Tom Schroeter

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SULLIVAN GEOLOGICAL MEETING

Kimberley, BC

November 9, 2001

PROGRAM WITH ABSTRACTS

Technical Session Schedule
Sullivan Geology Meeting, Kimberley, B.C.
Friday November 9, 2001

Chair: John Hamilton, Teck Cominco Limited (ret.)

8:30	Welcome	Jon Collins, V.P. Exploration Business Development, Teck Cominco Ltd.
8:45	Sullivan Waste Bed Sedimentology	Paul Ransom, Consultant
9:15	Some New Perspectives on the Sullivan Deposit	John Lydon, Sr. Research Scientist, Geological Survey of Canada, Ottawa
10:00	Discussion	
10:15	Coffee	
10:30	The History of Geological Work in the Aldridge Formation	Hugh Morris, Chairman, Eldorado Gold Corporation
11:00	Tectonic, Magmatic and Metallogenic History of the Early Synrift Phase of the Purcell Basin, Southeastern British Columbia	Trygve Höy, Project Geologist, B.C. Geol. Survey Branch; Rob Edmunds, Consultant; Doug Anderson, Consultant; Bob Turner, Research Scientist, Geol. Survey of Canada and Craig Leitch, Consultant
11:45	Discussion	
12:00	Lunch hosted by Teck Cominco Ltd., at ski hill. Ticket required due to advance notice needed by the caterer.	

Chair: Rob Edmunds, Consultant

1:00	"Sullivan Camp" Exploration Activity Overview	Dave Terry, Regional Geologist, Mines Branch and Tom Schroeter, Sr. Regional Geologist, Geol. Survey Branch, B.C. Min. Energy and Mines
1:25	Tectonics and Sub-basin Development at Sullivan Time - PAKK Property	Doug Anderson, Consultant
1:50	Exploration in the Greenland Creek-Doctor Creek-Findlay Creek Area: Potential for Sedex-type Deposits in the Aldridge Formation Other than at "Sullivan Time"	Charlie Greig, Consultant, Tim Termuende and Chuck Downie, Eagle Plains Resources
2:15	The Search for the Next Sullivan: New Thoughts and Exploration Approaches	Sig Weidner, Sr. Geologist, BHP-Billiton
2:40	Six Years of Sedex Exploration in the Purcell Basin	Richard Hughes, President, Klondike Gold Corp. and Glen Rogers, Consultant
3:05	Discussion	
3:15	Coffee	

Chair: Hugh Morris, Chairman, Eldorado Gold

3:45	Finding the Faulted Continuation of Sullivan	Paul Ransom , Consultant; Jules Lajoie, Chief Geophysicist, Teck Cominco and André Pauwels, Consultant,
4:15	Sullivan and the Sedex Spectrum	Cameron Allen, Chief Geologist , Teck Cominco American Inc.
4:45	Closing discussion	
6:00	Cash Bar, Upstairs	
7:00	Supper hosted by Teck Cominco Ltd., at ski hill. Ticket required due to advance notice required by caterer.	

Note: Shuttle Bus service between skill hill and hotels:

Time			
From	To	Small Bus	Large Bus
5:00	6:45 p.m.	Trickle Creek Inn	Quality Inn
9:30	10:30 p.m.	Trickle Creek Inn	Quality Inn

Sullivan Waste Bed Sedimentology

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Abstract

The Sullivan Pb-Zn-Fe sulphide orebody at Kimberley B.C. is a SEDEX deposit in a turbidite sequence of middle Proterozoic age. Unique sediments and their inter-relationships with adjacent sediments or sulphides indicate the orebody accumulated in a local depression, or sub-basin, in the sea floor. These include accumulations that are interpreted as:

- a mud volcano complex,
- slurry deposits,
- sulphide slumps,
- argillaceous debris flows containing rafted masses of eroded sulphides and of siliciclastic sediment,
- micro debris flows,
- exhalite horizons,
- unusually thick (I, H and Hu) graded beds that formed when turbidites were "ponded" within the sub-basin, and
- one widespread conglomerate unit that represents resedimentation and deformation that resulted from a single tectonic event (H Conglomerate).

Combined stratigraphic thickness of these units is about 100 metres.

Enveloping this package is Carbonaceous Wacke Laminite (CWL), approximately 10 metres above and 6 metres below, that west of the limits of the Sub-basin is a 20+ metre thick unit of regional extent. As well, CWL is intercalated with other sediments and ore as individual laminations or in units up to 1 or 2 metres thick. On Concentrator Hill CWL is present below Concentrator Hill Horizon (CHH), and above the 10 to 15 m of turbidites that overlie CHH.

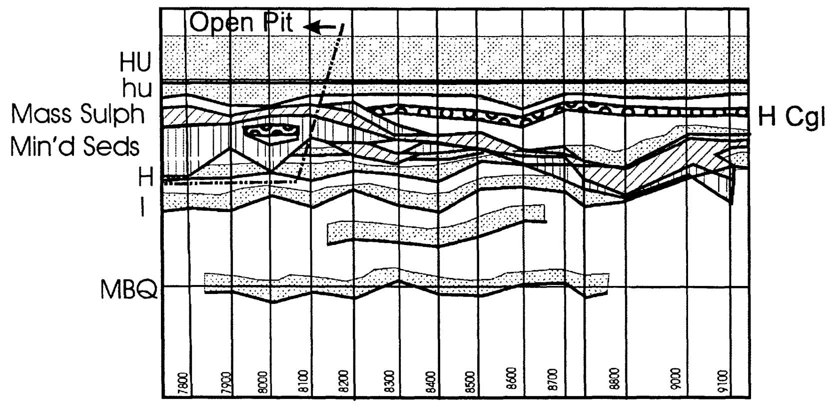
Deep in the footwall in the 10 km directly south of Sullivan, paleo water currents (not turbidites), as determined from ripple cross-laminations, diverge slightly from regional trends. This possibly indicates there was an irregularity in the sea floor such as one or more growth faults along a zone that was to later evolve into the Sub-basin.

Selected drawings will be presented that show waste bed stratigraphy provides critical information about the Sullivan deposit.

1. Fig. 1, from a report by Brian Hamilton, shows a transition of sulphides across strata at the south end of the mine. It should be noted that the sulphides are described as deformed, and today would be labelled durchbewegung. No

through-going structures were mapped in this area, and the deformation is probably limited to strain partitioning of, and possibly limited movement within the plane of, sulphides. Assuming the limitation of the preceding, the meaning of the transition of the sulphides may indicate either:

- migration of feeder zones toward the south, which may be valid considering the amount of sub-ore below the open pit floor; or the ore depocentre moved south in response to a lowering of this part of the sub-basin and sulphidic fluids flowed downslope from the vent area to the new low.



