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Major features[edit] Physiographic divisions of the western United States include three mountain systems: Physiographic divisions of Mexico include three mountain systems: This cordillera extends from the U. The North American Cordillera includes some of the highest peaks on the continent. For example, the Laramide orogeny changed the topography of the central Rocky Mountains and adjoining Laramide regions from central Montana to central New Mexico during the Late Cretaceous 80 million years ago. Further topographical evolution occurred during the Eocene 55â€"50 million years ago and Oligocene 34â€"23 million years ago , but since that time the region has been relatively stable. The Nevadan belt runs up and down the middle of the North American Cordillera. Therefore, the intermontane areas of the cordillera can be divided up into the areas east of the Nevadan belt, and those west of the Nevadan belt. Pacific Coast Belt[edit] Main article: Along the British Columbia and Alaska coast, the mountains intermix with the sea in a complex maze of fjords , with thousands of islands. On the inland side of the Boundary Ranges are the Tahltan and Tagish Highlands and also the Skeena Mountains , part of the Interior Mountains system, which also extend southwards on the inland side of the Kitimat Ranges. Of the three subdivisions, the Pacific Ranges are the highest and are crowned by Mount Waddington , while the Boundary Ranges contain the largest icefields, the Juneau Icefield being the largest. The Kitimat Ranges are lower and less glacier-covered than either of the other two groupings, but are extremely rugged and dense. The Coast Mountains are made of igneous and metamorphic rock from an episode of arc volcanism related to subduction of the Kula and Farallon Plates during the Laramide orogeny about million years ago. The California Coast Ranges are one of the eleven traditional geomorphic provinces of California. This province includes several â€" but not all â€" mountain ranges along the California coast the Transverse Ranges, Peninsular Ranges and the Klamath Mountains are not included. Nevadan belt[edit] The Nevadan belt is located between the Pacific coast belt and the Laramide belt. Nevada means "snow-covered" in Spanish. These ranges are the Cariboo Mountains , which are the northernmost and sometimes considered to be part of the Interior Plateau, the Selkirk Mountains , the Purcell Mountains , and the Monashee Mountains. There are many named subranges of all four subgroupings, particularly in the Selkirks and Monashees. The southward extension of the Selkirks, Purcells and Monashees into the United States are reckoned to be part of the Rocky Mountains and the designation Columbia Mountains is not used there the Purcells, also, go by the name "Percell Mountains" in the United States. The Salish and Cabinet Mountains south of the Kootenai River are essentially part of the same landform, but are officially designated part of the Rocky Mountains in the United States. To the west of the Monashees and Cariboos, there are three intermediary upland areas which are transitional between the mountain ranges and the plateaus flanking the Fraser and Thompson Rivers. These â€" the Quesnel , Shuswap and Okanagan Highlands , are sometimes considered as being part of the neighbouring ranges rather than the plateaus and are often spoken of that way locally but are formally designated as being part of the Interior Plateau. The southernmost extends into the Washington, where it is named by the American spelling Okanogan Highland and was the first-named of these groupings. It consists of non-volcanic and volcanic mountains: The small portion of the Cascade Range in Canada is called the Cascade Mountains or Canadian Cascades, and in its southwestern area is similar in terrain to the area north of Glacier Peak , known as the North Cascades , and its northern and eastern extremities verge on the Thompson Plateau in a less rugged fashion than in most other parts of the range. The North Cascades are very different in character from the series of high volcanic stratovolcanoes from Rainier southwards to Mount Shasta and Lassen Peak , and is more severely alpine and steeply rugged, particularly the Skagit Range. Inland portions of the range are dryland and plateau-like in character, e. The Sierra Nevada forms an inland mountain spine of northern California, extending from the terminus of the Cascade Range south of Lassen Peak southwards along the east flank of the Central Valley of California to the Transverse Ranges , forming a mountain region of complex terrain and varied geology which separates the Central Valley from the Great Basin to the east. From east to west, the Sierra is wedge-shaped: The high plateau that is formed by the range is cut by deep river valleys. It is named for the Laramie Mountains of eastern Wyoming in turn named for Jacques La Ramee , a trapper who disappeared in the Laramie Mountains in and was never heard from again. Major subranges include the British Mountains and Richardson Mountains , towards their eastern end, and at their farthest west is the small