intrusive margin of the Coast Plutonic Complex, and on the south, east, and north by high angle normal faults which are major regional tectonic features. It appears that the Stewart Complex has been essentially frozen to the east margin of the Coast Plutonic Complex, and has been involved in major uplift along with the Coast Geanticline, whereas the adjacent basin is separated by major normal faults and exhibits a relative depression.

In the area of this study there have been several distinct periods of metamorphism, plutonism, volcanism, and sedimentation, marked by deformation and erosion. The intensity of deformation as expressed by the intraformational relationships has apparently decreased since the mid-Triassic Tahltanian Orogeny, although plutonism as measured by the apparent volume of granitic material increased in apparent activity and reached a climax in the Tertiary.

Structure

Members of the Hazelton Group rocks in the Stewart Complex have been mapped as elongated lenticular masses. In the third dimension they are apparently lenticular as well, and illustrate what can be termed grossly a mackerel structure in which each lens overlaps the others. Weak foliation, minor folds, and some lineations are present to some degree in all the members of the assemblage. It appears that these structures have developed variably throughout the Hazelton Group and that they frequently exhibit a sense of selection based upon rock particle size and competency.

Faulting as defined by loss of cohesion, displacement, or loss of resistance has been recognized as of major importance in the Stewart Complex in regards to simple landscape evolution as well as the complex evolution of the major tectonic units. The bulk of the evidence with respect to folding, faulting and sedimentation clearly indicates that the Bear River Uplift and Stewart Complex in particular, have been subjected to a sequence of tectonic events in which faulting has played a major role in controlling erosion and sedimentation, and a significant role in the development of the complexly folded late Middle and Upper Jurassic Hazelton Group.

In the Stewart Complex, widespread late Lower Jurassic volcanism and sedimentation, assumed here to represent shallow marine conditions, was followed by post-Toarcian folding and plutonism related to regional compression. This was accompanied by cataclastic deformation, metasomatism, and normal faulting, which was followed by regional uplift and extensive erosion.

Tertiary plutons that occur along the margin of the Central Gneiss Belt, and as satellite plutons and dyke swarms east of the margin, followed predominantly northwesterly trends cutting across the northerly trends of the older gneisses, Triassic and Jurassic sediments and volcanics as well as the Mesozoic plutons. Quaternary volcanism has been concentrated along a northerly trending belt that is included in a broad Cenozoic tension zone and along a northeasterly zone outlined by the writer. To the east, extensive Cenozoic volcanism has been largely confined to the margins of the Bowser Basin.

The bulk of the evidence favours the evolution of the Western Cordillera eugeosyncline by continuous plutonism, volcanism, and contemporaneous sedimentation. Early Paleozoic evidence of plutonism in the Coast Plutonic Complex indicates that this feature has evolved along the continental margin accompanied by trough and successor basin development along both flanks. Folding as an expression of directed componental stress has played a minor part in the regional tectonics. Block-like uplifts related to faults and sequential vertical tectonics have responded to, and accompanied motion of the major tectonic units.

Unconformities, between major stratigraphic units as well as within any of the units have been developed because of block-movements along well defined faults, developed in response to regional motion. The mainly Mesozoic Stewart Complex has responded to the development of the Coast Geanticline and finally, as a result of Tertiary plutonism, has been essentially fused to the geanticline with the uplift outlined by faults.

Mineral Deposits

The writer has defined four broad regional copper, gold, silver, and silver-gold zones which include the northerly trending mineral belts. This indicates that the mineral belts which represent map distribution patterns, are in the Stewart Complex at least, not representative of regional mineral deposit patterns. The mineral deposits in the Stewart Complex include a variety of types of various ages, which are exposed as a result of faulting, folding, and erosion. The apparent mineral deposit distribution therefore, merely represents the depth of erosion within various parts of the Stewart Complex.

I. Vein Deposits

(a) fissure veins
(b) replacement veins

II. Massive Sulphide Deposits

(a) stratiform
(b) concordant

III. Porphyry Deposits

The bulk of the mineral deposits in the study area are tabular lenses, pods, and sheets, and stockwork quartz-breccia veins found as fissure fillings in the country rocks and plutons. Gold, silver-gold, and silver bearing sulphide minerals are localized within these tabular quartz-rich bodies as discrete isolated, en echelon, and composite lenticular shoots.

