PhD RESEARCH PROGRAMME FOR MR. DENNIS BROWN (BSc., MSc.)

TO: DEPARTMENT OF INDIAN AFFIARS AND NORTHERN DEVELOPMENT, WHITEHORSE, YUKON, CANADA

Structural controls on the massive sulphide deposits of the Anvil Pb-Zn District: A case study of the Vangorda deposit.

From:

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Jan 29th 1992

Aims

A three year PhD research programme by Mr. Dennis Brown, a Canadian, is currently under way to investigate the structural evolution of the Anvil District and the Pb-Zn-Ag massive sulphide orebodies in the district, in particular the Vangorda deposit.

The research programme aims are-

1). To define the structural geometry of the Vangorda orebody and the host rocks;
2). To determine the structural evolution of the Vangorda deposit;
3). To define the distribution of ore types and ore mineralogy and their structural relationships. To develop predictive models for the structural control and distribution of mineralisation;
4). To determine the nature of any alteration features and their relationships to structure;
5). To develop a genetic model for the Vangorda deposit - the origin and distribution of the sulphide mineralisation and the relationships to structure.
6). To undertake limited regional mapping on both the south and the north sides of the Anvil Batholith in order to gain an increased knowledge of the structural geometry of the Anvil District, and to determine the mechanisms of unroofing the Anvil Batholith.
7). Relate the structural style of the Vangorda deposit to the regional structural framework and provide structural and genetic models for the deposit that will help in future exploration.

Introduction

The Anvil District, central Yukon lies along the northern margin of the Cretaceous-Tertiary Tintina strike-slip fault system. Rocks in the district consist mostly of Late Precambrian through Mississippian-Permian parautochthonous platformal rocks that can be related to ancestral North America, and, along the southern flank, suspect allocthonous rocks of the Yukon-Tanana terrane.The parautochthonous rocks consist of poly-deformed greenschist to amphibolite facies metasediments and volcanics with of up to 5 km structural thickness. Five ductile deformations have been documented in the region. The first two deformations, D_1 and D_2, produced penetrative foliations (S_1 and S_2, respectively), ductile folding, and faulting. D_3 to D_5 produced minor folding

and steeply dipping crenulation foliations that deform S_1 and S_2.

The dominant structure in the region is a broad, doubly plunging antiform, the Anvil Arch, which is attributed to emplacement of the Anvil Batholith, uplift and associated ductile extensional faulting.

D_1 Deformation

D_1 deformation is documented by sparse outcrops of F_1 folds and their associated S_1 foliation. Where observed in outcrop F_1 folds are upright, close to isoclinal, with a subvertical axial planar S_1 foliation, and appear to verge consistently towards the northeast. The S_1 foliation is typically crenulated by a flat lying to shallowly southwest-dipping S_2 foliation.

The overall appearance of the first generation structural elements is consistent with that of a large, penetratively deformed thrust sheet or thrust nappe. The basal detachment to this thrust sheet has not been clearly identified on the south side of the Anvil Arch to date.

D_2 Deformation

D_2 deformation is characterised by a penetrative southwest-dipping foliation, S_2, and minor- to meso-scale, southwest-verging F_2 folds. F_2 folds are close to tight, typically similiar folds in which the limbs have been attenuated and the hinges thickened. F_2 folds commonly preserve the S_1 foliation in the hinge zones, whereas in the limbs S_1 is transposed into parallelism with the F_2 axial surface, making it difficult to determine which is S_1 and which is S_2.

Extensional Faulting. A number of extensional faults occur around the margins of the Anvil Batholith, most of which appear to link into the major extentsional fault in the district, the Tie Fault. These faults are zones of intense shearing and development of cataclasites and ultra-cataclasites with, locally, characteristic S-C bands. The amount of transport on these faults has yet to be determined, but is probably in the order of 1 - 3 km.

The D_2 structures and lithologies outlined above are characteristic of those common to metamorphic core complexes. In the Anvil District, they are associated with emplacement and uplift/unroofing of the Anvil Batholith.

