

ANTIQUITY OF THE OKANAGAN VALLEY

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These days many of us spend time contemplating what disaster is going to impact our beautiful planet next, and where it is going to hit? Earthquakes, volcanic eruptions, wild fires, hurricanes, tornadoes, tsunamis, landslides and floods, and even debris falling from space are seemingly daily occurrences, and front-page news. This is all the stuff of geologists but touch the lives of everyone on Earth at one time or another. The Okanagan has not escaped the evolutionary ravages of Mother Nature, and indeed here we find the most extreme kaleidoscope of events that have combined to create this gorgeous part of Canada. In fact, the antiquity of this valley is awesome, and it is of interest to trace the contributions of “pioneering” geologists and progress of geologic science in terms of our present understanding.

I would like to thank all the geologists, in geologist’s heaven, or still on Earth, that have contributed to the geology of the Okanagan.

Speaking of Heaven, I should explain that every geologist who finally manages to graduate, makes a deal with God. God says, “hey guy, or girl, get out there, do the best you can, and if you don’t really find what you are looking for, don’t worry about it. We have a special place in heaven for geologists where all the clouds have gold linings instead of silver...and a huge library with reports on what really and truly happened”!! That’s good enough for me, if I ever make it there.

I would like to acknowledge Andrew Okulitch and Bob Fulton, retirees of the Geological Survey of Canada, and John Greenough of Okanagan University College, for their hard work helping to make this summary actually presentable!

This summary is divided into three periods. The first one is the Age of Discovery dealing with earliest geological expeditions in southern British Columbia ending about the turn of the 20th Century. The second period is called the Age of Stabilization that takes us to about 1960. The principle activity here was the systematic mapping of geologic resources employing traditional and long established geologic theories. The third and final period is the Age of De-stabilization, which brings us to present day. The turning point between Stabilized geology and Destabilized geology, happened in the

1960's when the concept of plate tectonics and Continental Drift began to revolutionize geologic thinking.

AGE OF DISCOVERY

The driving force behind the Age of Discovery in British Columbia was the rapid but difficult development of rugged terrain, about which very little was known in BC. This involves the boundary survey between Canada and the United States, construction of the Brigade Trail, the Dewdney Trail, the Fraser-Caribou Trail, and the early surveys for the Canadian National and Canadian Pacific Railways. Much of this early work was also driven by the lust for gold.

All of the geologists during this phase were armed with Sir Charles Lyell's "Principles of Geology" published in 1833, and as of 1859, Charles Darwin's "Origin of Species", embodying the concepts of evolution. It was a time of only vague notions about the origin of the Earth, and quite restricted guidelines about what the rocks and their characteristics were telling us. Thus, for example, George Mercer Dawson, the first geologist to visit the Okanagan in 1877 on behalf of the Geological Survey of Canada, at first looked at all the glacial features of the area from the viewpoint of a biblical flood. Boulders strewn across the landscape were transported there not by glaciers but by ice floating and drifting in a great inland sea. But by 1887 this little man, he was no larger than a boy of twelve, had weak lungs and a hunched back, finished a remarkable reconnaissance of 164,000 square kilometres in western Canada and the Yukon, on horseback and by canoe. He then had a firm and correct grasp of the fact that thick extensive glaciers had affected all of the mountainous terrain. His maps, sketches and notes are still used today. UBC Press has published two volumes of the Dawson Journals that make fascinating reading.

The next geological pioneer was Reginald Daly. He took on the task to map the boundary terrain between the US and Canada through the Cascades and Rocky Mountains. He published a three-volume account in 1912. Anyone that has seen this boundary, a straight cleared line running along the 49th parallel, down valleys and over peaks, cannot help be overwhelmed with the immensity of this task. No helicopters, no computers, no air photographs, and no mosquito dope, made this a daunting task indeed. Nevertheless this mapping was the first to systematically outline the major

geologic formations right across the province forming the basis of the next advancement.

AGE OF STABILIZATION

The Geological Survey of Canada established in 1842, always struggling for funds, even to this day, figured large in the 19th Century. But the Survey's greatest contribution in the Okanagan began when systematic geologic mapping started in Canada. During the early part of the 20th Century, geologic mapping was given a major boost when paleontology became extensively employed. Paleontology is the study of fossils and for geologists certain fossils are time-markers. It became possible to begin to make sense of the layers and layers of rock by assigning ages to the rocks using fossils. Radiometric and isotopic dating, well known today and widely employed, did not exist. Thus the geologists of this period can be referred to as "stabilized" or in other words they practised traditional field geologic techniques employing comfortable concepts born of the 19th Century.