SULLIVAN - SOUTH END
DEPARTURE 4000
MARKERS AND RELATION TO ORE

• after S.B. Hamilton 1959 Fig. 1

2. Fig. 2. is a drawing by P. Marler from a report by Owen Owens that shows geographic distribution of the I and H thick graded beds, and absence of these beds in the central west part of the mine. The Hu bed is present in the area where the others are absent. This information was gleaned looking through alteration that overprinted part of this area, however the sleuthing skills of Sullivan geologists has established a critical feature of Sullivan, that during sulphide deposition the central western part of the Sullivan deposit was elevated, and possibly a mound. In much the same manner the A, B and C waste beds pinch-out against massive sulphides consisting of uninterrupted Main+A+ B+C sulphides on mine Section 37.

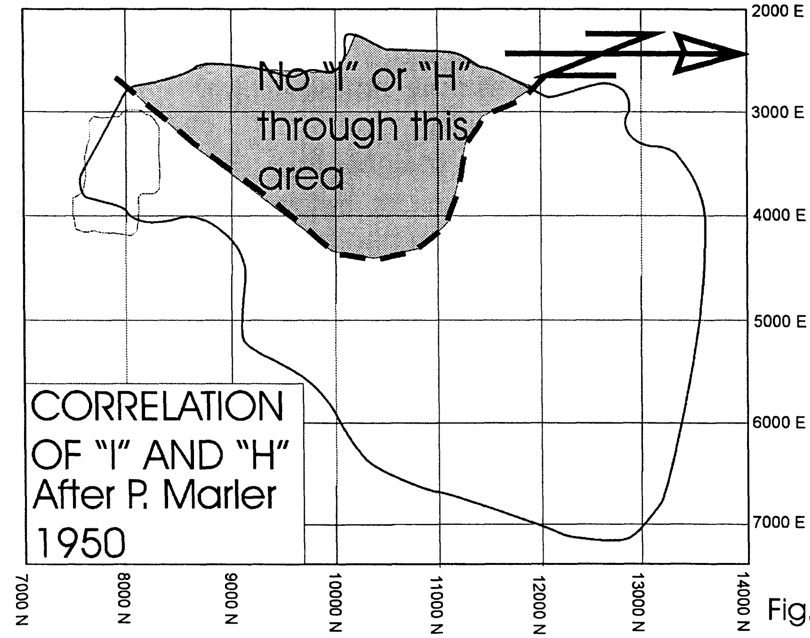


Fig. 2

3. Fig. 3 from Ransom and Lydon, is a map that shows the area of the Sullivan deposit including the thin barren sulphide sheet to the east that extends beyond Lois Creek Fault. Southeast of the orebody, within the limits of the distal sulphide sheet, is an area where several holes did not intersect sulphides. Detailed logging has demonstrated that normal growth faults and erosion of sulphides on the high standing footwall blocks are likely to have occurred. This is the inferred source area of abundant barren sulphide clasts and huge erratics in the waste beds overlying the Main Band, especially in the A Waste.

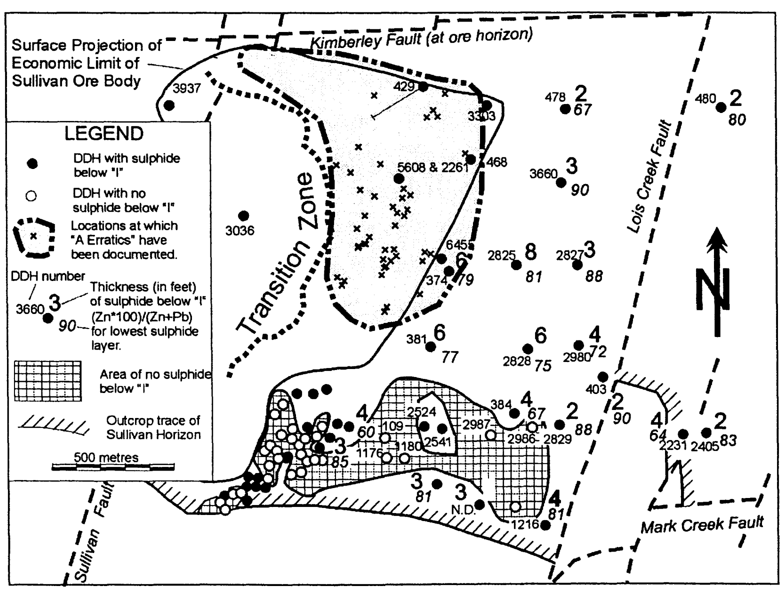


Figure 3. A, B, C and D Waste Beds are present east and north of Transition Zone. Sulphide clasts, including Erratics to 1 m thick by tens of metres in extent, occur throughout most of the area of the A Waste. Sulphide clasts, although less abundant, are present in the B, C and D Waste Beds and occasionally in thinner waste beds. Modified after Ransom and Lydon (2000).

Some New Perspectives on the Sullivan Deposit

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Abstract

The recent Sullivan Project, involving collaborative documentation and research between the Geological Survey of Canada, Cominco Ltd., the British Columbia Geological Survey , United States Geological Survey and Universities, together with on-going work, has filled in some of the holes in the understanding of the processes and circumstances that led to the formation of the Sullivan deposit. Details of the results of this work are reported by various authors in the Sullivan Volume.

Regional Setting

The Sullivan deposit formed in an active intracontinental rift and is hosted by marine turbidites shed from a deltaic complex that was prograding to the northwest. Very high average accumulation rates of up to 60 cm/1000 years persisted from the time of Aldridge Formation deposition until the time of deposition of the Sheppard Formation after which average accumulation rates dropped to 2.8 cm/1000 years. The period of high accumulation rates was punctuated by episodes of mafic volcanism, particularly around 1468 Ma (Moyie Sills) and 1443 Ma (Purcell Lavas). The combination of high sedimentation rates and voluminous sill emplacement accelerated compaction and dewatering rates and gave rise to widespread mud volcano activity during lower-middle Aldridge time. By far the largest of these mud volcano field is the Sullivan-North Star Corridor, which covers an area of about 20 km^2.

Hydrothermal Systems.