D_3 - D_5 Deformation

D_3 to D_5 deformations are mostly developed as crenulation lineations on S_2 surfaces. Mesoscale, post D_2 folds do occur locally, but their relative ages are difficult to determine (i.e. D_3, D_4, or D_5). Care must be taken in assigning relative ages to these features since they are locally important

The Vangorda Deposit

The Vangorda Pb-Zn-Ag deposit is a small polydeformed, mid-greenschist facies strataform, stratabound massive sulphide orebody in the Anvil mining district. Geological reserves in the deposit are estimated at 7.1 million tonnes with a combined Pb + Zn grade of 7.7%. Rocks in the deposit have undergone both regional deformation events (i.e. D_1 and D_2), and, locally, post D_2 deformation.

The Vangorda deposit occurs 50 to 120 meters beneath the base of the Vangorda Formation. The orebody plunges shallowly towards the northwest and is interpreted to be structurally located in the hinge to overturned limb of a regional-scale F_2 fold. Syn- to post D_2 extensional faults truncate the deposit to the northwest and southeast. The deposit consists of a number of lenses of sulphide lithofacies of varying thickness in which the entire lithostratigraphic sequence may not always be present.

Metamorphic grade in the Vangorda deposit, recorded by muscovite-chlorite assemblages in the host rock phyllites, is sub- to mid-greenschist facies.

All rocks in the Vangorda deposit have been penetratively deformed and metamorphosed by D_1 and D_2 deformation events, making definition of any primary depositional features on a scale other than microscopic ambiguous at best. Direct evidence of F_1 folding is restricted to refolded folds in drill core and in pit wall exposures, suggesting that F_1 folding may play an important role in the present geometry of the deposit. In most lithofacies a S_1 pyritic banding is well developed on a scale of millimetres to centimetres. In phyllites and the ribbon banded, carbonaceous quartzite, S_1 is commonly preserved as lithons in the hinges of F_2 folds. In the more sulphide-rich lithofacies, however, S_1 is typically transposed subparallel to the F_2 axial surface.

The dominant fold phase in the Vangorda deposit is F_2. F_2 folds are shallowly east-west to northwest-southeast-plunging, tight to isoclinal (interlimb angle is commonly between 5 to 25 degrees) similar folds. F_2 fold morphology changes somewhat between different lithofacies as a result of relative competency and ductility contrasts between them, but in general a similar style is maintained.

In the surrounding phyllites, a penetrative sub-horizontal, wavy F_2 axial planar cleavage (S_2) is developed. In some sulphide lithofacies, such as the ribboned-banded, carbonaceous quartzite, a differentiated axial planar S_2 cleavage is also well developed. However, S_2 appears to be non-penetrative in the sulphides and is found only rarely in fold hinges. In high strain zones, S_1 banding in the sulphide lithofacies is discontinuous as a result of shearing and a new, inhomogeneous S_2 foliation is developed. In ore rocks with a S_2 foliation pyrite porphyroblast often grow across the foliation indicating post-S_2 pyrite growth.

Thin, discontinuous, anastomosing shear zones are widespread in the deposit, and are typically parallel to the S_2 orientation. Within these zones, massive pyrite has deformed by brecciation whereas other sulphides, such as pyrrhotite, sphalerite, and galena, have deformed by ductile mechanisms. As well, there is evidence that pyrite in these zones has altered to pyrrhotite, possibly inducing reaction enhanced ductility.

The Vangorda deposit is very strongly faulted by steeply northwest- to southeast-dipping brittle extensional faults that, together with F_2 folding, provide the dominant structural control on the present geometry of the orebody. All extensional faults examined truncate the S_2 cleavage and F_2 folds and therefore clearly post-date or are late D_2. Faults have an apparent offset of centimetres to (tens?) metres but, due to paucity of marker horizons, it is often impossible to determine the exact amount of offset on any one fault. Pyrite slickensides on polished fault surfaces typically have a shallow pitch angle suggesting a final strike-slip to oblique-slip phase of fault movement.

A number of low-angle, post-D_2, northeast-directed thrusts occur within phyllites in the southeast end of the deposit. These thrusts cut the S_2 cleavage, and locally the extensional faults, and have offsets ranging from centimetres up to several tens of metres.

Ore Lithofacies

The Vangorda deposit consists of a number of sulphide lenses of

varying thickness and bulk sulphide composition that are typically accompanied by a footwall biased phyllitic, muscovite-chlorite alteration zone. The salient features of each ore lithofacies in the Vangorda deposit are outlined below.