The fissure vein and replacement vein deposits in the Stewart Complex comprise a common group of simple ore and gangue minerals. Wallrock alteration associated with these deposits, is generally simple and cannot be defined as a characteristic of the complex. Secondary enrichment is not significant in any of the deposits, and is generally absent throughout the Stewart Complex. The ore bodies are typically shallow and appear to be related to surface topography, but this feature is in fact related to the general method of mine development and exploration.

The major massive sulphide deposits in the Stewart Complex include the Granduc property at Granduc Mountain, and the Hidden Creek, Double Ed, Redwing, and Bonanza properties at Anyox.

Porphyry deposits include the molybdenum deposit at Kitsault (British Columbia Molybdenum), and the copper-molybdenum property at Mitchell-Sulphurets Creeks.

Table 1. Correlation of rock formations of various investigators

in the Portland Canal area

*Intrusive units not shown (see Fig. 17).

Era	Period and Epoch	McConnell, 1913	Schofield and Hanson, 1922	Hanson, 1929	Buddington, 1929	Hanson, 1935	Grove, 1972*	Period and Epoch	Era
Cenozoic	Quaternary	Superficial deposits	Pleistocene and Recent	Recent and Pleistocene	Pleistocene and Recent	Recent and Pleistocene	Surficial deposits, basalts	Quaternary	Cenozoi
	Tertiary					Tertiary - basaltic lava flows	(Sustut Group)	Tertiary	
Mesozoic		Later diorite porphyry dykes	Lamprophyre dykes Quartz diorite dykes Augite porphyrite stock	Dykes	Coast Range intrusives	Dykes	(Skeena Group)	Upper	Cretaceous
			Coast Range Batholith Premier sills	Coast Range intrusives Augite porphyrite and related intrusives		Coast Range intrusives		Lower	
		Nass Formation	Nass Formation	Nass Formation	Not mapped	Hazelton Group	Nass Formation	Upper	Jurassic
		Bear River Fm.	Salmon River Fm.	Bear River Fm.	Hazelton Group		Salmon River Fm.	Middle	
			Bear River Fm.				Bitter Creek Fm.		
		Bitter Creek Fm.	Not mapped	Bitter Creek Fm.			Unuk River Fm.	Lower	
		Not mapped	Not mapped	Not mapped	Not mapped	Not mapped	Takla Group	Upper	