A high proportion of mud volcano vent breccias (discordant "fragmentals") throughout the Aldrdge Formation are tourmalinized, likely reflecting the abrupt release of boron from marine clays due to their rapid premature compaction and heating by sill emplacement and the concentration of boron into the "vapour" phase of formational water heated to supercritical temperatures by the sills. Highly saline fluid inclusions (>30 wt.% NaCl equivalent and likely Fe-rich) in veins within the Aldridge Formation of the Purcell Mountains, especially in association with Moyie Sills, probably reflect contributions by the highly saline "liquid" phase of supercritical boiling. This regional occurrence of highly saline, likely Fe-rich, fluid inclusions indicates that highly saline formational waters were pervasive throughout Aldridge rocks of the Purcell Mountains prior to peak metamorphic conditions (at about 1350 Ma) and explains the prevalence of pyrrhotite (as opposed to pyrite) as the main diagenetic iron sulphide. Most Aldridge-time hydrothermal alteration effects can be explained by the upflow of these two contrasting fluid types. Tourmalinization by the low salinity fluids is typically accompanied by As enrichment. In contrast, galena and sphalerite enrichment, suggested to be due to the upflow of the high salinity, Fe-rich, formational brines is characteristically accompanied by pyrrhotite enrichment and chloritization of siliciclastic rocks.

The Sullivan deposit formed on a subsiding mud volcano mound, probably in less than 1 m.y. during the interval 1470-1475 Ma. The very large amount of tourmalinization at Sullivan, which formed subsequent to most mud volcano eruption but prior to most sulphide deposition, indicates the extraordinary focusing of a very large amount of boron-rich fluid upflow along the Sullivan mud volcano conduit. The subsequent focusing of a very large amount of Fe-, Pb- and Zn-rich fluid along the same conduit indicates that the Sullivan upflow zone continued to be the preferred or only escape path for regional hydrothermal cells or for sediment dewatering over a very large area. The linearity of discordant fragmental bodies parallel to extensional rift faulting, the siting of the Sullivan upflow zone close to the rift axis, and the timing of hydrothermal flow as a herald to the period of most voluminous tholeiitic sill emplacement, links the generation of Sullivan ore fluids to the thermal effects of magmatic activity on the formational waters of rapidly accumulating sediments in an active submarine rift and the upflow of these fluids along rift-related fault zones.

The presence of tourmalinite in the hanging wall to the Sullivan deposit indicates that the upflow of boron-rich fluids continued to be interspersed with the upflow of the iron-, lead- and zinc-rich fluids over the life of seafloor hydrothermal activity at Sullivan, indicating either intermittent tapping of a stratified reservoir system or the ongoing generation of the two hydrothermal fluid types by recurrent sill emplacement at depth. Later albitization is related to the emplacement of the Mine Sill, and pyrite-carbonate replacement of sulphides in the Iron Core and along the Kimberley fault as late as about 1370 Ma is perhaps related to the rise of anatectic melts such as the Hell –Roaring Creek stock. Interpretation of the wide range of fluid inclusion salinities, including highly saline fluids (>30 wt.% NaCl equivalent) in the footwall, ore zone and hanging wall to Sullivan, is complicated by these multiple fluid upflow events and two periods of major metamorphic recrystallization.

Sulphide Deposition

Although the general architecture of the Sullivan deposit has been preserved, most microscopic and many small scale megascopic textures and structures are the result of metamorphism and tectonic deformation. The major deformational effects are the result of the relative movement of the hanging wall with respect to the footwall, particularly during Jurassic thrusting. The fragmental sulphides at the base of the Main Band represent durchbewegan structure along the main decollement, and includes pyrrhotite-rich sulphides that have been tectonically squeezed outwards from the Vent Complex. The peripheries of the deposit also largely consist of tectonically mobilized sulphides, distributing sulphides beyond their original extent. Low angle thrusting towards the east is particularly evident in the Southeast Fringe.

The typically massive sulphides in the Vent Complex over the upflow zone at Sullivan were formed by the subsurface deposition and replacement by hydrothermal upflow through a sulphide mound and/or crater-fill. The typically interlaminated sulphides and argillites of the Bedded Ores originated as a brine-pool sediment in the surrounding depressional moat, with a Waste Bed and its overlying Ore Band forming a single sedimentation unit. The Waste Bed represents the gravitationally settled, less porous arenite-siltite component of a mud flow, and the overlying Ore Band the slower-settling, highly porous mixture of i) the argillic component of the mud flow, ii) hemipelagic sediment, and iii) both sedimented and early diagenetic sulphides. The most convincing evidence for a sedimentary sulphide component to the Bedded Ores is the preservation of a correlatable sulphur isotope stratigraphy. Distal hydrothermal products, notably the as pyrrhotite- and muscovite-enriched argillic laminites with elevated trace lead and zinc contents of the Concentrator Hill Horizon, represent buoyant plume fall-out.

Contours of metal contents and metal ratios are concentric about the vent complex and cross-cut stratigraphy, reflecting a strong chemical zonation of the whole deposit along a single thermal and chemical gradient upwards and outwards from the central part of the hydrothermal upflow zone. This zonation reflects the progressive replacement and remobilization and of sulphides by the subsurface flow of hydrothermal fluid through buried sulphides at the same time as hydrothermal venting sulphide accumulation was taking place at the sea floor. "Higher temperature" metals such as Cu are concentrated in the core of the Vent Complex; "lower temperature" metals such as Hg are concentrated in the peripheries of the Bedded Ores. Because the distributions of pyrrhotite, galena and sphalerite are an integral part of this zonation pattern, most of the ore at Sullivan is technically a replacement by galena and sphalerite of a lower grade sulphidic protolith. Laminated pyrite-magnetite, preserved in all Ore Bands of the Southeast Fringe, likely represents the least-replaced protolith.

The History of Geological Work in the Aldridge Formation

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Abstract

Geological investigations in the Aldridge formation have taken place at varying levels of intensity since the last quarter of the nineteenth century. There have been four broad stages of endeavour – Prospecting (1885-1910); Early Systematic Investigation (1910-1945); Development of Comprehensive Understanding (1945-1975); and Full-scale Testing of Contemporary Models (the current stage). The sequence is similar to the evolution of investigation in other mining camps.

Work has fluctuated in intensity in tandem with and responding to several key factors. These include – (a) the discovery and economic importance of lead-zinc-silver and other deposits in the Aldridge formation and related rocks (Sullivan, Spar Lake); (b) the growth of universally available geological knowledge, especially in sedimentary geology and ore genesis; and (c) the development of new technologies and tools (exploration geochemistry, airborne geophysical methods, deep-penetration electrical surveys, etc.).