Ribboned-banded, carbonaceous, pyritic quartzite: a well banded, sulphide-bearing quartzite, with minor sphalerite and galena. Bands are on a millimetre- to centimetre-scale and consist of quartz-sulphides and carbonaceous quartzite. Pyrite grain size ranges from 0.1 mm to 1.0 mm.

Pyritic quartzite: consists predominantly of quartz with up to 40% pyrite and minor sphalerite and galena. These rocks have a moderate to poorly developed pyrite banding with, locally, a well developed micaceous (muscovite) foliation. Pyrite typically forms 0.1mm - 1mm sized porphyroblasts, with local coarse grained patches in which grain size reaches approximately 3.0 mm. Galena, and less commonly sphalerite, occur in coarse-grained patches with grain size ranging from 0.05 to 0.5mm.

Massive pyritic sulphides: these are typically massive pyrite with minor sphalerite, galena, pyrrhotite, and magnetite. Quartz, barite, and carbonates are disseminated throughout or occur in coarse aggregates.Total pyrite content varies from between 60% to close to 100% with grain size ranging from 0.1 to 1.5mm.

Baritic, massive pyritic sulphides: these consist predominantly of barite with pyrite, sphalerite, galena, with minor magnetite. Quartz and carbonate are major matrix components. Clasts of massive pyrite and phyllite are common. Total barite content varies but may be has high as 50 %.

As well as the above lithofacies, whose distribution are believed to be relics of primary depositional ore types, another lithofacies occurs in areas of high strain and is interpreted to be the result of metamorphic reactions and strain related mobilisation during deformation.

Pyrrhotite-sphalerite-pyrite-galena (breccia): this lithofacies is a variant of the pyritic quartzite in which the dominant sulphides are pyrrhotite and sphalerite with lesser pyrite, and galena. Coarse patches of sphalerite or galena are common. Pyrite typically occurs as 0.1 to 1.5mm-sized porphyroblasts and as isolated breccia clasts. These rocks are typically highly strained and often contain clasts of other rock types around which a well developed foliation anastomoses. Tailed clasts and rolling structures are common.

Research Programme

The research programme envisioned will employ an intergrated regional structural mapping program with a detailed structural and metamorphic analysis of the Vangorda deposit. This will provide an expanded understanding of the structural style and geometry, and metamorphism, of the Anvil District and their effects on the ore deposits in the district, in particular the Vangorda deposit. This research programme can provide constraints on possible genetic and structural models for the Anvil deposits that can be applied to both local and regional exploration targets.

The research programme will involve a detailed structural analysis on both the south and north sides of the Anvil Batholith to get a better understanding of the regional structural style and mechanisms of unroofing of the batholith. Throughout the study emphasis will be placed on determining the nature and effect of both D_1 and D_2 deformations and the subsequent overprinting relationships. Clearly the extent and structural style of the extensional fault system in the district is of extreme importance if the geometry of the district is to be elucidated. A regional understanding of these factors is deemed essential since they provide the structural control on the present geometries of the deposits in the Anvil District.

The research programme also involves a detailed structural analysis, mineralogical, geochemical and isotopic investigations of the Vangorda deposit.The structural analysis includes detailed mapping of open pit development and structural logging of drill core. Particular attention will be paid to definition of structurally homogeneous sub-areas, zones of intense fabric and shear zone development, and to definition of F_2 and F_3 fold zones. This programme is particularly relevant to determining the exact geometry of the orebody and determining the continuity and extent of deformation of the deposit. This will better enable the construction of more rigorously constrained cross-sections and the projection of structural data down-plunge. In addition detailed microstructural and fabric analyses will carried out to analyse the effects of deformation and metamorphism on the ore assemblages.The studies of the genesis of the deposit involves limited geochemical analyses of the mineralisation and host rocks, fluid inclusion and stable isotopic studies, combined with collation of existing data sets, to determine the effects of metamorphism and deformation on the primary ore body.

Timetable

The research programme will run for three years - 1991 to 1994. It will involve three extended periods of fieldwork at the Vangorda deposit and in the Anvil District with supervision by Dr. L.Pigage (Curragh Resources) and Prof. K.R. McClay (RHBNC). To date, two, three month field seasons have been carried out, in 1990 and 1991.

The research programme is being carried out in the Department of Geology, Royal Holloway and Bedford New College, University of London.