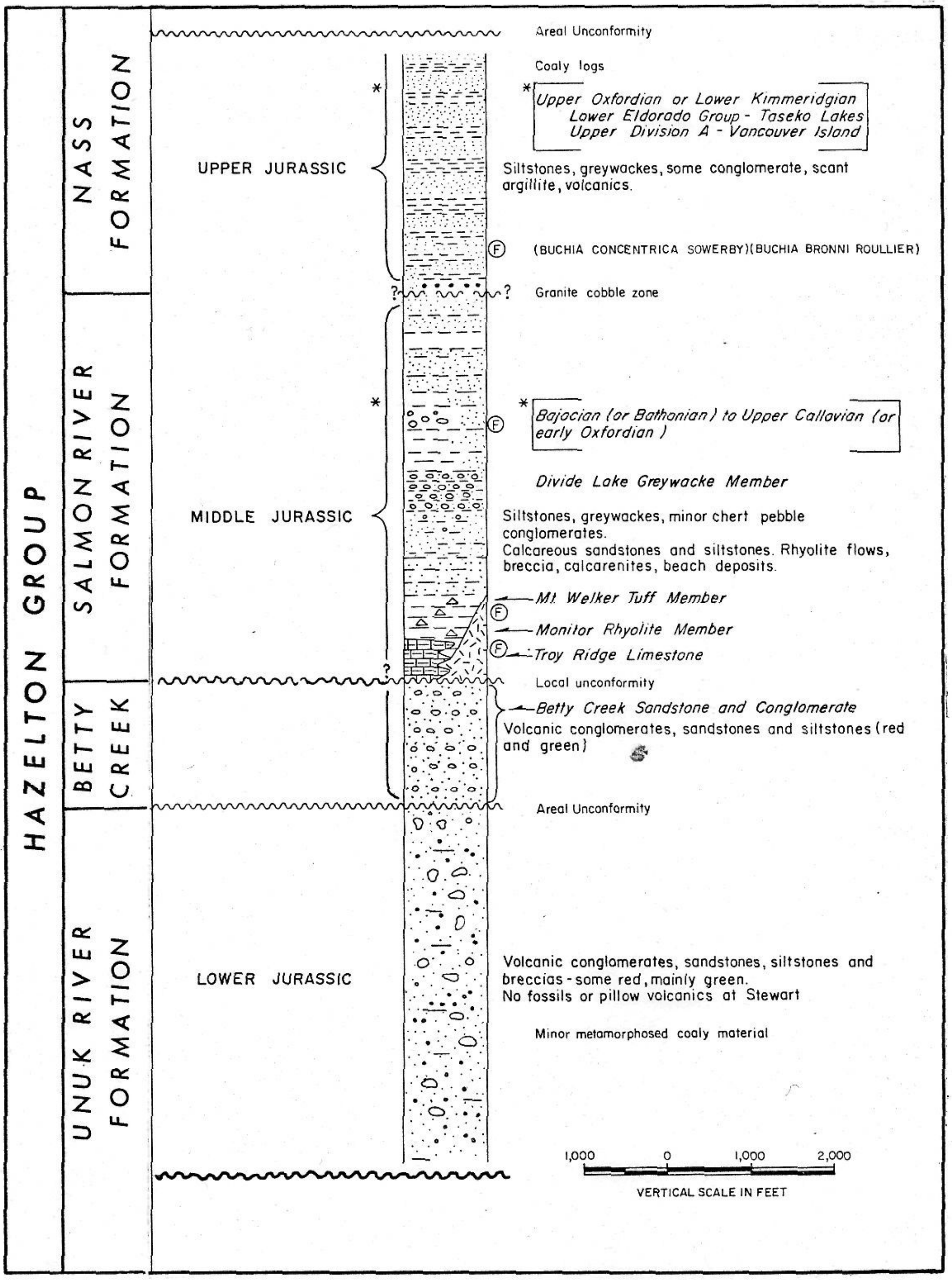

FIG. 11 General stratigraphic column, Stewart area.

Period	Epoch	Tectonic Event	Plutons		Volcanics	Formations	Mineralization.
QUAT.	RECENT TO MIOCENE (1 m.y.)	Uplift & Erosion Faulting ?		Basalt dykes	Flows		
TERTIARY	OLIGOCENE	?		Dykes, Sills			Vein deposits: silver, lead, zinc
	EOCENE-PALEOCENE	Folding & Faulting		Hyder pluton etc. Alice Arm Intusions		(SUSTUT)	vein deposits: silver, lead, zinc porphyry deposits: molybdenite
70							
CRETACEOUS	UPPER	?	?			(SKEENA)	?
	LOWER	? Erosion	?	Satellite plutons			Vein deposits: silver, lead, zinc
130							
JURASSIC	UPPER	Erosion ? Faulting & Folding	?	Satellite plutons		NASS (HAZELTON GROUP)	?
	MIDDLE	Erosion ± Faulting Erosion Faulting		Texas Creek pluton etc. Unuk River Intusions (Satellite plutons)	Rhyolite, and and. pillow lavas; Andesite and basalt flows, pillow lavas	SALMON RIVER; BETTY CREEK (HAZELTON GROUP)	?; Silbak-Premier deposit: gold-silver; Anyox deposits-massive sulphides; Mitchell Creek: hydrothermal dep. chalcopyrite, molybdenite
	LOWER	Erosion Faulting Cataclasis Folding	?	Satellite plutons	Andesites, basalts, and rhyolite flows, pillow lavas	UNUK RIVER FM (HAZELTON GROUP)	Granduc deposit: massive sulphide-chalcopyrite, pyrite pyrrhotite; minor gold-quartz veins
180							
TRIASSIC	UPPER	Erosion Faulting Folding Faulting	?	Satellite plutons	Andesite and basalt flows	TAKLA GRP.	Max deposit: magnetite and chalcopyrite
230		Erosion	?				