The products of over a century of investigation in the Aldridge formation are clear. Today's geoscientists have at their disposal comprehensive working hypotheses and a formidable array of exploration tools. The challenge is the efficient and effective use of these intellectual assets in the search for new deposits.

Tectonic, Magmatic and Metallogenic History of the Early Synrift Phase of the Purcell Basin, Southeastern British Columbia (from Höy et al, 2001).

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Abstract

The Belt-Purcell basin is a Middle Proterozoic intracratonic basin with an early synrift fill succession, the Prichard and Aldridge formations, and an overlying rift cover succession that comprises the Creston through Van Creek formations. These rocks contain a variety of base metal deposits including the massive to stratiform Sullivan SEDEX deposit and many veins in the Aldridge, stratabound Cu-Co in the Prichard Formation and some of the Ag-Pb-Zn-rich veins of the Coeur d'Alene camp in Idaho. Overlying, dominantly shallow water rocks of the rift cover succession contain a number of large stratabound Cu-Ag deposits in Montana, the majority of the veins of the Coeur d'Alene camp and massive Pb-Zn-barite carbonate-replacement deposits in Canada. The total thickness of the Purcell Supergroup in the central part of the basin in Canada is estimated to be at least 19 km, with approximately 12.5 km of Aldridge Formation and 7 km in the overlying cover succession.

The Aldridge Formation, the focus of this presentation, comprises northward prograding marine turbidites deposited in a north to northwest-trending rift basin. Slope, shelf and alluvial fan deposits flank the basin on the east and south. Extensional basin margin faults are recognized by prominent facies and

thickness changes in Aldridge and correlative rocks. Rift axis faults within the central part of the basin are less conspicuous but produced small north-trending grabens or half grabens marked by hydrothermal upflow zones, sedimentary fragmentals and gabbroic dykes. The Purcell basin axis is offset by northeast-trending faults that paralleled underlying basement structures. These accommodation zones are recognized by major offsets in the palinspastically restored basin axis and local changes in paleocurrent directions and, along the basin margin, alluvial fans and facies changes.

The Aldridge Formation has been subdivided into three informal members. The Lower Aldridge is a sequence of thin to medium-bedded, pyrrhotite-rich, distal argillaceous turbidites within the central part of the basin and more proximal, thick-bedded quartzites of the Ramparts Facies to the southwest near Creston. The Middle Aldridge comprises up to 2400 metres of medium-bedded quartzitic turbidites with prominent inter-turbidite intervals of laminated siltstone, and the Upper Aldridge, approximately 300 metres of thin-bedded to laminated, pyrrhotite-rich argillite and siltite deposited on a shallowing basin plain.

The tectonic and structural control of sulphide deposits, hydrothermal alteration and sedimentary fragmentals in the Aldridge Formation are reflected in both their regional distribution and stratigraphic position. Hydrothermal discharge centers are localized in small north-trending structural basins. Those in close proximity to, or intersecting rift offset faults are more commonly mineralized. Those farther removed more typically comprise barren unmineralized fragmentals that occasionally are overprinted by tourmalinite alteration. Hence, the intersection of basin parallel and transverse structures focused the discharge of higher temperature, metal-bearing brines whereas farther removed from the transverse structures, fluidization of sediments and possibly lower temperature tourmalinite alteration occurred. This spatial control of sulphide mineralization and alteration is related to geothermal gradients within the basin. The total volume of gabbroic magma within the basin, the Moyie sills, increases towards the central part of the basin and in easterly-trending rift offsets south of the Sullivan deposit, and individual sills and dykes thicken and increase in number towards their intersection with offset faults.

Sulphide concentrations in the Aldridge/Prichard, in the central rift zone of an intracratonic basin near intersection with rift offsets, are analogous to many modern tectonic settings. Metalliferous brine pools in the Red Sea are concentrated in the axial deeps at intersections with rift offsets and massive sulphide deposits in oceanic spreading centers (*e.g.* Middle Valley) are also commonly located at ridge offsets.

The stratigraphic distribution of Aldridge sulphide deposits is also controlled by basin tectonics. Most deposits and occurrences are localized at stratigraphic levels that record episodic basin wide extension and associated rapid basin deepening. Extension involves initial development of small axial grabens, associated with fragmental development and extensive hydrothermal discharge, followed by flooding by coarse turbidites and intrusion of high level gabbroic magmas. Hence, these levels contain many of the Aldridge fragmentals and tourmalinites as well as the highest concentrations of gabbroic sills.

Four periods of basin expansion followed by basin filling are recognized or inferred within the exposed Aldridge succession. One of these, within the central part of the Middle Aldridge Formation, correlates with a shallowing upward succession documented in the Prichard Formation in the Perma/Plains area, Montana. Within the Aldridge Formation, these shallowing or basin fill successions define large-scale sedimentary cycles, with thicker bedded arenaceous turbidites grading upward to finer grained turbidite siltstone packages and finally anoxic muds. Stratiform mineralization, disseminated sulphides or sulphide stringer zones tend to concentrate at the transition from one cycle to a higher cycle, reflecting periods of enhanced structurally controlled fluid flow, rise of geothermal gradients and development of small structural basins. One of the most prominent is at the transition from the Lower to the Middle Aldridge, the stratigraphic interval that hosts Sullivan, widespread disseminated and vein sulphides, locally intense hydrothermal alteration and abundant sedimentary fragmentals.

The setting of these SEDEX deposits is somewhat unusual, occurring in deepwater marine turbidites and in the synrift rather than the rift cover succession. However, important similarities with Middle Proterozoic basins in northern Australia, including the McArthur basin, are the recognition of active extensional tectonics and intersecting syndepositional faults controlling hydrothermal centers. These features control both the spatial distribution and stratigraphic levels of sulphide deposits within the Aldridge Formation.