The first detailed geology in the Okanagan area was done on the silver deposits of Beaverdell by L. Reinecke, published as a Memoir in 1915. But even before that there was mining at Fairview and McKinney in the valley. The mines at Beaverdell produced silver, gold, lead, zinc and cadmium over a continuous production period of an astonishing 88 years! The search for more minerals spurred geologic mapping in between the World Wars. C.E. Cairnes completed the west half of the Kettle Valley map sheet in which the Okanagan was located, and Hugh Bostock mapped the Keremeos, Olalla and Okanagan Falls map sheets, all published in 1940 and 1941. It was not until this time that the complexity of the bedrock geology in the Okanagan became apparent. The main discoveries include the following:

1. The Okanagan Valley Faults were recognized. Rocks on either side of the valley do not match up.
2. The system of rocks now known generally as the Shuswap Metamorphic Complex of Precambrian age was mapped.
3. Hugh Bostock's work recognized sedimentary rocks abutting the Shuswap rocks and a major unconformity between the Permian Period and the Triassic Period, 350 to 250 million years ago.

4. Numerous granitic plutons and batholiths were recognized, all related to phases of igneous intrusion of then unknown origin and age. These igneous rocks underlie over half of the terrain in the Okanagan.
5. An extensive chain of explosive volcanics 50 to 60 million years old was recognized during this early work in the Okanagan.
6. Another volcanic episode 10 to about 2 million years ago, was also recognized on the uplands of the region. This was a much different volcanic event involving a great outpouring of highly fluid basalt from cracks and vents.

H.M.A. Rice of the Geological Survey of Canada began mapping bedrock of the north Okanagan in 1945. This work was continued in 1947 by Alex Jones who extended the work into the Monashee Mountains east of the valley.

Jones exemplified the toughness of early geologists and devotion to their science. His *modus operandi* was to work with 4 assistants (students). They would drive their truck to the end of one of the few roads that went into the mountains. From there, they would each take a pack with equipment and food for 8 to 10 days and run solo traverses into the mountains. They would arrive back at the truck exhausted and several pounds lighter, go back to town for several days of eating and sleeping to build up reserves, and then run another backpacking traverse. This was the way they spent the summers. On the second day of one of these solo traverses, Jones broke his leg. There were no portable radios at that time so help could not be called. Jones spent the next 8 days crawling back to the truck where he arrived on schedule. When head office heard of this incident, a memo went out banning solo traversing. This was a massive job undertaken when there were few roads and virtually no previous work except the notes of Dawson. Alex's work is still a major reference memoir for this part of the Okanagan.

Hugh Little, in 1958, re-mapped the Kettle Valley sheet and described the Okanagan Fault as "a chain of zigzag faults", probably the best description of this structure to date. Work on the Shuswap rocks of the south Okanagan about this time by UBC's John V. Ross and his students James S. Christie, Barry Ryan and Garry Medford revealed that these rocks have been

involved in at least three orogenic or mountain building processes. During some of these orogenies, great slabs of the Okanagan were folded on top of each other at great depth forming what are called nappes after the Swiss Alpine mountain system of nappes. The top part of these structures is now visible in the Okanagan, and the grandest feature is McIntyre Bluff just south of Okanagan Falls (Figure 1).

Just as the period of “Stabilization” was coming to a close, in the late 1950’s, Hugh Nasmith undertook mapping of the surficial or glacial geology of the Okanagan Valley, including the south Okanagan. A Provincial Government group that was to become the Geological Survey of British Columbia did this. The white silt bluffs of the valley had long ago attracted the casual attention of numerous and famous geologists, such as Flint, but it was left to Nasmith to explain the incredible diversity of the Okanagan landscape. Hugh’s work, published in 1962, still stands as the key terrain map in the Okanagan that is referred to for numerous contemporary investigations. Of special interest is that Hugh likened the valley to the fjords of Norway that have been deeply gouged by solid rivers of powerful glaciers. Indeed, later work proved him correct when seismic and drilling revealed that bedrock below the lake is at an astounding depth of –640 meters (2100 feet) below sea level. Over 90 cubic kilometres of glacial sediment occurs in the lake including sections that are over 750 meters thick. After completing this landmark work, Hugh joined Thurber Engineering and led that company to world-class status.