Personnel

The research student carrying out this project is Mr. Dennis Brown. His curriculum vitae is enclosed with this proposal. The project will be supervised by Prof. K.R. McClay in conjunction with Dr. Lee Pigage (Curragh Resources).

Finances

In order to successfully carry out the final phase of this research project the financial support necessary is sought from the DIAND. This is needed to support field work during the summer of1992. Details of field expenses are outlined below. Travel costs are sought for Dennis and Prof. McClay to return to Vangorda in the summer of 1992.

Dennis has a scholarship which covers his fees but does not provide adequate living support as the cost of living in London is very high (e.g. rent for a room for 1 week is approximately $120.00). Royal Holloway and Bedford New College does not operate a TA system as the PhD students are engaged full time on research. Therefore, a personal supplement for Dennis Brown is sought in the form of a salary for field work during the summer of 1992. Details of the financial support necessary is outlined below.

FINANCIAL SUPPORT SOUGHT FROM DIAND, 1992

1992	**Personnel - PhD Student**
Salary for 3 month field season	$9,500.00
Field expenses (food, fuel, etc)	$2,000.00
Truck rental (3 months)	$5,000.00
10 hours helicopter time	$7,500.00
Sub-Total	$24,000.00
Travel and Expenses	
Travel to Vangorda (Dennis and Prof. McClay)	$6,000.00
Sub-Total	$6,000.00
TOTAL	**$30,000.00**

Liaison

Close liaison is maintained with Curragh Resources, and it is therefore appropriate that Dr. Lee Pigage at Faro/Whitehorse be a joint supervisor of the project in order to monitor the progress of the research. Annual reports on the research programme have, and will continue to be presented to both Curragh Resources, DIAND, and the GSC, Whitehorse.

Curragh Resources, DIAND, and GSC will be provided with copies of the completed PhD thesis and with copies of all publications arising from this project. It is anticipated that the results of this research project will be presented to DIAND in the form of Open File reports, and contributions to Yukon Geology and Special Papers published by DIAND, and for GSC in the form of Current Research papers (see below for publications, reports, and seminars presents so far on this project).

Confidentiality

During the course of this project (3 years) confidential data released by Curragh for this research programme will not be communicated to a third party (parties) without express permission of Curragh Resources. During tenure of the project publication of such data can only be undertaken with full permission of Curragh Resources. Data collected whilst supported by DIAND and GSC will be presented in annual reports such as Yukon Geology and Current Research of the Geological Survey of Canada. Upon termination of the research project it is anticipated that the

results will be written up for open scientific publication.

Publications, Reports and Seminars

Brown, D., and McClay, K.R. (in review). Deformation textures in pyrite from the Vangorda Pb-Zn-Ag deposit, Yukon, Canada.Mineralogical Magazine.

Brown, D., and McClay, K.R. 1992. Structure of the Vangorda Pb-Zn-Ag deposit, Anvil Range, Yukon. *In* Current Research, Geological Survey of Canada, Paper 92-1a.

Brown, D., and McClay, K.R. 1991. Deformation textures in pyrite; an example from the Vangorda deposit, Yukon, Canada. (Abstract) Mineralogical Society of Great Britian and Ireland Annual Meeting, Program with Abstracts, p. 51-52.

Brown, D. Prelimary report on the macroscopic and microscopic structure of the Vangorda deposit. Report submitted to Curragh Resources, 1991.

Brown, D. Geology of the Vangorda Pb-Zn-Ag deposit, Yukon, Canada. Report submitted to the Industry Association, Royal Holloway and Bedford New College, 1991.

Brown, D. A structural analysis of the Vangorda deposit open pit. Report submitted to Curragh Resources, 1990.

Brown, D., and McClay, K.R. Deformation textures in pyrite; an example from the Vangorda deposit, Yukon, Canada. Paper presented at the Metamorphic Studies Group Annual Meeting, special session on Deformation and Metamorphism of Sulphides, Cardiff, Dec 16-18,1991.