subrange that De Long Mountains. The Brooks Range is considered part of or an extension of the Rockies. Rocky Mountain System in contiguous U. The United States definition of the Rockies includes the Cabinet and Salish Mountains of Idaho and Montana, whereas their counterparts north of the Kootenai River , the Columbia Mountains , are sometimes considered a separate system lying to the west of the huge Rocky Mountain Trench which runs the length of British Columbia. The Mexican Plateau lies to the west of the range. Intermontane areas seaward from the Nevadan belt[edit] The Nevadan belt runs down the middle of the North American Cordillera. Therefore, the intermontane areas can be divided up into the areas east of the Nevadan belt, and those west of the Nevadan belt. It is bordered on the south by the Canadian Cascades and on the north by the Thompson River. The Okanagan Highland is described as being a hilly plateau, and is located in southern British Columbia and northern Washington. Portion in contiguous U. Its northern half is referred to as the Sacramento Valley , and its southern half as the San Joaquin Valley. The two halves meet at the huge Sacramento-San Joaquin River Delta of the Sacramento and San Joaquin Rivers, which along with their tributaries drain the majority of the valley. The general orientation of the Trench is almost uniformly pointing north. Some of its topography has been carved into glacial valleys , but it is primarily a byproduct of faulting. For convenience the Rocky Mountain Trench may be divided into northern and southern sections. The dividing point reflects the separation of north and easterly flows to the Arctic Ocean versus south and westerly flows to the Pacific Ocean. In one of various usages, the term " Columbia Basin " refers to more or less the same area as the Columbia Plateau. It is an extremely arid region characterized by basin and range topography. It is a large arid-to-semiarid plateau that occupies much of northern and central Mexico. A low eastâ€”west mountain range in the state of Zacatecas divides the plateau into northern and southern sections. These two sections, called the Northern Plateau Spanish: Mesa del Norte and Central Plateau Spanish: Mesa Central , are now generally regarded by geographers as sections of one plateau.

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A tectonic synthesis chapter and a summary of outstanding problems round out the volume. Accompanying plates include physiographic, tectonic assemblage, terrane and metamorphic maps, correlation charts, structural cross sections, and special maps showing distribution of Proterozoic and Miocene plutonic suites and the metallogeny of terranes.

Pyrometasomatic, tactite, or contact metasomatic Au deposits. Gold-dominant mineralization genetically associated with a skarn gangue consisting of Ca - Fe - Mg silicates, such as clinopyroxene, garnet and epidote. The vast majority of Au skarns are hosted by calcareous rocks calcic subtype. The much rarer magnesian subtype is hosted by dolomites or Mg-rich volcanics. On the basis of gangue mineralogy, the calcic Au skarns can be separated into either pyroxene-rich, garnet-rich or epidote-rich types; these contrasting mineral assemblages reflect differences in the hostrock lithologies as well as the oxidation and sulphidation conditions in which the skarns developed. Most Au skarns form in orogenic belts at convergent plate margins. They tend to be associated with syn to late island arc intrusions emplaced into calcareous sequences in arc or back-arc environments. Most deposits are related to plutonism associated with the development of oceanic island arcs or back arcs, such as the Late Triassic to Early Jurassic Nicola Group in British Columbia. The unusual magnesian Au skarns of Western Australia are Archean. Gold skarns are hosted by sedimentary carbonates, calcareous clastics, volcaniclastics or rarely volcanic flows. They are commonly related to high to intermediate level stocks, sills and dikes of gabbro, diorite, quartz diorite or granodiorite composition. Economic mineralization is rarely developed in the endoskarn. The I-type intrusions are commonly porphyritic, undifferentiated, Fe-rich and calc-alkaline. Variable from irregular lenses and veins to tabular or stratiform orebodies with lengths ranging up to many hundreds of metres. Rarely, can occur as vertical pipe-like bodies along permeable structures. Igneous textures in endoskarn. Coarse to fine-grained, massive granoblastic to layered textures in exoskarn. Fractures, sill-dike margins and fold hinges can be an important loci for mineralization. The gold is commonly present as micron-sized inclusions in sulphides, or at sulphide grain boundaries. To the naked eye, ore is generally indistinguishable from waste rock. Due to the poor correlation between Au and Cu in some Au skarns, the economic potential of a prospect can be overlooked if Cu-sulphide-rich outcrops are preferentially sampled and other sulphide-bearing or sulphide-lean assemblages are ignored. The ore in pyroxene-rich and garnet-rich skarns tends to have low Cu: They generally have a high sulphide content and high