A PALEOTECTONIC RECONSTRUCTION OF THE NORTHERN BELT - PURCELL BASIN AND ITS SIGNIFICANCE TO EXPLORATION FOR LARGE STRATIFORM Pb-Zn-Ag DEPOSITS

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With the construction of deep diving submersibles in the last two decades numerous insights have been gained into the structural controls relating to major base metal producing systems on the present-day seafloor. This work has also led to the refinement of models that describe basin evolution and set the groundwork for paleotectonic reconstructions. Much has changed from previous times when geologists viewed stratiform sulphide deposits as oddities of nature to considering metal accumulation as an integral part of the basin evolution process.

Impetus for striving to gain insights into the workings of the Belt-Purcell basin lie in the fact that it hosts one of the world's giant stratiform base metal deposits, the Sullivan Mine at Kimberley, B.C.

Previous workers at the Sullivan Mine have recognized a 2 kilometre wide north-south trending zone of alteration, zinc-lead-silver mineralization, gabbro intrusive complexes and intraformational conglomerates extending southward for 6 kilometres from the mine area to the St. Mary's Fault. This zone has been termed the Sullivan Corridor and encompasses the Sullivan Mine, Stemwinder deposit, Northstar deposit and Polaris prospect as well as numerous zones of pervasive mineralization and alteration.

Sullivan is located where this corridor intersects on the north with the east-west trending Kimberley Fault. Recent work (T.Hoy, Leask Associates, D.L. Pighin) has documented a north-south trending corridor (Cranbrook Graben) in a structural block 15 kilometres south of Sullivan which is bounded on the north by the Cranbrook Fault and on the south by the Moyie Fault. As in the Sullivan block, several zones of tourmalinite, albite alteration, cross-cutting gabbro, intraformational conglomerate, and stratiform sulphide are known. A south trending extension to this feature is inferred to coincide with the hinge of the Moyie Anticline southward from the Mt. Mahon prospect to the Canada-U.S. boundary (Leask Associates).

In 1986, as a result of the accumulation of field data in the Purcell Basin from Goatfell westward to the basin's western edge near Creston B.C., the author proposed the existence of an east-west trending feature analogous to the Sullivan Corridor extending from Goatfell B.C. to Mt. Rykert, west of Creston. This feature, termed the Creston Corridor, exhibits all the geologic features of the Sullivan Corridor, except for a known sulphide deposit of major proportions, although an alteration zone and attendant mineralization of considerable magnitude are known within the Goatfell/Kidd Star structural blocks.

Introduction

Geologic evidence suggests that the largest stratiform sulfide deposits within sedimentary basins occur preferentially where zones of rifting are linked to transform faults. Empirical observations of deposit densities within rifted intracratonic basins worldwide led to the conclusion that the likelihood was strong that more large Sedex Pb-Zn-Ag deposits lay undiscovered within the Aldridge basin.

In order to develop a framework to focus exploration for undiscovered stratiform zinc-lead-silver deposits a paleotectonic reconstruction of the Aldridge Basin, Middle Protozoic time, was initiated.

This paper details the findings and insights derived as a result of these efforts.

Tectonic Setting

The Belt-Purcell basin is postulated to have formed from a branching rift system within an Intracratonic basin (Sears and Price 1978). The rapid and thick deposition of quartz wacke turbidites of the Middle Aldridge is believed to coincide with the onset of tectonic instability along a rifted axis (Sullivan Corridor) and complimentary basin edge growth faults. Elements of the reconstruction included recognition of third order basins within paleo-rift zones, paleo-transform faults, and basin edge faults.

Corridors or Paleo-rift Zones

Within the Purcell Basin ancient zones of rifting and extension are mappable features which are defined by local accumulations of second-order basin infill sequences, localized sedimentary channelled fan complexes, graben edge growth faults that show only early dislocation, zones of tourmalinization, cross-cutting alkalic gabbro intrusive complexes, albitization, intraformational conglomerates, and disseminated, fracture and stratiform zinc-lead-silver mineralization.