Departmental Facilities

The Geology Department at Royal Holloway and Bedford New College has all the field and laboratory equipment necessary for the successful completion of this project. Analytical equipment include microprobe, scanning electron microscopes equipped with EDAX analysers, fluid inclusion apparatus, INNA, 2 x XRDs, 2 x XRFs, 3 x ICPs and two new VG Isotopes Mass Spectrometers - for stable and radiogenic isotopes. In addition the Department has an extensive range of rock and mineral preparation equipment, in house computing, digitising and plotting equipment

Additional Information

This research project is built upon the wide experience gained by Professor McClay on the geology of massive sulphide deposits in deformed terrannes including - Mount Isa, Australia; Sullivan, J&L and Salmo Camp in SE British Columbia; Driftpile and Cirque deposits of NE British Columbia; Tom, Howards Pass and Faro deposits, Yukon Territory; Buchans deposit Newfoundland and the Black Angel deposit, Greenland.

Recent Publications by Professor K.R. McClay,

Professor of Structural Geology, University of London, and Adjunct Professor, Memorial University of Newfoundland.

1981. K.R. McClay and N.J. Price. Thrust and Nappe Tectonics. Spec. Publ. 9, Geol. Soc. London, 544pp.

1981. K.R. McClay and M.P. Coward. The Moine Thrust Zone. An Overview. In Thrust and Nappe Tectonics, McClay, K.R. and Price, N. J. (eds.). Spec. Publ. 9, Geol. Soc. Lond., 241 - 260.

1981. K.R. McClay. What is a Thrust? What is a Nappe? In Thrust and Nappe Tectonics, McClay, K.R. and Price, N.J. (eds.). Spec. Publ. 9, Geol. Soc. Lond., 7 - 9.

1982. K.R. McClay. Fabrics in Deformed Ores. In Atlas of Deformational and Metamorphic Rock Fabrics. Springer Verlag, 376 - 383; 406 - 407.

1982. K.R. McClay. Sedimentary and Tectonic Structures in the Sulphide Orebodies at Mount Isa (Australia) and Sullivan (Canada). Trans. I.M.M. B91, B146 - 151.

1983. K.R. McClay. Fabrics of Deformed Sulphides. Sander Memorial Volume, Geol. Rundshau. 72, 1/2, 469 - 491.

1983. M.P. Coward and K.R. McClay. Thrust Tectonics of SW England. Jl..Geol. Soc. London, 140, 215 - 228.

1983. K.R. McClay. Structural Evolution of the Sullivan Orebody, Kimberley, British Columbia. Economic Geology, 78, 1393 - 1424.

1983. K.R. McClay and P.G. Ellis. Deformation and Recrystallisation of Pyrite. Min. Soc. 75th Anniversary Volume, 47, 527 -38.

1983. K.R.McClay. Deformation of Stratiform Lead-Zinc Deposits. Ch.. 8 in Sangster, D.F. (ed..) MAC Short Course Notes, Sediment Hosted Stratiform Lead-Zinc Deposits, 283 - 309.

1984. K.R. McClay and P.G. Ellis. Deformation of Pyrite. Economic Geology, 79, 400 -04.

1984. K.R. McClay. Mapping Geological Structures. Geological Association of Canada Short Course Notes 1, 225pp.

1984. K.R. McClay. Deformation of Stratiform Lead-Zinc Deposits, Case Histories. Geological Association of Canada Short Course Notes 2, 153pp.

1986. K.R. McClay and M.W. Insley. Structure and Stratigraphy of the Gataga Fold and Thrust Belt, Northeastern

British Columbia. Current Research, Geological Survey of Canada Paper 86-1A, 259 -264.

1986. K.R. McClay and M.W. Insley. Structure and Mineralisation of the Driftpile Creek area, Northeastern British Columbia (94 E/16, 94 F/14, 94 K/4, 94 L/1). in British Columbia Ministry of Energy Mines and Petroleum Resources, Geological Fieldwork 1985. Paper 1986 - 1, 343-350.

1986. K.R. McClay, Norton, M.G., Coney, P.J. and Davis, G.H. Collapse of the Caledonian Orogen and the Old Red Sandstone. Nature 323, 147 - 150.

1986. K.R. McClay and M.W. Insley. Duplex structures in the Lewis thrust sheet, Crowsnest Pass, Alberta. J. Structural Geology, 8, 911-922.

1987. K.R. McClay and P.G. Ellis. Geometries of extensional fault systems developed in model experiments. Geology, 15, 341 - 344.