pyrrhotite: Mineral and metal zoning is common in the skarn envelope. At Nickel Plate for example, this comprises a narrow proximal zone of coarse-grained, garnet skarn containing high Cu: Au ratios, and a wider, distal zone of finer grained pyroxene skarn containing low Cu: Au ratios and the Au-sulphide orebodies. They generally have a low to moderate sulphide content and low pyrrhotite: They generally have a moderate to high sulphide content with low pyrrhotite: Olivine, clinopyroxene Hd , garnet Ad , chondrodite and monticellite. Retrograde minerals include serpentine, epidote, vesuvianite, tremolite-actinolite, phlogopite, talc, K-feldspar and chlorite. Extensive exoskarn, generally with high pyroxene: Prograde minerals include diopsidic to hedenbergitic clinopyroxene Hd , K-feldspar, Fe-rich biotite, low Mn grandite garnet Ad , wollastonite and vesuvianite. Other less common minerals include rutile, axinite and sphene. Late or retrograde minerals include epidote, chlorite, clinozoisite, vesuvianite, scapolite, tremolite-actinolite, sericite and prehnite. Extensive exoskarn, generally with low pyroxene: Prograde minerals include low Mn grandite garnet Ad , K-feldspar, wollastonite, diopsidic clinopyroxene Hd , epidote, vesuvianite, sphene and apatite. Late or retrograde minerals include epidote, chlorite, clinozoisite, vesuvianite, tremolite-actinolite, sericite, dolomite, siderite and prehnite. Abundant epidote and lesser chlorite, tremolite-actinolite, quartz, K-feldspar, garnet, vesuvianite, biotite, clinopyroxene and late carbonate. At the QR deposit, epidote-pyrite and carbonate-pyrite veinlets and coarse aggregates are common, and the best ore occurs in the outer part of the alteration envelope, within 50 m of the epidote skarn front. Moderate endoskarn development with K-feldspar, biotite, Mg-pyroxene Hd and garnet. Endoskarn at the epidote-rich QR deposit is characterized by calcite, epidote, clinozoisite and tremolite whereas at the Butte Highlands Mg skarn it contains argillic and propyllitic alteration with garnet, clinopyroxene and epidote. In temperate and wet tropical climates, skarns often form topographic features with positive relief. The ore exhibits strong stratigraphic and structural controls. Orebodies form along sill-dike intersections, sill-fault contacts, bedding-fault intersections, fold axes and permeable faults or tension zones. In the pyroxene-rich and epidote-rich types, ore commonly develops in the more distal portions of the alteration envelopes. In some districts, specific suites of reduced, Fe-rich intrusions are spatially related to Au skarn mineralization. Ore bodies in the garnet-rich Au skarns tend to lie more proximal to the intrusions. Many Au skarns are related to plutons formed during oceanic plate subduction. There is a worldwide spatial, temporal and genetic association between porphyry Cu provinces and calcic Au skarns. Pyroxene-rich Au skarns tend to be hosted by siltstone-dominant packages and form in hydrothermal systems that are sulphur-rich and relatively reduced. Magnesian subtype can be associated with porphyry Mo deposits L05 and possibly W skarns K In British Columbia there is a negative spatial association between Au and Fe skarns at regional scales, even though both classes are related to arc plutonism. Fe skarns are concentrated in the Wrangellia Terrane whereas most Au skarn occurrences and all the economic deposits lie in Quesnellia. Most Au skarns throughout the world are calcic and are associated with island arc plutonism. The intrusions related to Au skarns may be relatively enriched in the compatible elements Cr, Sc and V, and depleted in lithophile incompatible elements Rb, Zr, Ce, Nb and La , compared to intrusions associated with most other skarn types. Airborne magnetic or gravity surveys to locate plutons. Induced polarization and ground magnetic follow-up surveys can outline some deposits. Any carbonates, calcareous tuffs or calcareous volcanic flows intruded by arc-related plutons have a potential for hosting Au skarns. Favorable features in a skarn envelope include the presence of: Any permeable calcareous volcanics intruded by high-level porphyry systems particularly alkalic plutons have a potential for hosting epidote-rich skarns with micron Au. During exploration, skarns of all types should be routinely sampled and assayed for Au, even if they are lean in sulphides. These deposits range from 0. Nickel Plate produced over 71 tonnes of Au from The QR epidote-rich Au skarn has reserves exceeding 1. Recently, there have been some significant Au skarn deposits discovered around the world e. Buckhorn Mountain, Wabu, Fortitude. Nevertheless, total historic production of Au from skarn more than 1 t of metal is minute compared to production from other deposit types. The Nickel Plate deposit Hedley, British Columbia was probably one of the earliest major Au skarns in the world to be mined. An Overview and Geological Study; B. Geological Survey , Circular , pages Geological Survey, Circular , page Geological Survey, Open File Report , 50 pages. Skarns in British Columbia;, B. Gold Bearing Skarns; U. Geological Survey; Bulletin , 61 pages.