Graben edge structures are commonly the locus of tourmalinization, gabbro emplacement, intraformational conglomerates, and basin dewatering structures. These may have been manifested as escarpments on the ancient seafloor so it is uncertain whether unusual sedimentary structures are a result of violent dewatering or debris flows or both.

Evidence suggests movement on graben edge faults was early and not ongoing. Offsets of up to two hundred metres have been observed.

Paleo-Transform Faults

These structures have orientations that are transverse to the trend of the paleo-rift zones. As with the rift zones, stratigraphic evidence also supports the initiation of movement in Lower Purcell Time (Hoy). Unlike the corridors, movement was penecontemporaneous and continued intermittently into at least the Devonian. Significant strike-slip and normal movements in the range of 2 to 10 kilometres are common on faults of this class and they are the major control of the basin wide outcrop pattern. Examples are the Kimberley Fault, Cranbrook Fault, St. Mary's Fault, and the north-south and southwest-northeast trending segments of the Moyie Fault.

Basin Edge Faults

Major faults of this type were commonly initiated as early growth faults. They commonly mark abrupt facies changes from mid basin quartz wacke turbidite sequences to shelf type clean quartzites and carbonate lithologies as well as abrupt changes in the total thickness of the Aldridge sequence. In central Montana thick channelled fan complexes and debris flows occur adjacent to two basin edge faults, the Volcano Valley and Camp Creek Faults. A thick intraformational conglomerate occurs adjacent to the Hall Creek Fault at the Vulcan Prospect near the northern edge of the basin. Crosscutting gabbro intrusive complexes are emplaced near basin edge faults at the Vulcan and Estella properties.

Reactivated Tectonics

The major dominant structure within the Belt-Purcell basin is the Purcell Anticlinorium, a north-south doubly plunging structure that is cored by rocks of the Lower Purcell Supergroup. The Anticlinorium is allochthanous (R.A. Price) being thrust eastward onto underlying cratonic basement in the west and Paleozoic miogeoclinal rocks on the east.

The axis of the Purcell Anticlinorium roughly coincides with the present position of the central depositional axis of the originai Belt-Purcell basin. The geographic centre of the basin, near Plains, Montana, likewise coincides with the Anticlinorium core and also the thickest measured section of Lower Belt rocks.

The writer and others have noticed an interesting pattern of fault bounded uplift blocks in which the zones of mineralization, Sullivan type indicators and Corridor development are present. Hitzman and Price suggest these Graben-Horst reversals are a function of sole-fault detachment and thrusting and result from adjustment along zones of early basement dislocation. This view suggests the uplifted blocks have more importance than just the fact they bring the target stratigraphy closer to surface. They are in fact the areas of early structural preparation and correspondingly are likely candidates to host stratiform base metal deposits of some magnitude.

Deposit Modelling

When formulating a working model to describe the mechanisms for large accumulations of stratiform base metal sulphides within the Belt-Purcell basin, it was felt that the model should discriminate between the two settings in which stratiform sulphides have been observed, mid-basin and edge of basin. Although many similarities exist, important differences are noted in the mineralogy, architecture and alteration of these deposits.

Deposits in the Mid-Basin

Observations of analogous present-day base metal producing systems in the mid basin, coupled with extensive data on the Sullivan deposit has formed the basis for a model that attempts to describe the key aspects for the formation of a focused vent system such as the footwall feeder pipe below Sullivan.

It has been noted by empirical observation that large Sedex deposits preserved in the geologic record are generally located near a major normal fault. When a depositional graben or zone of extension is present, these are inevitably in a transverse orientation to the normal faults. Although these faults are almost always present, it is rarely obvious what relationship they have to the mineralizing systems. One insight from present day systems suggests these transverse faults are zones of seawater recharge (J.M. Franklin) and are regions of high hydrostatic pressure. Tectonic and geologic evidence suggests that large base metal generating Sedex systems are initiated by the onset of tectonic instability in a specific region of that sedimentary basin. Tectonic instability as rifting provides cross-stratal permeability and the mechanism for release of massive amounts of over-pressured pore water from the great thicknesses of unconsolidated sediments in an immature sedimentary basin.