Stuart Holland completed a synthesis of British Columbia’s landforms in 1964 that included physiographic divisions of the Okanagan. This work is still one of the main sources of general geologic information for the Province.

AGE OF DESTABILIZATION

The Age of Destabilization had its long and agonizing birth in the 1950’s, in the Caribbean and Atlantic Ocean, of all places. It was here that first Arthur Holmes, then the American Harry Hammond Hess from Princeton University recognized a world-encircling fracture system and spreading process on the ocean floors. But it was a Canadian group including J. Tuzo Wilson along with F.J.Vine and D.H. Mathews, and separately Lawrence Morley, that explained the strange paleomagnetic signature of the volcanic belts on each side of these fractures. They found

that the belts closest to the fracture system were very young, and the further away they got the belts were older and older. Thus, it was realized that the fracture systems were in reality ocean floor spreading centers. The ocean floor was spreading at remarkable rates, the latest phase beginning nearly 200 million years ago. As it spread it started to push continents apart. Today we know this revolutionary geologic concept as Plate Tectonics, and it is still going on but at a reduced rate comparable to the growth of finger nails.

At last geologists had found the energy source that uplifted mountain ranges, drifted exotic terrains and plastered them onto the edges of unsuspecting continents. As some parts of the ocean floor were folded or sunk beneath continents, sediments and water were dragged down too and melted at great depth in what are known as subduction zones. We have one beneath the west coast in British Columbia. This material, being relatively light, reforms and melts at depth and punches through crustal rocks on the continent. This explains, finally, the widespread granitic plutons and batholiths of the Okanagan and the Coast Range Mountains, for example.

Geologists had to completely re-organized their approach and “way of thinking”, which is the reason that this is called the Age of Destabilization, a term playfully introduced by Athol Sutherland Brown. By the late 60’s plate tectonics began to be considered in every aspect of geologic studies over the entire world, including of course the Okanagan. Some, like Neil Church of the BC Geological Branch, working in the White Lake basin in the south Okanagan, got caught in the early stages of destabilization. Despite this Church went on to elucidate the vast array of Tertiary volcanics in the Okanagan Valley. Towering explosive volcanic eruptions plagued the Okanagan 50 to 60 million years ago, the results of which can still be recognized in mountains such as Dilworth, Grouse, Black Knight, Boucherie, Layer Cake Hill, Giants Head, Knox, and others. Neil’s maps so far are the most detailed in the Okanagan at a scale of 1:50,000.

Church also documented a major pre-historic river in southern BC. The river is represented by the White Lake Formation that developed during the waning phases of Tertiary volcanism. The river deposited up to 1000 meters of conglomerate, sandstone, siltstone and lignite interspersed with volcanic conglomerate and tuff beds, in an early Okanagan valley system that still is not well enough mapped. But in the Okanagan this north-flowing massive river served to infill a great rift valley that clearly must have existed in early Tertiary time. The river finally buried some of the volcanic

landscape. Near the end of this river's life, swamps formed represented now by widespread but thin coal layers...the first forests of the Okanagan!

During the late 1950's helicopters began to enjoy widespread use by the geologic mappers, allowing great strides in mapping on much improved topographic maps. Paleontology became even more important, and the growing field of radiometric age dating of igneous rocks was becoming routine. This was also a time of revolution in the field of geophysics when seismic surveys, magnetic, electromagnetic, gravity and sonar surveys, on land and at sea, began to gain substantial sophistication and allowed geologists to look deep below the surface. Also, extensive coverage of aerial photographs provided a far more accurate base on which to map. It was also during this time that the age of the Earth was finally revealed through the study of meteorites and man's first step on the moon. The space age also introduced satellite photographs to the tool box of geologists. Taken all together, it was in many ways a giant leap for most geologists to get tuned into the new "destabilized" era!

The profound implications of the Triassic unconformity, discovered by Bostock much earlier were not too well understood until Peter Read and Andrew Okulitch (also a student of John Ross) of the Geological Survey of Canada in 1976 published their remarkable analysis of this geologic catastrophe in the Mount Kobau area. This terrane probably originated somewhere in the Pacific Ocean 1000 kilometers west of North America.

Lest we forget, Brenda Mines went into production of molybdenum and copper in 1968 near Peachland. It pioneered the development technology of low-grade large tonnage mineral deposits in an open pit that had world-wide application. It generated a total of \$800 million dollars locally and for its shareholders before a rockslide in 1990 brought the mining to a sudden end.