Chapter 3 : North American Cordillera - Wikipedia

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The first interval, lasting for about years, was one of simply trying to determine what was there. The epic canoe, foot and horse traverses of Hector, Dawson, McConnell, Selwyn, Daly and many others, together with early mineral exploration in the Yukon, Cariboo, Atlin and Kootenay districts gradually led to a comprehension of our geological inventory. The discovery of oil beneath the plains of Leduc, Alberta in resulted in extensive exploration by petroleum companies throughout the Rockies and Mackenzie Mountains. Coal and base metal mines added considerably to the economy of British Columbia as did the Department of Geology at the University of British Columbia whose outstanding and memorable staff supplied the Cordillera with an incredible array of talent. This first stage ended in when Bill White of the University of British Columbia published his benchmark paper entitled Cordilleran Tectonics in British Columbia, the first attempt at a regional synthesis of much of the Cordillera invoking classical geosyncline and orogenesis theory White, The second stage began with the development of modern plate tectonic theory and the widespread use of helicopters to conduct regional reconnaissance mapping which had begun during the mids. Regional helicopter reconnaissance surveys such as Operations Stikine, Mackenzie, Liard, Nahanni, Porcupine and Bow-Athabasca added vastly to our knowledge of the orogen and permitted the second synthesis to be published by Jim Monger, Jack Souther and Hu Gabrielse Monger et al. Perhaps as a reflection of the mobilist versus stabilist arguments that characterized the initial stages of the plate tectonics revolution, the third stage, towards the end of which we currently find ourselves, is a time of reassessment. During the past two decades the formulation of the terrane concept and proposals for their large-scale translations have led to differences in championed tectonic histories between proponents of precise measurement and experimentation, and those who prefer geological inference based on stratigraphic and structural field observations. To the extent that the answers will undoubtedly be found by each of these approaches, and not necessarily by compromise, we must await the post Decade of North American Geology years to witness the next chapter in the developmental history of geoscientific ideas in the Canadian Cordillera. During his return trip in up the river that bears his name, near the modern community of Fort Norman he noted several smokes along the shore and experienced a very sulphurous smell and at length discovered that the whole bank was on fire for a very considerable distance. He concluded that it proved to be a coal mine,to which the fire had communicated from an old indian encampment. The locality comprises a series of bocannes within Early Tertiary alluvial fan deposits that include lignite and pyroclastics. Serious geological observations began in when James Hector, a physician and naturalist attached to the first CPR route expedition led by Captain John Palliser, made observations on the stratigraphy of the southern Rockies and recorded the first observations of coal deposits on Vancouver Island. Comprehensive studies of the Cordillera began in the s by Dawson and McConnell. A far-ranging reconnaissance journey by these two men in and provided the initial geological information on the northern Cordillera, including much of northern British Columbia and the Yukon where the respect and affection of the people for George Dawson is expressed in the name of one of its most important communities. Work in the Cariboo region in the s by Amos Bowman set the foundation for subsequent mapping in a geologically complex area where, 20 years previously, a major gold rush spurred efforts of the McDonald government to persuade this distant territory to join our ever quarrelling confederation. In the late s much geological survey activity arose from mineral exploration in the Klondike, elsewhere throughout the Yukon and in the Atlin and Kootenay districts of British Columbia. Names such as Joseph Keele, W. Gwillim made lasting contributions, some of which were superceeded only three decades ago. Also important was D. The first was R. Similar surveys some three decades earlier across the American Cordillera by Clarence King and John Wesley Powell had recognized the same fundamental divisions, thus allowing for J. The other survey was C. Between and mapping in the southern Cordillera was conducted by many geologists who, in later years, were to attain international recognition as university researchers and teachers, men such as N. Bowen, author of the Bowen reaction series of igneous petrogenesis, R. Daly who went to Harvard, and A. Bateman who, while at Yale University, wrote his famous textbook on economic geology which became the standard text for many years. Two frequent visitors of note were C. The former drew attention to the remarkably well preserved, soft-bodied fauna in the Lower Cambrian Burgess shale near Field in the southern Rockies, a locality which