"Sullivan Camp" Exploration Activity Overview

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Abstract

The "Sullivan Camp" encompasses an area of southeastern British Columbia, northern Idaho and Montana underlain by the Purcell Supergroup, which is a thick sequence of terrigenous clastic, carbonate, and minor volcanic rocks of Middle Proterozoic age. The Purcell Supergroup rocks host a variety of metal deposit types including: **1)** Stratabound clastic-hosted (sedex) Pb-Zn-Ag (Sullivan, Kootenay King), Cu-Co (Sheep Creek, Mont., Blackbird, Idaho), sedimentary Cu (Spar Lake, Mont.), and Fe (Iron Range) deposits; **2)** stratabound silica-hosted deposits (York, Mont.); **3)** stratabound carbonate-hosted Pb-Zn (Mineral King) deposits; **4)** vein Cu (Bull River), Pb-Zn (St. Eugene, Estella, Stemwinder), and Au (Perry Creek area, Midway) deposits; and **5)** shear-hosted Au deposits (David-Lew) (Hoy, 1993). Mineral exploration in the "Sullivan Camp" was launched in the 1860s with the rush to Wild Horse Creek, near Fort Steele, for placer gold. In the 1880s the focus shifted to Pb, Cu, and Ag, and the North Star deposit, located on the Kimberley ski hill, was one of the first of the sediment-hosted Pb-Zn-Ag occurrences to be discovered in the "Camp". Shortly afterwards, in 1892, the Sullivan deposit was discovered, followed in 1893 by the St. Eugene deposit on the shore of Moyie Lake. The Sullivan commenced mining in 1900 and was acquired by Consolidated Mining and Smelting Company of Canada (Cominco) in 1910. The Sullivan deposit is the longest-lived, continuous mining operation in Canadian history and one of the largest Zn-Pb-Ag deposits in the world, originally containing more than 160 million tonnes grading 6.5% Pb, 5.6% Zn, and 67 g/t Ag.

By the early 1940s the enormous size and main geological and geochemical aspects of the Sullivan deposit were recognized. From 1945 through to the 1990s Cominco carried out regional exploration covering the Aldridge Formation in Canada and the equivalent Pritchard Formation in the northwestern United States. Significant milestones in the evolution of exploration for Sullivan-type deposits in the "Camp" include: **1)** development in the early 1940s of a detailed hangingwall and ore-layer stratigraphy from comprehensive examination of archival drill core; **2)** recognition in the early 1940s of the association between the ore deposit and tourmaline and albite alteration, the presence of a localized

sedimentary basin, and discordant diorite/gabbro sills and faults; **3)** about 1949, the Aldridge Formation was subdivided into Lower, Middle, and Upper divisions and it was observed that the Sullivan deposit was located at the contact between the Lower and Middle Aldridge (LMC); **4)** in the late 1950s and early 1960s the concept that the ore was predominantly exhalative rather than replacement in origin was developed; and, **5)** in the 1960s it was recognized, by two separate parties, that light and dark laminated argillite "markers" could be correlated bed-for-bed across hundreds of kilometres. This provided a tool to accurately estimate the stratigraphic distance to "Sullivan time" at the LMC, from anywhere in the 3000m thick monotonous Middle Aldridge turbidites (Hamilton et al., 2000). This last accomplishment proved extremely important in the implementation of deep-penetrating electromagnetic surveys to evaluate the LMC over large areas and was also invaluable in locating and interpreting drillholes for stratigraphic studies.

Cominco dominated exploration in the "Camp" until the 1980s. Since the early 1980s several senior mining companies and a large number of junior exploration companies have explored for Sullivan-type sedex deposits in the "Camp". Flow through share financing facilitated increased exploration in the "Sullivan Camp" during the late 1980s by the junior company sector. Since 1988 more than $20 million has been spent on sedex exploration in the British Columbia sector of the "Sullivan Camp". In 1996 the Government of British Columbia and the Geological Survey of Canada funded a $600,000 state-of-the-art airborne geophysical survey that covered three areas of high potential Aldridge stratigraphy. The release of the survey resulted in increased mineral exploration in these areas.

Increased exploration spending in the "Camp" over the last decade has resulted in the discovery of a number of new alteration zones, hydrothermal vents and mineralized systems within the Aldridge Formation. Despite these successes, an economic discovery has remained elusive. Some of the exploration highlights from this period include: **1)** intersection in 1992 of 1m of massive sulphides grading 9.35% Pb, 16.4% Zn, 0.09% Cd, and 98 g/t Ag on the **Fors** property, west of Moyie Lake, by Consolidated Ramrod Gold Corporation (Britton and Pighin, 1995); **2)** intersection in 1997 of 2.6m of massive to semi-massive sulphides grading 9.65% Zn, 5.82% Pb, and 49.4 g/t Ag at a depth of 505m by Kennecott on the **Irishman/Lewis** property in the upper Moyie River area (Wilton, 1997); **3)** the discovery in 1997 of a stratabound sulphide breccia within Lower Aldridge siltstones on the **Greenland Creek** property, located in upper Skookumchuck Creek, by Eagle Plains Resources. Drilling intersected up to 6.06% Zn over 0.33m (Wilton, 1997); **4)** identification of large zones of geochemically anomalous tourmalinization and fragmental rocks on the **Findlay** property northwest of Kimberley by Eagle Plains Resources; and **5)** the discovery of three new showings on the **Pakk** property, west of Kimberley, by prospectors for Supergroup Holdings Inc.. Cominco's exploration in the "Camp" in later years focused on pursuing the fault-displaced extension of the Sullivan deposit with deep drilling north of the Kimberley Fault. In 1988 a drillhole, located 4.3km northwest of Sullivan on **Mark Creek**, intersected a short interval of deformed laminated sulphides containing 5% combined Pb-Zn, believed to be the extension of the Sullivan orebody, at 2600m depth, before entering a thick gabbro sill and granophyre.

Exploration for Sullivan-type and other targets in the "Camp" has decreased significantly over the past two years. This is due in large part to the difficulty that the mining sector is having in attracting financing, the impacts of low metal prices internationally, the ramifications of corporate consolidation, and strong off-shore competition for exploration dollars, combined with a poor resource development environment in the Province during the past decade. Although many properties have had significant amounts of surface exploration and drilling, the "Camp" continues to be an attractive place to explore for large sedex deposits due to excellent access, infrastructure, a continually growing base of geological knowledge, and an abundance of untested targets.

References:

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Tectonics and Sub-Basin Development at Sullivan Time - PAKK Property

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Abstract

The Pakk property is a large block of claims centered about 30 kilometres southwest of the Sullivan orebody. At more than 200 units for its centre-west block, the Pakk covers Lower Aldridge stratigraphy on the east to upper Middle Aldridge sequences on the west. Recognition of outcropping Sullivan Time and float of tourmalinized fragmental containing Pb-Zn-Fe sulfides led to staking.

The Pakk area has long been recognized for its excellent Middle Aldridge exposures and numerous small copper showings within Moyie intrusions. Cominco conducted the majority of exploration work in the area, intermittently from 1979 through 1995.