1987. K.R. McClay, M.W. Insley, N.A. Way and R. Anderton. Stratigraphy and Tectonics of the Gataga area, Northeastern British Colombia (94E/16, 94F/14, 94K/4, 94L/1, 94L/7, 94L/8); in British Columbia Ministry of Energy Mines and Petroleum Resources, Geological Fieldwork 1986. Paper 1987 - 1,193 - 200.

1987. K.R. McClay and P.G. Ellis. Analogue Models of Extensional Fault Geometries. In Coward, M.P., Dewey, J.F. and Hancock, P.L. (eds.), Continental Extensional Tectonics, Spec. Publ. Geol. Soc. London 28, 109 - 125.

1987. K.R. McClay and G.E. Bidwell. Geology of the Tom Deposit, MacMillan Pass, Yukon Territory. In Morin, J. (ed.), Mineral deposits of the Northern Cordillera, CIM Special Volume 37, 100 - 114.

1987. K.R. McClay. Aspects of the Structural Geology of the Buchans area. in Buchans Geology, Newfoundland. R.V. Kirkham, (ed..) Geological Survey of Canada Paper 86 - 24, 47 - 59.

1987. M.G. Norton, K.R. McClay and N.A. Way. Tectonic Evolution of Devonian Basins of Northern Scotland and Southern Norway. Nor. geol. Tiddskr. 67, 323 -338.

1988. K.R. McClay. Mapping Geological Structures. Geol. Soc. London Handbook Series, Open University Press, 164pp.

1988. P.G. Ellis and K.R. McClay. Analogue Models of Listric Extensional Fault Systems. Journal of Basin Research, 1, 55 - 70.

1988. K.R. McClay, M.W. Insley and R. Anderton. Tectonics and Mineralisation of the Kechika Trough, Gataga area, northeastern British Columbia. in Current Research, Part A,

Geological Survey of Canada, Paper 88-1A. 1 - 12.

1988. K.R. McClay and James. P.R. 1988. Advanced Structural Geology for Mineral Exploration. Australian Mineral Foundation Course Notes, Vols. 1 & 2.

1988. K.R. McClay, James. P.R. and Lemon, N. 1988. Structural Geology for Petroleum Exploration. Australian Mineral Foundation Course Notes, Vols. 1 & 2.

1989. K.R. McClay, M.W. Insley and R. Anderton. Inversion of the Kechika Trough, Northeastern British Columbia, Canada. In: Cooper, M.A. and Williams, G.D. (eds..), Inversion Tectonics, Spec. Publ. Geol. Soc. London, 44, 235 - 257 .

1989. K.R. McClay. Analogue Models of Inversion Structures. In: Cooper, M.A. and Williams, G.D. (eds.) Inversion Tectonics, Spec. Publ. Geol. Soc. London, 44, 41 - 59.

1990. K.R. McClay. Physical Models of Structural Styles during Extension. in Balkwill and Tankard (eds). Extensional Tectonics and Stratigraphy of the North Atlantic Margins. AAPG Memoir 46, 95 - 110.

1990 K.R. McClay. Extensional fault systems in sedimentary basins. A review of analogue model studies. Marine and Petroleum Geology, 7, 206 - 233

1990 K.R. McClay. Deformation mechanics in analogue models of extensional fault systems. in Rutter, E.H. & Knipe, R.J. (eds) Deformation Mechanisms, Rheology and Tectonics, Geological Society of London Special Publication, 54,. 445 - 454

1991 K.R. McClay, D.A Waltham, A.C. Scott and A. Abousetta. Analogue and seismic modelling of listric fault systems. in Roberts, A., Yielding, G. & Freeman, B. (eds) The Geometry of Normal Faults. Spec. Publ. Geol Soc. London, 56, 231 - 239.

1991 K.R. McClay, T. Calon and A. Pope. Modern Structural Geology in Mineral Exploration, Vols I & II. CERR Short Course, Memorial University of Newfoundland.

1991 P.G. Buchanan and K.R. McClay. Analogue models of inversion structures. Tectonophysics, 188, 97 - 115

1991 K.R. McClay and A. Scott. Hangingwall deformation in ramp-flat listric extensional fault systems. Tectonophysics, 188, 85 - 96

1991 K.R. McClay. Deformation of stratiform, clastic hosted Zn-Pb (Barite) deposits in the northern Canadian Cordillera. Ore Geology Reviews, 6, 435 - 462.