has since been designated as a World Heritage site by the United Nations. The latter conducted several seasons of fieldwork on southern Vancouver Island and was the first to define the basic stratigraphic and tectonic elements of the southern Insular Belt. Regional studies in the Stikine region by F. Kerr were supported by student assistants who themselves made significant contributions to Canadian geology, people such as Cliff Lord and Stu Holland, the former becoming Chief Geologist of the Geological Survey of Canada GSC in the early s and the latter, Chief Geologist of the British Columbia Survey at the end of that decade. In the north, W. Cockfield carried out diverse studies in the Yukon, mainly in mineral districts such as Keno Hill and Galena Hill. Bostock became the best-known geologist in the Yukon as a consequence of his extensive mapping program, his reports on the mineral industry and through his contacts with mining and exploration personnel. He greatly advanced our knowledge of the physiography and physiographic development of the northern Cordillera and his maps and reports continue to serve as valuable guides to placer and lode exploration. One of the most interesting examples of integrated industry and government exploration took place during the early stages of the Second World War in the Mackenzie and Franklin Mountains region of the Northwest Territories. In recognition of the strategic importance of the Norman Wells oil field which had been discovered and developed during the s, in early a cooperative exploration and development project, called the CANOL Project, to increase the known limited reserves was undertaken by the Geological Survey of Canada and the United States Navy under the direction of the late Ted Link of Imperial Oil. Although the threat to American coastal oil supplies was abrogated during the first week of June of the same year at the Battle of Midway, the project went ahead and produced forty reports, several maps and at least one vast fortune as a consequence of the cost - plus 20 per cent construction of the CANOL pipeline from Norman Wells to Fairbanks, Alaska. In oil was discovered beneath the plains of Leduc Alberta and a year later the blowout of Atlantic No. The Geological Survey and several oil companies intensified exploration in the Rockies during which Digby McLaren and Helen Belyea established stratigraphic and biostratigraphic correlations between the exposed Upper Devonian reefs in the mountains with their producing equivalents in the subsurface of the plains. At the same time structural, stratigraphic and biostratigraphic studies were conducted by Con Hague, Frank McLearn and Bob Douglas, the latter chosen to be the editor of the edition of Geology and Economic Minerals of Canada. It was these studies in the Foreland Belt that provided the impetus for the large, helicopter-supported reconnaissance mapping projects undertaken by petroleum companies and the GSC in the late s and s. Kindle, Con Hague, M. Williams and Cliff Lord. A reconnaissance study of the northern Rockies and Cassiars by Mat Hedley and Stu Holland of the British Columbia Survey emphasized the profound lithological discordance between the two areas and illustrated the great areal extent of Mesozoic granitic rocks in the Cassiars. Detailed structural studies in the southern Omineca Belt by Mat Hedley and Jim Fyles led to the recognition of large recumbent folds involving the entire regional stratigraphic assemblage, the first of such structures to be recognized west of the Foreland Belt. Following the appointment of R. Brock, formerly Director of the Geological Survey of Canada, in as Dean of Applied Science, many outstanding teachers and researchers joined the Department of Geology. Williams as professor of paleontology and Henry Gunning, one of the greatest professors of economic geology of his time. Several major oil companies carried out regional helicopter-supported reconnaissance projects throughout the entire length of the Foreland Belt. At the same time the GSC began several projects in western Canada, one of the largest being Operation Stikine which, in , covered six 1: The British Columbia Survey continued its detailed studies of mineral districts but also conducted investigations of regional scope. The work of Gerry Henderson in the Stanford Range of the Rockies in the early s resulted in the first clear picture of stratigraphy and structure in the westernmost part of the southern Foreland Belt. Geoff Leech, in a study of the Shulaps ultramafic body, recognized the importance of the Yalakom fault, later seen to be one of the most important terrane-bounding faults in the Cordillera. This was the first regional synthesis of Cordilleran geology and the first attempt to outline its complete evolution. Naturally it was based upon classical geosynclinal and stabilist hypotheses which remained essentially unassailed until August of when, in the Bulletin of the Geological Society of America, Arthur Raff and Ronald Mason published their famous magnetic anomaly map of the Juan de Fuca Plate Raff and Mason, The early years of the second century of Cordilleran geology were