In 1999, Super Group Holdings Ltd. became interested in the area because of shallow Sullivan Time and greatly improved access. Prospecting located mineralized, altered fragmental float. The property was optioned to Chapleau Resources Ltd. who expanded the property to the west and north. Aggressive exploration led to more prospecting, mapping, soil grids, and drilling. The Jack showing was located in Middle Aldridge rocks. It is a gabbroic dyke complex with intricately associated fragmental, alteration including tourmalinite, and sulfides. Short holes tested the showing, verifying its dyke-like configuration and the presence of significant galena and sphalerite. Drilling efforts moved south, down-dip of outcropping Sullivan Time and closer to the original float discovery. This drilling proved negative. In 2000, efforts were re-focussed to the north, more mapping documents significant changes in the stratigraphy across the northeast-trending Pakk fault. Hiawatha marker to Sullivan Time thickens 45%. On surface east of the fault, the Lower to Middle Aldridge contact is sharp; immediately west of the fault interbedded fragmental and bedded sediments are at least 20 metres thick. An existing hole down-dip was deepened, intersecting 15.2 metres of finely laminated subwacke identified as Sullivan Time underlain by 115 metres of pyrrhotite-enriched fragmental then Lower Aldridge rocks.

The surface mapping and drill holes to date document an active depositional basin with at least one northeast-trending fault syndepositionally active in upper Lower Aldridge through lower Middle Aldridge time. Substantial thickening of the lower Middle Aldridge, changes in sedimentological character and thickening of Sullivan Time and its footwall fragmental all vector to the west. Added incentive for future drilling is provided by the mineralized, altered feeder system recognized in the hangingwall rocks at the Jack showing.

Exploration in the Greenland Creek-Doctor Creek-Findlay Creek Area: Potential for Sedex-type Deposits in the Aldridge Formation other than at "Sullivan Time"

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Abstract

Eagle Plains' "North Sullivan Block" consists of 700 contiguous claim units in a 10-15 km wide, 20 km long, north-northeast trending belt which traverses a well-exposed stratigraphic section of the Middle Proterozoic Aldridge Formation (lowermost Purcell Supergroup). The area lies north of the Cretaceous White Creek batholith, about 25 km north-northwest of the Sullivan mine and not far west of Canal Flats. Rocks in the belt include a complete and continuous section from the Lower Aldridge through to the lower part of the Creston Formation. They are typically gently west-northwest to north-northwest dipping and occur immediately west of the hinge of the gently north-plunging Purcell Anticlinorium; they are among the northernmost of Aldridge Formation exposures in British Columbia.

Since the discovery of the Sullivan Mine in the late 1800's, exploration for Sedex deposits in the Aldridge formation has focused almost exclusively on the Lower-Middle Aldridge Formation contact (LMC) which is generally considered to represent "Sullivan time." In addition, most of this model-driven exploration work targeting the LMC has been directed to the south of Sullivan, in the Kimberley–Moyie–Creston area. The North Sullivan block, which includes LMC stratigraphy in the locally well-known exposures along "Rusty Ridge," has been the focus for sporadic exploration since the 1950's. The past five years, however, have been among the most exciting for exploration in this area because of the recognition of new sedex-type targets and because the area has finally been the focus for systematic work, which includes local diamond drilling. A review of this recent work in the light of a comprehensive geochemical and geological framework indicates that attractive targets for Sullivan-type sedex deposits exist and remain to be tested. The highest priority targets in this area, however, are not associated with the Lower-Middle Aldridge contact (LMC), but occur within the Lower and Upper Aldridge formations.

Within the Lower Aldridge Formation, a number of lines of evidence suggest proximity to an active, deep-seated Middle Proterozoic structure or structures that may have vented base metal-bearing hydrothermal fluids. These include: 1) geochemically anomalous strata, relatively rich in pyrrhotite and pyrite (hence, Rusty Ridge), and locally hosting stratiform(?) pyrrhotite, sphalerite, and galena;

2) abundant fragmental units that are locally extensively tourmalinized; and 3) thick, commonly pyrrhotite-rich sill complexes that display local discordances and peperitic contacts. Thickening trends in fragmental units within the Lower Aldridge Formation in the Greenland Creek area suggest that the major structure(s) lie toward the west, and as such a major untested drill target remains at depth on the property.

Within the Upper Aldridge Formation, stratiform horizons of tourmalinized mudstone with a distinct and highly anomalous Sedex-type geochemical signature (Pb, Zn, Mn, Ba, Ag, and As) outline a remarkable alteration footprint that has been traced along strike for at least eleven kilometres. The section of tourmalinized mudrocks apparently thickens to the southwest, such that along the divide between Doctor and Middle Findlay creeks, mudstones within nearly the entire Upper Aldridge formation are tourmalinized, and the altered part of the succession may be hundreds of metres thick. In spite of its great lateral and vertical extent, however, the alteration is commonly subtle on the outcrop-scale. This is because the mudstones are subordinate in abundance to the thin- to medium-bedded, very fine-grained to fine-grained sandstone and siltstone which comprise the bulk of the Upper Aldridge Formation, and because the tourmalinite typically consists of distinctive "laminated tourmalinite," which is characterized by crenulated, dark grey to black, millimetre-scale laminae in which tourmaline needles are not visible to the naked eye. Locally, however, tourmaline (schorl) needles are visible to the naked eye, and the outcrop expression of alteration is unmistakable. The thickening trend observable in the tourmalinized mudstones appears to end somewhat abruptly, at or near to a series of northerly striking high angle faults which typically display late-stage, west-side-down displacement of probable Tertiary age. The faults appear to be part of a system that is more or less continuous along the length of the properties. The fact that they appear to be coincident with such an abrupt change in thickness of tourmalinized rocks, and the fact that the alteration appears to be early-stage (it appears to predate the emplacement of the Proterozoic Moyie sills), suggests that the faults may have reactivated Proterozoic, syn-depositional(?) structures, and that such structures may have controlled a large-scale hydrothermal system. In addition, the fact that similar young structures cut the Lower Aldridge Formation on the south part of the property and are cospatial with features suggesting syn- or closely post-depositional movement in early Aldridge time (see above), further suggests that the structures were long-lived, and, by inference, deep-seated, even in Proterozoic time. Like the Lower Aldridge Formation in the south part of the property, the thickest and most westerly part of the tourmalinized Upper Aldridge section in the north also remains to be drill-tested. The potential is similar: a significant syngenetic sulphide deposit fed by a major mid-Proterozoic structure.