Turning once again to the glacial history, Robert Fulton of the Geological Survey of Canada was arriving in the area just as Hugh Nasmith was wrapping up his work. He worked in the southern interior of BC from 1960 until 1972, covering an area that stretched from Merritt east to the Kootenay valley. Ideas developed during his studies considerably altered views on what was happening during the advance and retreat of glaciers in central British Columbia. He and his co-workers, in addition to mapping the surface materials, laid out a fascinating history indicating glaciers covered

southern British Columbia at least four times during the past 2 million years. He liked the Okanagan Valley so much that on retirement he moved to Westbank where he remains active today.

During the 70's and 80's, the mysterious rock of the Shuswap Metamorphic Complex was tackled by a number of workers. Not many were up to the complexities presented in the Okanagan. Working from Vernon to Clearwater and on to Valemount and McBride, Dick Campbell and Andrew Okulitch unravelled some of the secrets of these rocks. Okulitch went on to make this group of rocks his special project. His synthesis was published in 1984 and in the opinion of this geologist, it is one of the most important geologic studies relevant to the Okanagan from that time.

About the same time Dirk Templeman-Kluit, then with the Geological Survey of Canada, began a re-map of the Okanagan's Penticton map sheet that includes Kelowna. Adapting quite nicely into the destabilized era, Dirk and Dave Parkinson of UBC postulated that the Okanagan fault was a surface of great extension of the land. What is definitely an unusual event they postulated that terrane on the west part of the lake slid off a slowly rising core of Shuswap rocks that affected the entire spine of the Monashee Mountains. The uniform structure of what he called the Okanagan Gneiss (a part of the Shuswap complex) was one proof of this rise and extension. The magnitude of the sliding was possibly 100 kilometers, although there is no general agreement on this. Still...that's a lot of real estate that we in British Columbia owe to this major fault movement! The Shuswap rocks, referred to as Monashee Gneiss in the book "Okanagan Geology" (by yours truly and John Greenough and many others) were formed by heat and pressure at depths of 15 to 20 kilometers. They flowed upward as the crust was stretched. Cooler rocks at the surface were brittle and broke into fault systems that can be seen today. Some time in the Tertiary Period molten granitic rocks invaded these rocks, and their age was reset in this process.

Through the work of Okulitch, Templeman-Kluit, John Wheeler, Monger, Parish and others, we at least now know a great deal more about the metamorphic rocks of Precambrian age in the Okanagan. At one time they represented the edge of an ancient North American continent that had its own complex history, related to a largely unknown period of earlier plate tectonic activity. I have been informed that in the last ten years the ancient margin is becoming even better known through work by Bob Thompson of

the Geological Survey of Canada, and Phillippe Erdmer and students at the University of Alberta.

The extensive plateau basalts capping the highlands of the Okanagan were of special interest to the tireless and brilliant Bill Mathews of the University of British Columbia. These volcanics range in age from 2 to 10 million years. They erupted out of fissures and were very fluid-like. The flows inundated all of the shallow ancient valleys of a central rolling upland surface that had formed in the Okanagan by that time. Beneath these lavas, in places, uranium deposits were precipitated in river gravels of the ancient valleys. Mathew's work was published in 1988.

About this time also Peter Christopher of the BC Geological Survey made a special study of the uranium deposits in the Okanagan Highlands. Ken Daughtry, a long time consultant in Vernon spent his life searching for mineral deposits in the Okanagan, and did contract mapping for the Geological Survey of Canada. One of his interests was the occurrence of placer gold in the ancient riverbeds of the uplands of the Okanagan. Ken, just before his untimely death last year (2004), mapped the bedrock of the Harper Valley Ranch area just to the north of Kelowna on the west side of the lake. This work confirmed that marine carbonate rocks of Carboniferous age (the Cache Creek group) mapped by High Little also occurred to the north bringing into question some aspects of plate tectonics in the Okanagan.

The Age of Destabilization was so profound that by 1980 geologists in North America decided that everything should be revised. Hence, the Geological Survey of Canada joined the Geological Society of America, in what they referred to as "The Decade of North America Geology". Some geologists refer to this period as the "Decade of No Actual Geology" (because it involved appraisals of previous geology rather than new geology)! This resulted in 20 comprehensive volumes (15000 pages) covering all aspects of geology of North America, Greenland and adjacent ocean and sea basins. The reports kept coming into the early 1990's. Chris Yorath, J.W. Monger, and Jack Souther also contributed with various papers bringing other destabilized geologists up to date on the Plate Tectonics of the Province.