Extension within a rifted basin also allows mafic magma to invade the rift zone raising the geothermal gradient markedly. When the zone of extension is linked to a transform fault the result is a focused geothermal cell with cold seawater descending down the transform fault forming a region with high hydrostatic pressure adjacent to a zone of ascending hot metalliferous fluids discharging on the seafloor. Structural focus may be further aided by coincident intersecting zones of conjugate shear.

Within the Sullivan and Cranbrook structural blocks the onset of tectonic instability within the Sullivan Corridor is well documented to coincide with the abrupt charge in depositional environment which is recorded as the Lower Aldridge/Middle Aldridge lithologic contact.

Along the Creston Corridor, recent geologic evidence strongly supports the timing for the initiation of tectonic instability as occurring slightly later than on the Sullivan Corridor. The active horizon in this area is approximately 700 metres above the projected Lower/Middle Aldridge contact. It should be noted that outcrop or subcrop of the active horizons within the Corridors is very limited.

Outcrop or subcrop along the active horizon within the corridors are known at the Sullivan, Fors, Polaris, Goatfell, Kid-Star, and Sullivan II-Dodge properties.

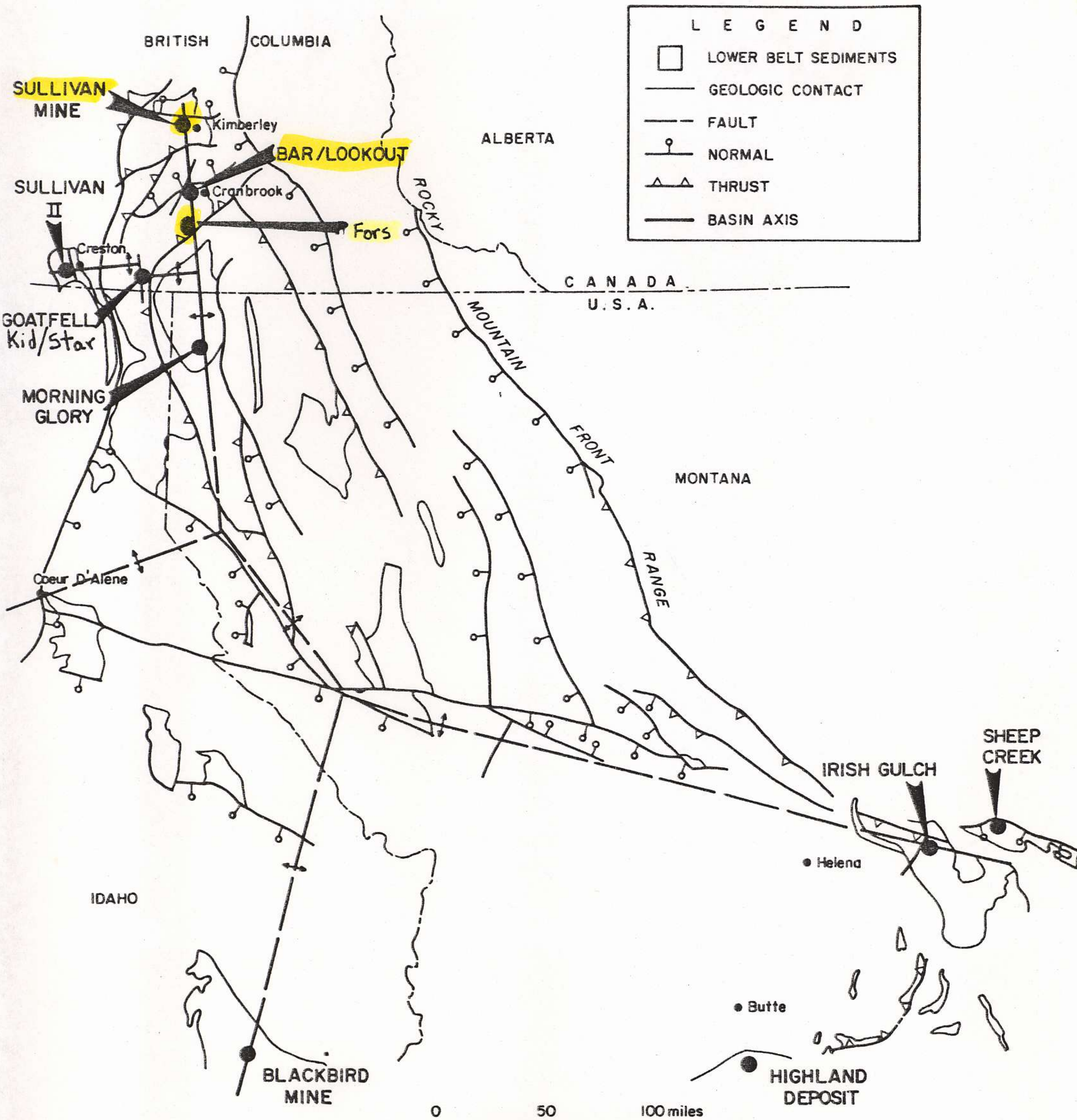
Deposits on the Basin Edge

In the edge of basin setting, growth faults that mark the basin edge are commonly the mineralized feeder zones to the adjacent or overlying stratiform mineralization. Mineralogically, edge of basin feeder systems differ from the mid-basin systems as they are commonly dominated by Fe-Cu-Co-Ba as opposed to Fe-Zn-Pb-W-Sn-B. Edge of basin deposits have similar mineralogy and fit closely with the model proposed for shale