The Search for the Next Sullivan: New Thoughts and Exploration Approaches

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Abstract

The presentation covers exploration work carried out from 1998 to 2000 by Rio Algom Exploration Inc. and Billiton in the Proterozoic Purcell Supergroup. Rio Algom began exploration in the summer of 1998 when it optioned the Pyramid Peak , the Yahk Property and the Kitchener claim blocks of Abitibi Mining Corp. In 1999 Rio Algom optioned the South Findlay Project and the Bootleg Property from Eagle Plains Resources Ltd.. Billiton Plc began their "Junior Alliances" initiative in the same period and jointly with Eagle Plains Resources Ltd. explored the North Findlay property. Both companies approached the exploration for a Sedex deposit as a "concept play" using geological parameters in areas of limited lead-zinc mineralization of the Sullivan character. Rio Algom's focus of exploration the Sullivan horizon located immediately below the Lower Aldridge – Middle Aldridge contact (LMC). Billiton targeted the Middle Aldridge–Upper Aldridge contact. Rio Algom's target was a 90 MT deposit grading 12% combined lead and zinc, that R.A. engineers believed was economically viable to depths of up to 1000m. The "footprint" of such a deposit was estimated at a minimum of 1,500m in diameter. Rio Algom completed geologic mapping on all it's properties and drilled a total of 6615m of diamond core on the properties in 8 drill holes. The LMC was intersected in 6 holes. No significant mineralization was cut and the best analytical results were 87 ppm lead and 226 ppm zinc over 7.43m on the Pyramid Peak property.

Billiton Exploration completed geological mapping, soil sampling and wide spaced step-out holes (6 holes – 1616m) to delineate a geo-chemical gradient in a hydrothermal system as a vector toward zinc-rich, vent facies mineralization. Whilst lead and silver vectors are present, no real indication of increasing zinc values was noted.

Prior to the take-over by Billiton and subsequent merger with BHP, Rio Algom considered additional properties to continue their exploration approach. These included the PAKK and DAVent properties.

Currently, BHPBilliton is not active in the camp.

Six Years of Sedex Exploration in the Purcell Basin

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Abstract

Subject:

- Past results on Gravity, Mag, and Geochem on several properties Creston, Yahk, Cranbrook and Kimberley areas.
- Diamond Drill results on the Irishman Property – Moyie Basin
- Prospecting – why a useful exploration technique
- Vent indicators – Purcell Basin

Finding the Faulted Continuation of Sullivan

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Abstract

The Sullivan deposit is truncated on its north side by the 55° north dipping Kimberley fault, where the main ore band is 8m thick over a 600m strike with a grade of 21.7% Zn, 9%Pb, and 0.8oz/T Ag. Cominco Ltd. has sought the faulted offset of the Sullivan deposit on the north side of the Kimberley fault for about fifty years.

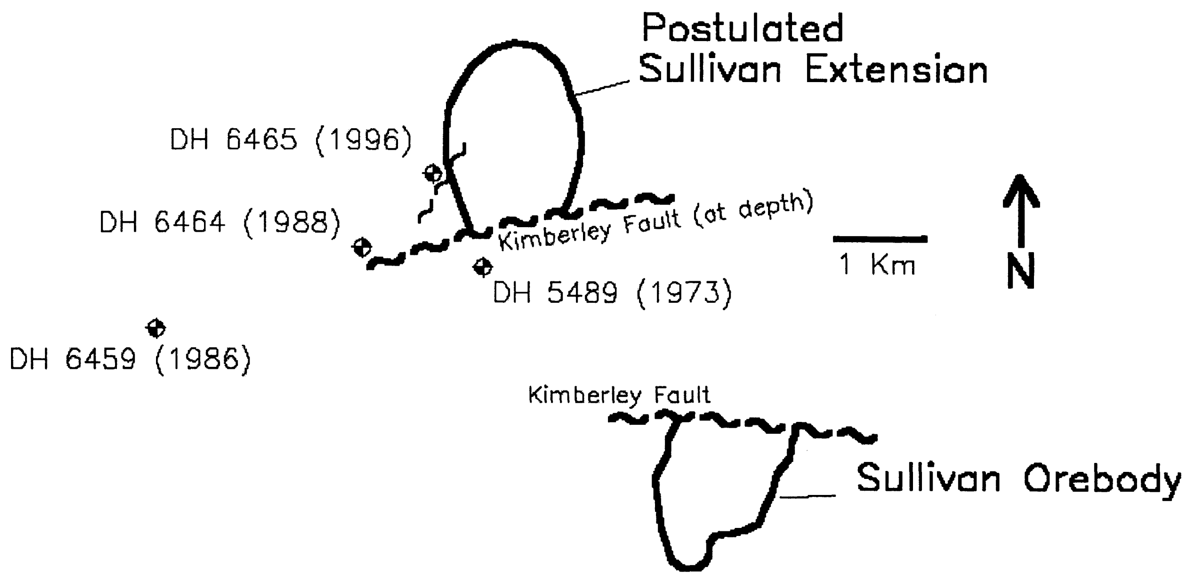
DDH 5489 drilled to 2674m in 1972 intersected the Kimberley fault before reaching Sullivan Horizon Time (SHT), because previously unrecognized large folds had moved the target much deeper than it had been projected. DDH 6434 (1717m, High Pass) and 6459 (650m, Matthew Creek), drilled in 1979 and 1986 respectively, were the first and second intersections of SHT north of the Kimberley fault. In these holes SHT was comparable to intersections south of Kimberley Fault on North Star Hill near Low Pass and in Matthew Creek. In 1988, DDH 6464, 3.4 km west of Sullivan and north of Kimberley Fault, intersected a sub-basin assemblage resembling the succession 1 to 2 km west of Sullivan. At 2592m, within a thick massive slurry-like sediment, a 30 cm thick clast of deformed laminated sulphides was intersected that assayed 4.1%Zn, 0.16%Pb, 11 gm/T Ag, and 33.7% Fe.