John Wheeler of the Geological Survey of Canada took on the task of leading the Canadian contribution to that Decade. Hugh Gabrielse and Chris Yorath, both of the Geological Survey of Canada, spearheaded preparation

of the 800+ pages of the Cordilleran (includes British Columbia) volume published in 1992. Andrew Okulitch did the Arctic and Greenland part of the compilation. As part of this work a number of new compilation maps were prepared for the Canadian Cordillera; J.O. Wheeler along with P. McFeely prepared a "Tectonic Assemblage Map" of the Cordillera, Peter Read, Glen Wadsworth and several others a "Metamorphic Map", and Bill Mathews a new "Physiographic Map". This work, which is the first explanation of British Columbia geology taking plate tectonics into account, is the starting point for any one who is seriously interested in the geology of the area. In addition to the bedrock geology syntheses, John Clague of the Geological Survey of Canada (now with Simon Fraser University) compiled a 95 page synthesis of the glacial geology of British Columbia for the Quaternary of Canada volume, published in 1989, part of the Decade of North American Geology series.

As the 21st century approached the Canadian geosciences community mounted another major project called Lithoprobe. From 1980 to 2003 a multidisciplinary team of geologists and geophysicists conducted deep seismic reflection probes of the crust below the Cordillera and other parts of Canada. Scientists are still working on the significances of their findings. So some "actual work" was done!

With all of these world-class destabilization studies going on, mapping of the bedrock geology and surficial geology in the Okanagan, real geology, and probably the whole of Canada, appears to be suffering a Cinderella type of existence at the present time. Nothing new has been done for at least fifteen years in the Okanagan! Having said this, I am happy to announce that the Geological Survey of Canada is returning to the Okanagan to launch a major project studying the surficial geology and groundwater resources of the valley over the next three years. Very recently, in February of 2005, an entire issue of the Canadian Journal of Earth Sciences has been devoted to a comprehensive review of Early Tertiary geologic features of the Okanagan Highland based on plant, insect and fish fossil remains in rocks of Eocene age.

Well into the 21st Century destabilized geologists in the Okanagan are heading three ways. First, they are choosing detailed research on micro-corners of the plate tectonic concept using highly technical and state of the art instrumentation to further our understanding. The more they know, the

more there is to know. Secondly, they have started to collect and analyze more closely, previous work.

Thirdly, is the global warming issue. Great barrels of money and geoscientific effort have been funnelled into this new arena in the last ten years. We are just emerging from the Little Ice Age of the 18th Century, so part of the global warming is a natural trend. As a matter of fact a great deal of glacier ice still has yet to melt to reach a sea level that is even close to the high sea level of the Sangamon Interglacial interval 120,000 years ago. This will take an astounding six meters of sea level rise world wide to achieve. Our efforts to reduce greenhouse gas emissions are not in vain, however. If nothing else the air we breathe will at least be cleaner, and we might save some gas money. But, really, who knows what health effects on the human body are related to the tons of carbon dioxide from our automobiles and sulphur dioxide churned out in the multitude of industrial plants across the planet? What we really need are medical doctors to study these impacts and their cure.

Last but not least is the issue of clean and adequate water supplies in the Okanagan. A conference on this subject just concluded in Kelowna. Everyone hopes that the politicians are listening. For at least the last ten years the need for more research and sustainable environmental planning of water resources has been heralded by a number of geologists and engineers, including yours truly. Of special concern is the health of our watersheds, and the integrity and inventory of groundwater supplies, and of course our beautiful lake. Hopefully we can look forward to some attention to this during the next three years.

Casting back for a moment to George Dawson and his early concept of ice bergs floating in an inland sea, it is interesting to note that today's destabilized geologists are now setting entire continents adrift across a molten interior. Has there really been any "progress" here?

More seriously, we are poised in the Okanagan to be endowed with a real university. But there is some question whether or not the geological sciences will gain a prominence in this institution that it sorely needs and deserves. We would like to have the local capability to produce professional level graduates in this important science. Is this going to happen? Of thirty new staff planned, not a single one is a geologist! Even in the existing department there are only two geologists! Yes, two! Despite this, the

department, mainly under the long-term leadership of John Greenough, has produced over half of the peer-reviewed publications in science at the “College” over the last fifteen years. Now that is an accomplishment!

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