hosted stratiform Zn-Pb-Ag-Ba deposits proposed by Morganti (1981). A mafic intrusive component is less common in these systems. Evidence suggests these deposits form from the release of over pressured pore water up the growth faults. Convection may or may not be an important mechanism in their deposition. The Sheep Creek, Highland Mountains deposit in central Montana and the Kootenay King and Vulcan prospects in southern British Columbia are examples of edge of basin deposits.

Conclusions

Paleo-tectonic reconstruction of the Aldridge basin has provided insights into the potential location of large undiscovered stratiform Zn-Pb-Ag deposits prompting the author and associates to acquire four new exploration projects in the Aldridge of southeastern B.C. Goatfell, on the Creston Corridor, and MR/Leigh, adjacent to the Fors discovery on the Sullivan Corridor, are being actively explored. Recent work has indicated the Sullivan II/Dodge on the Creston Corridor may be a remnant of a larger eroded eystem. Bar, located 6 kilometres north of the Fors on the Sullivan Corridor, is on hold because of the depth to the active time horizon.

Recent developments have prompted the small group of explorationists who have specialized in the search for "Sullivan 2" to increase their level of confidence that persistence and geological breakthroughs will lead to a discovery of major proportions.



L E G E N D
LOWER BELT SEDIMENTS
GEOLOGIC CONTACT
FAULT
NORMAL
THRUST
BASIN AXIS
BRITISH COLUMBIA
ALBERTA
SULLIVAN MINE
Kimberley
BAR/LOOKOUT
SULLIVAN II
Cranbrook
Fors
Creston
ROCKY MOUNTAIN FRONT RANGE
CANADA
U.S.A.
GOATFELL
Kid/Star
MORNING GLORY
MONTANA
Coeur D'Alene
SHEEP CREEK
IRISH GULCH
Helena
IDAHO
Butte
BLACKBIRD MINE
HIGHLAND DEPOSIT
0 50 100 miles
0 80 160 km

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