Finally, in 1996, the first successful intersection of formal Sullivan mine stratigraphic units north of the Kimberley Fault was obtained in DDH 6465. This location was 2.5 km west of Sullivan. Unfortunately, a fault was intersected at 2470m, 10m stratigraphically above where the first of the ore band is projected; below the fault were fairly characteristic footwall rocks. Clearly the Kimberley Fault has a left lateral offset of about 2.5 km and a throw of about 2.2 km. The hole was completed to a depth of 2608m using a drill rig designed by Connors, the drill contractor. A temperature of 80.4° Celsius measured at the bottom of the hole is unusually high for the gradient determined from other deep holes nearby, and it is postulated that this could be caused by higher thermal conductivity in nearby massive sulphides, as sphalerite has a very high thermal conductivity. Geochemical analyses of core show anomalous concentrations of several indicator elements within the immediate ore hanging wall interval. What appears to be albitite near the base of the Middle Aldridge is silicified quartz arenite in which there is a small amount of fine tourmaline.

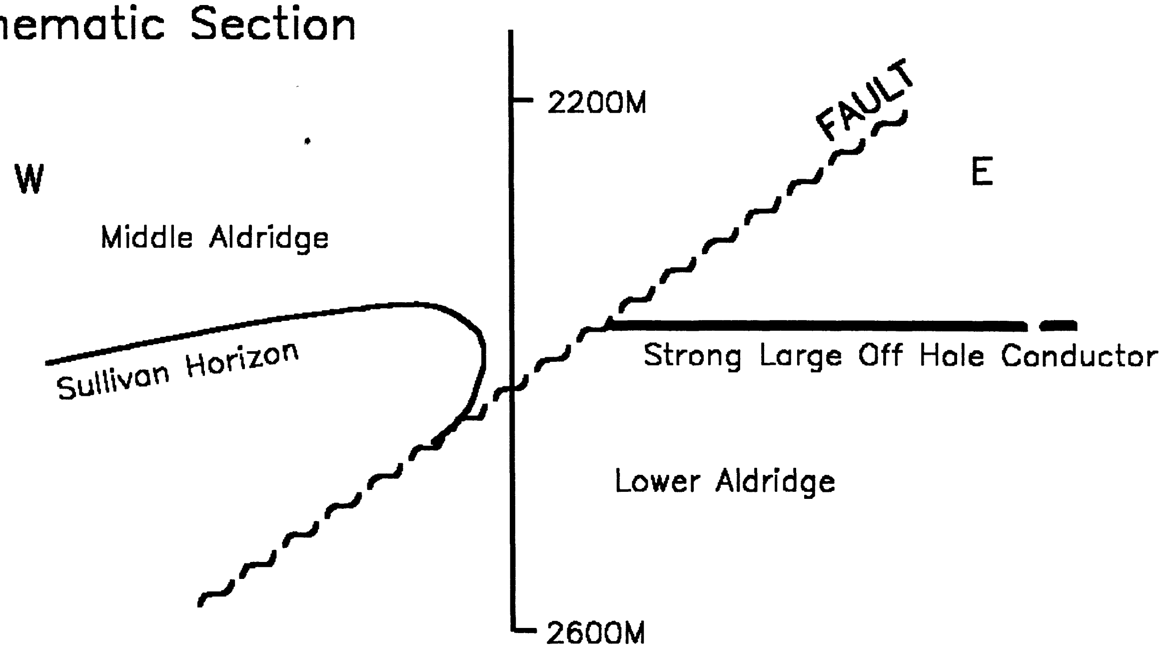
A single component (axial) downhole Utem 3 survey was performed using 4 surface loops. An off-hole conductor corresponding to the folded top ore band was detected some 10M away from the hole, at a depth of 2460M. Of greater significance , a large (>2 km) conductor was interpreted east of the hole using 2 independent modelling algorithms. There is a high probability that this conductor is a large mass of massive sulphides, the faulted continuation of the Sullivan deposit on the north side of the Kimberley fault.

The economics of other mines at similar depths and high temperatures were studied. A preliminary economic scenario would indicate that at least 20 million tonnes grading 18% Zn would be needed to make mining at that depth profitable. There is a high probability of finding such a resource given the geophysical data.

Schematic Plan



Schematic Section



Bottom of DH 6465

Sullivan and the Sedex Spectrum

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Abstract

The geological understanding of the Sullivan deposit, and its relationship to the evolution of the Belt-Purcell Basin have contributed enormously to a global understanding of sediment-hosted massive sulphide (or Sedex) Zn-Pb deposits. Sullivan shares some fundamental similarities with other members of the Sedex Spectrum, yet many specific attributes of Sullivan render it sufficiently distinct from deposits such as Broken Hill, Mt. Isa, etc. It is evident that no single genetic or exploration search model applies for the diverse spectrum of Sedex deposits.

An analysis of the attributes of global Sedex Zn-Pb deposits and reconstruction of the tectonosedimentary character of their hosting sedimentary basins reveals that Sedex deposits form in divergent, intraplate and certain convergent and transform tectonic settings. The recognition that disparate types of basins in these multiple settings can all host small to large Sedex deposits suggests both a possible classification for Sedex subtypes and a potential tool for prioritizing exploration.

Using a system of basin classification established by Busby and Ingersoll (1995), Sedex deposits are interpreted to occur in proto-oceanic rift troughs in divergent settings; both continental rises and terraces (aka passive margins) and intracratonic basins in intraplate settings; extensional backarc basins in convergent settings; and transtensional basins in transform settings. Major basin types not known to host Sedex deposits include continental platforms, and forearc and retroarc foreland basins. In addition, Sedex deposits occur at both the rift and sag stages of basin development and with or without associated magmatism. Deposit ages range from Paleoproterozoic to Jurassic with maximum development in the late Paleoproterozoic and Devono-Carboniferous, corresponding to periods of plate tectonic dispersion.

Sedex deposits can be entirely exhalative or largely sub-surface replacive; they universally display spatial associations with multiple order sub-basins, extensional pulses, and with intrabasin framework or growth faults that act as both down-flow recharge sites and up-flow discharge conduits. Ore fluid temperatures, salinities, redox conditions, host-rock alteration, and ambient seawater precipitation conditions vary dramatically amongst deposits. However, the four fundamental favourability criteria for Sedex deposits in any of the above tectonic settings are: 1) a sedimentary basin undergoing crustal extension or rifting, 2) a thick basal clastic reservoir (either oxidized or reduced) with evidence

of advanced diagenesis, 3) evidence of growth faulting, and 4) the presence of reduced shales in second- and third-order basins at the site of ore deposition.

A better understanding of the stratigraphic architecture and the tectonic and fluid evolution of basins which are known hosts to the world's large Sedex deposits is required. This will provide a means of critically evaluating other Proterozoic and Phanerozoic basins for their permissiveness for large undiscovered deposits, and allow for exploration prioritization.