1991 K.R. McClay. Thrust Tectonics; An Introduction, in McClay, K.R. (ed.) Thrust Tectonics, Chapman and Hall, v-vii.

1991	Lui Huiqi, K.R. McClay & D. Powell. Physical Models of Thrust Wedges. in McClay, K.R. (ed.) Thrust Tectonics, Chapman and Hall, 71-81.
1991	K.R. McClay and P.G. Buchanan. Thrust faults in inverted extensional basins. in McClay, K.R. (ed) Thrust Tectonics, Chapman and Hall, 93-104.
1991	K.R. McCLAY. Glossary of thrust tectonic terms, in McClay, K.R. (ed) Thrust Tectonics, Chapman and Hall, 419-433.
1991	K.R. McClay (ed.), Thrust Tectonics, Chapman and Hall, 447p.
1992	W.G. Higgs and K.R. McClay, Analogue sandbox modellinf of Miocene extensional faulting in the outer Moray Firth. Special Publication Geological Society of London (in press).
1992	D. Brown and K.R. McClay. Structure of the Vangorda Pb-Zn-Ag deposit, Anvil Range, Yukon. In Current Research, Geological Survey of Canada paper 92-1A.

Curriculum Vitae

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Education

1983 - 1988
BSc. (Hons. 1st class) in structural geology, Memorial University of Newfoundland.
Thesis Title: Thin-skinned, basement involved thrust tectonics in the Emma Lake area, Grenville Front zone, southwestern Labrador.

1988 - 1990
MSc. in structural geology, Memorial University of Newfoundland
Thesis Title: A structural analysis of northeast Gagnon Terrane, Grenville Front, southwestern Labrador.

Jan. 1991 - present
Presently enrolled in a PhD. programme at Royal Holloway and Bedford New College, University of London.
Thesis Project: The structure and genesis of the Vangorda massive sulphide deposit, Yukon, Canada.

Work experience in geology
Summer 1991
Detailed structural mapping and drill core logging of the Vangorda Pb-Zn deposit.

Summer 1990
Detailed structural mapping and drill core logging of the Vangorda Pb-Zn deposit, Anvil District, Yukon, Canada. Field work related to PhD. thesis.

Summer 1989
Detailed structural/metamorphic mapping of a metamorphic fold-thrust belt, Grenville Province, southwestern Labrador. Field work related to MSc. thesis.

Summer 1988
Detailed structural/metamorphic mapping of a metamorphic fold-thrust belt, Grenville Province, southwestern Labrador. Field work related to MSc. thesis.

Summer 1987
Senior field assistant, Geological Survey of Canada. Detailed structural/metamorphic mapping of the Grenville front fold-thrust belt, southwestern Labrador.

Fall 1987
Roadside outcrop mapping for Geological Association of Canada roadmap of Newfoundland.

Summer 1986
Junior field assistant, Newfoundland Department of Mines. Structural/metamorphic mapping of high grade terranes, Grenville Province, eastern Labrador.

As well as field work, I have been a teaching assistant in third and fouth year structural, metamorphic, and tectonics courses and field schools.

Scholarships and awards

Sealand Helicopter Scholarship. Provided helicopter support for work on honours thesis project.

Northern Sciences Training Program (NSTP) award. Provided financial support for work on honours thesis project.

NSTP award. Provided financial support for work on MSc. project.

NSTP award. Provided further financial support for work on MSc. project.

H.R. Peters Award for best undergraduate thesis in the Department of Earth Sciences, Memorial University, 1988.

First place in the Canadian Institute of Mining and Metallurgy national undergraduate BSc. thesis competition (geology), 1988.

"Special scholarship for studies in the sciences related to resource development". Provided personal financial support while working on MSc. thesis, 1989, 1990,1991,1992.

Rothemere Fellowship. Provides partial financial support and university fees for three years while undertaking PhD. studies.

Publications

BROWN, D., and Mason, R.A. (in prep.) Sectored extinction in almandine garnet. For submission to Canadian Mineralogists.

BROWN, D., Rivers, T., Calon, T.(in review). A structural analysis of a metamorphic fold and thrust belt, northeast Gagnon terrane, Grenville Province. Canadian Journal of Earth Sciences.

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