crowded with many exciting events. Although the stage had been set for the onslaught of the mobilist hypothesis in , when Ted Irving and Keith Runcorn independently published two important papers confirming the theory of continental drift, it was not until the years between and when Fred Vine, Drummond Mathews, Larry Morely, Andre Larochelle and John Tuzo Wilson explained the origin of the magnetic signature of the ocean floors and provided the interpretive support for the brilliantly intuitive ideas of sea-floor spreading and plate tectonics that had been proposed by Harry Hess of Princeton University at the beginning of the decade. Meanwhile, back in the Canadian Cordillera life went on. Atholl Sutherland Brown completed his work on the geology and mineral deposits of the Queen Charlotte Islands and to the south, Jan Muller was well along in his mapping of Vancouver Island. Helicopter-supported reconnaissance operations such as Bow-Athabasca led by Ray Price in the southern Rockies, and Operation Norman led by Jim Aitken in the District of Mackenzie essentially completed the reconnaissance mapping and establishment of the basic geological framework of the Cordillera as described in by the 5th Edition of Geology and Economic Minerals of Canada, edited by Bob Douglas. The realization of the basic geological framework of the Cordillera was much enhanced in the mids with the near simultaneous recognition of its five-belt architecture by John Wheeler and Atholl Sutherland Brown. Without this fundamentally simple architectural model which arose from some years of mapping, the current concepts about which we are arguing today could not have been developed. Moreover, were it not for the work of some remarkable paleontologists such as George Jeletzky, Hans Freebold, Tim Tozer and Howard Tipper, the understanding of this architecture would not have been achieved. Although the first seismograph was established in Victoria in it was not until the early s when other types of geophysical studies began. Earthquake on the west coast, and who later fathered the tumultuous birth of the Pacific Geoscience Centre in The necessary corollary to this observation was that the strata of the miogeocline had been detached from their basement and moved hundreds of kilometres eastwards. What caused the shortening was not to become clearly evident until a decade later. This synthesis, published in , was based upon plate tectonic principles wherein four of the five belts were shown to have developed through the superpositional accumulation of oceanic assemblages such as oceanic crust and island arcs Monger et al. Although each succession was thought to have developed in response to oceanic tectonic processes such as subduction, the concept of crustal mobilism and the realization of the significance of the many prominent northwesterly trending faults was to wait yet more years, in spite of the fact that in the following year, Jim Monger and Charlie Ross published their now classic paper on the Tethyan fusulinacean faunas of the Intermontane Belt. Although all found these results interesting, many tended to drift along, arriving at eight, departing at five, as though careless of the approaching bandwagon that was hurtling down Pender Street toward the Tower of the Sun [Ed. An exception was the tireless Dick Armstrong who continued to amass the enormous volume of geochronologic and isotopic data that was soon to become so fundamental to the understanding of the tectonic development of our beloved mountains. The line became a household word. Continental crust, oceanic crust, depleted mantle, calcalkaline, tholeiitic, MORBs and a host of other acronyms punctuated our language, which somehow had become disorganized and in need of an idea. That idea came in November of with the unfortunate name of Wrangellia. Big and small, fat and thin, suspect or tectonostratigraphic, they continue to tantalize us in much the same way as does the elusive Universal Theory linking the four fundamental forces of nature. From where have they come? How far have they moved? When and how did they collide with ancestral North America? Only interim answers are being proposed, some more forcefully than others. Tilt versus translation, Middle Jurassic and mid-Cretaceous versus Eocene: The people of the Cordillera are my heroes. Collectively they form a cult. Their language is expressed in contractions, is often metaphoric, and, to the uninitiated, utterly unintelligible. Their altars are rocks, their season is summer and their children tend to have birthdays in June. What distinguishes them from most others is their consuming passion for what they do. They long for summer when the mountains will ring with the blows of their hammers, when helicopters will carry them through the sky. They will gaze from windswept peaks and see continents in collision, entire oceans created and destroyed. They will lose themselves in time. Evolution of the Canadian Cordillera:

Chapter 4 : Notes and references | Burke Museum

www.nxgvision.com: Geology of the Cordilleran Orogen in Canada (Geology of Canada Series: No. 4) (): it is also Geology of North America volume G No.