FIG. 24 Relationships between plutonism, volcanism, and mineralization, Stewart Complex.

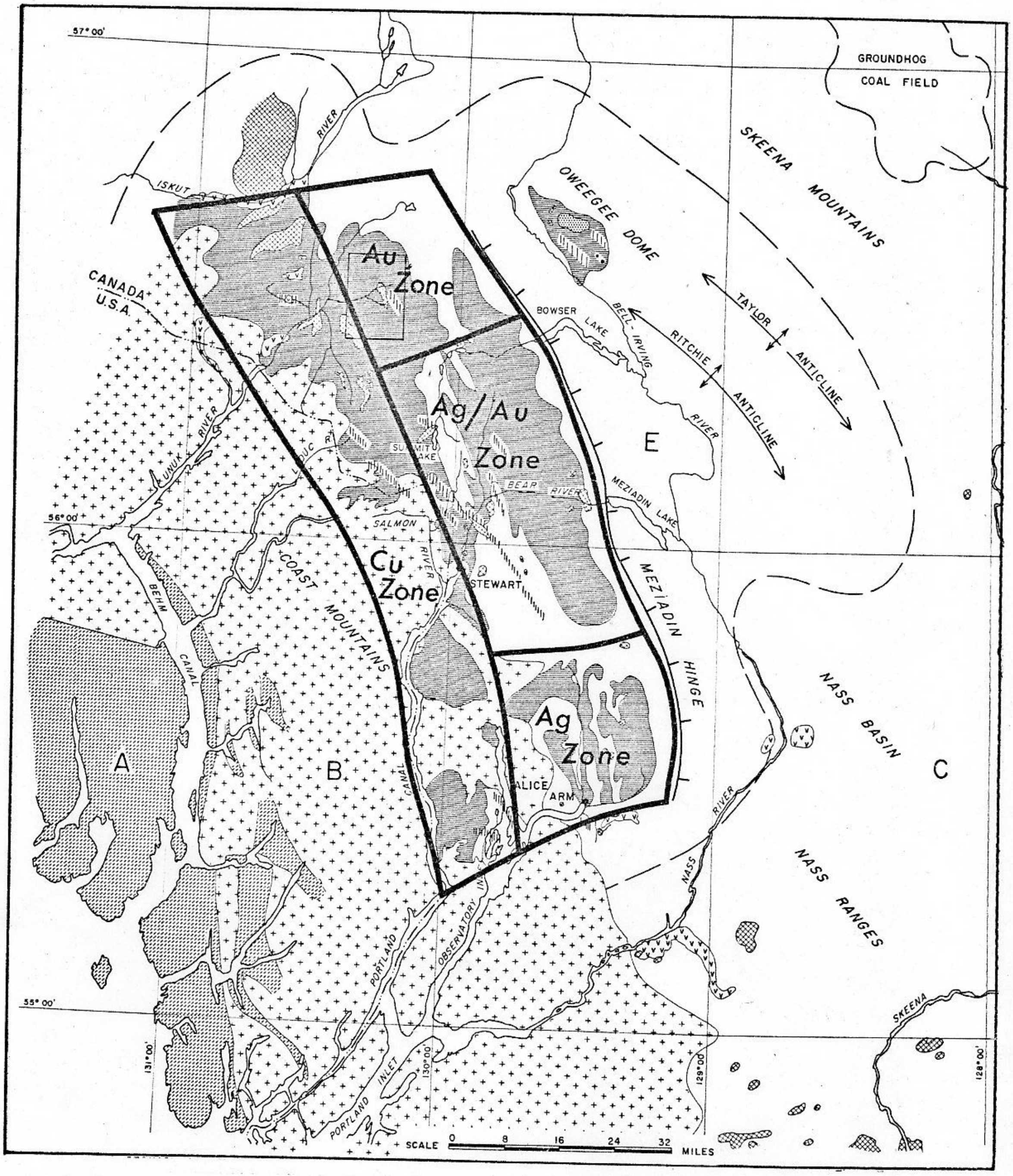

FIG. 23 Metal distribution zone, Stewart Complex.