Subduction , Plate tectonics , and Continental collision Two processes that can contribute to the formation of orogens. Subduction of lithospheric plate to mantle depths. The two processes lead to differently located metamorphic rocks bubbles in diagram , providing evidence as to which process actually occurred at convergent plate margins. Typically, continental crust is subducted to lithospheric depths for blueschist to eclogite facies metamorphism, and then exhumed along the same subduction channel. Generally, orogenic belts consist of long parallel strips of rock exhibiting similar characteristics along the length of the belt. Although orogenic belts are associated with subduction zones, subduction tectonism may be ongoing or past processes. The subducting tectonism would consume crust , thicken lithosphere, produce earthquake and volcanoes, and build island arcs in many cases. On the other hand, subduction zones may be reworked at a later time due to lithospheric rifting, leading to amphibolite to granulite facies metamorphism of the thinned orogenic crust. The processes of orogeny can take tens of millions of years and build mountains from plains or from the seabed. The topographic height of orogenic mountains is related to the principle of isostasy , [9] that is, a balance of the downward gravitational force upon an upthrust mountain range composed of light, continental crust material and the buoyant upward forces exerted by the dense underlying mantle. Orogenic processes may push deeply buried rocks to the surface. Sea-bottom and near-shore material may cover some or all of the orogenic area. If the orogeny is due to two continents colliding, very high mountains can result see Himalayas. An orogenic event may be studied: An orogeny produces an orogen, but a mountain range-foreland basin system is only produced on passive plate margins. The foreland basin forms ahead of the orogen due mainly to loading and resulting flexure of the lithosphere by the developing mountain belt. A typical foreland basin is subdivided into a wedge-top basin above the active orogenic wedge, the foredeep immediately beyond the active front, a forebulge high of flexural origin and a back-bulge area beyond, although not all of these are present in all foreland-basin systems. The basin migrates with the orogenic front and early deposited foreland basin sediments become progressively involved in folding and thrusting. Sediments deposited in the foreland basin are mainly derived from the erosion of the actively uplifting rocks of the mountain range, although some sediments derive from the foreland. The fill of many such basins shows a change in time from deepwater marine flysch -style through shallow water to continental molasse -style sediments. Wilson cycle Although orogeny involves plate tectonics , the tectonic forces result in a variety of associated phenomena, including crustal deformation, crustal thickening, crustal thinning and crustal melting as well as magmatism , metamorphism and mineralization. What exactly happens in a specific orogen depends upon the strength and rheology of the continental lithosphere, and how these properties change during orogenesis. In addition to orogeny, the orogen once formed is subject to other processes, such as sedimentation and erosion. The Caledonian Orogen resulted from these events and various others that are part of its peculiar orogenic cycle. Every orogeny has its own orogenic cycle, but composite orogenesis is common at convergent plate margins. Erosion[edit] Erosion represents a subsequent phase of the orogenic cycle. Erosion inevitably removes much of the mountains, exposing the core or mountain roots metamorphic rocks brought to the surface from a depth of several kilometres. Isostatic movements may help such exhumation by balancing out the buoyancy of the evolving orogen. Scholars debate about the extent to which erosion modifies the patterns of tectonic deformation see erosion and tectonics. Thus, the final form of the majority of old orogenic belts is a long arcuate strip of crystalline metamorphic rocks sequentially below younger sediments which are thrust atop them and which dip away from the orogenic core. An orogen may be almost completely eroded away, and only recognizable by studying old rocks that bear traces of orogenesis. Orogens are usually long, thin, arcuate tracts of rock that have a pronounced linear structure resulting in terranes or blocks of deformed rocks, separated generally by suture zones or dipping thrust faults. These thrust faults carry relatively thin slices of rock which are called nappes or thrust sheets, and differ from tectonic plates from the core of the shortening orogen out toward the margins, and are intimately associated with folds and the development of metamorphism. Even at a very early stage, life played a significant role in the continued existence of oceans, by affecting the composition of the atmosphere. The existence of oceans is critical to sea-floor spreading and subduction. Note the white Madison Limestone repeated, with one example in the foreground that pinches out with distance and another to the upper right corner and top of the picture. Mountain formation occurs through a number of mechanisms. Older inactive orogenies, such as the Algoman , Penokean and Antler , are represented by deformed and metamorphosed rocks with sedimentary basins further inland. Areas that are rifting apart, such as mid-ocean ridges and the East African Rift , have mountains due to thermal buoyancy related to the hot mantle underneath them; this thermal buoyancy is known as dynamic topography. In strike-slip orogens, such as the San Andreas Fault , restraining bends result in regions of localized crustal shortening and mountain building without a plate-margin-wide orogeny. Hotspot volcanism results in the formation of isolated mountains and mountain chains that look as if they are not necessarily on present tectonic-plate boundaries, but they are essentially the product of plate tectonism. Regions can also experience uplift as a result of delamination of the orogenic lithosphere , in which an unstable portion of cold lithospheric root drips down into the asthenospheric mantle, decreasing the density of the lithosphere and causing buoyant uplift. This range of fault-block mountains [24] experienced renewed uplift due to abundant magmatism after a delamination of the orogenic root beneath them. Mount Rundle , Banff, Alberta. Mount Rundle on the Trans-Canada Highway between Banff and Canmore provides a classic example of a mountain cut in dipping-layered rocks. That left Rundle with one sweeping, tree-lined smooth face, and one sharp, steep face where the edge of the uplifted layers are exposed. This was an extension of Neoplatonic thought, which influenced early Christian writers. Orogeny was used by Amanz Gressly and Jules Thurmann as orogenic in terms of the creation of mountain elevations, as the term mountain building was still used to describe the processes. Elie de Beaumont used the evocative "Jaws of a Vise" theory to explain orogeny, but was more concerned with the height rather than the implicit structures created by and contained in orogenic belts. His theory essentially held that mountains were created by the squeezing of certain rocks. Eduard Suess recognised the importance of horizontal movement of rocks. The concept of a precursor geosyncline or initial downward warping of the solid earth Hall, prompted James Dwight Dana to include the concept of compression in the theories surrounding mountain-building. The cooling Earth theory was the chief paradigm for most geologists until the s. It was, in the context of orogeny, fiercely contested by proponents of vertical movements in the crust similar to tephrotectonics , or convection within the asthenosphere or mantle. Gustav Steinmann recognised different classes of orogenic belts, including the Alpine type orogenic belt, typified by a flysch and molasse geometry to the sediments; ophiolite sequences, tholeiitic basalts, and a nappe style fold structure. In terms of recognising orogeny as an event, Leopold von Buch recognised that orogenies could be placed in time by bracketing between the youngest deformed rock and the oldest undeformed rock, a principle which is still in use today, though commonly investigated by geochronology using radiometric dating. Based on available observations from the metamorphic differences in orogenic belts of Europe and North America, H. Zwart [28] proposed three types of orogens in relationship to tectonic setting and style: Cordillerotype, Alpinotype, and Hercynotype. His proposal was revised by W. Pitcher in [29] in terms of the relationship to granite occurrences. Notice that both accretionary and collisional orogens developed in converging plate margins. In contrast, Hercynotype orogens generally show similar features to intracratonic, intracontinental, extensional, and ultrahot orogens, all of which developed in continental detachment systems at converged plate margins. Accretionary orogens, which were produced by subduction of one oceanic plate beneath one continental plate for arc volcanism. There is a general lack of ophiolites, migmatites and abyssal sediments. Typical examples are all circum-Pacific orogens containing continental arcs. Collisional orogens, which were produced by subduction of one continental block beneath the other continental block with the absence of arc volcanism. Orogenic peridotites are present but volumetrically minor, and syn-collisional granites and migmatites are also rare or of only minor extent. Typical examples are the Alps-Himalaya orogens in the southern margin of Eurasian continent and the Dabie-Sulu orogens in east-central China.