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GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7477

Geology, Chinook West, British Columbia

G.S. Stockmal and M.E. McMechan (compilers)

2015

Canada

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Publications in this series have not been edited; they are released as submitted by the author.

Geology, Chinook West, British Columbia; GSC Open File 7477

G.S. Stockmal and M.E. McMechan (compilers)

Preamble

Portions of this document are common to all three Chinook compilation maps: Chinook North (GSC Open File 7475; McMechan and Stockmal, 2015), Chinook South (GSC Open File 7476; Stockmal and Fallas, 2015), and Chinook West (GSC Open File 7477; Stockmal and McMechan, 2015). Although released as separate products, from the perspective of geological interpretation these maps should be viewed as seamless, and used in conjunction with each other.

Summary

The Chinook GIS compilation map series, compiled at a nominal scale of 1:100 000 on 1:50 000-scale topographic base maps, comprises three GSC open files that encompass twenty-six 1:50 000-scale map sheets in the Rocky Mountains and Foothills of southwestern Alberta and southeastern British Columbia. Source maps and other data used in compilation include GSC and provincial survey maps and reports, published page figures, unpublished thesis maps, unpublished GSC field notes, aerial photos, and field maps, as well as new spot field checking. Revision and reinterpretation during compilation also involved extensive use of Google Earth™ and traditional aerial photograph imagery.

The most intensive revisions or reinterpretations of source maps and other data within the Chinook West map sheet were made to the following areas or features:

- The feature formerly mapped as the Hosmer Thrust sheet is reinterpreted as at least two or possibly three distinct fault slices, where the underlying thrusts merge structurally upward with a regional, locally back-thrust, detachment horizon in the Fernie Formation.
- The Gypsum Fault is reinterpreted as a folded, east- to southeast-dipping, and dominantly foreland-directed detachment fault.
- The “veritable sinkhole of disappearing faults” described by Leech (1962) reflects the juncture of faults merging upward from below, and splaying upward from, the Gypsum Fault detachment zone.
- The overall structure from Mount Broadwood, through the Lizard Range and the Three Sisters to Mount Hosmer, is that of a blind thrust stack, where the upper detachment lies in the Fernie Formation, and the lower detachment lies below the Middle Aldridge Formation in the south but in the Gypsum Fault detachment in the north. Linkage between the two lower detachment levels may occur along the Bull Canyon and Dibble Creek faults.

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Introduction

The Chinook GIS compilation map series comprises Geological Survey of Canada open files 7475 (McMechan and Stockmal, 2015), 7476 (Stockmal and Fallas, 2015), and 7477 (Stockmal and McMechan, 2015). Together, these maps span the Rocky Mountains and Foothills of southwestern Alberta and southeastern British Columbia, from 49˚00'N to 50˚30'N (see the Index Map on each open file PDF). The name "Chinook" is derived from the Chinook Municipal District of the southern Foothills region of Alberta. Chinook Peak (2591 m; 49˚35"10"N, 114˚36'30"W), in the Flathead Range south of Crowsnest Pass near the centre of the combined map areas, was officially named in 1962 on the suggestion of Dr. R.A. Price of the Geological Survey of Canada (GSC). The name Chinook Peak had been informally applied by a local lifelong resident of Crowsnest Pass who could tell from snow and wind conditions on the mountain that a "chinook", strong warm winds that arrive abruptly in the winter, was imminent.

The Chinook map series was initially inspired by the 1:100 000-scale compilation map of Kananaskis Country by McMechan (1995), which abuts the Chinook North map on its northwestern edge. The physical size of mappable structures and formation-level stratigraphy in the southern Rocky Mountains and Foothills is very well suited to representation at a map scale of 1:100 000. This scale affords a high level of map detail as well as a sufficiently broad regional view to display the context and relationships of mapped features.

Although the nominal scale of the Chinook maps is 1:100 000, the data and interpretations have been compiled on 1:50 000-scale base maps, and can generally be considered precise at least to that level. However, in numerous instances where source maps are at a finer scale, or where original observations were made at the scale of aerial photographs (e.g., 1:20 000), the interpretations reflect this wherever possible The user should be aware that only a subset of geological features or observations in the databases may be displayed on the map PDF. For example, although 540 stations are shown on the PDF of Chinook West as strike-and-dip symbols, out of 663 stations in the database (i.e., more than 80%), only 2183 out of 7539 (less than 30%), and only 2340 out of 12,433 (less than 20%), are shown on the PDF maps of Chinook South and Chinook North, respectively.

The nucleus for the Chinook map series was the set of GSC bedrock maps in the southern Alberta Foothills produced between 1994 and 2003 by the Eastern Cordilleran NATMAP project (see details in documentation accompanying GSC OF 7475 and OF 7476). These NATMAP products were originally released only as hardcopy print-on-demand open file maps. The Chinook GIS maps also incorporate other pre-existing hardcopy maps, digitized specifically for this compilation effort, augmented with more recent work where appropriate (such as thesis maps, provincial government reports, spot field checks, etc.). These as well as the NATMAP maps have been variously reinterpreted during the compilation effort. The original GIS map compilation project included only Chinook South (OF 7476) and Chinook North (OF 7475), each comprising twelve 1:50 000-scale map sheets. However, during the course of the compilation effort the need to address structures that entirely encompass the Fernie Basin became clear, which led to production of the Chinook West map (OF 7477; comprising two 1:50 000-scale map sheets). The Chinook map compilation was originally an activity in the Petroleum Assessment and New Exploration Concepts (PANEC) Project of the Secure Canadian Energy Supply (SCES) Program.

Accompanying Files

The content of each Open File dataset is outlined in the accompanying *Readme.rtf* file. Of particular interest to the GIS user is the CGM documentation in *Bedrock Mapping Geodatabase Data Model v3_1.pdf* and *Bedrock Mapping Geodatabase Domains v3_1.pdf*. If applicable, addendums are included to define and explain any additions or changes to data structure or content in any of the datasets. The user should also be aware that the GIS files contain a greater variety and amount of supporting data than can be shown on the .pdf version of the map. This is particularly true for the Chinook South and Chinook North open files.

Chinook Series Data Sources

All map and other data sources for the Chinook West map appear in the reference list, below. Also, the *Sources* Shape files (see the *\Data\SHP\Bedrock* folder in the accompanying dataset for each Chinook series map) contain polygons that delimit the map area for each source of information or data, as applicable. See extensive details regarding data sources for the Chinook South and Chinook North compilation maps in their corresponding background documents.

Interpretations and observations were digitized from scanned and georeferenced raster images. Line work and structural attitudes, with corresponding attribute and original source information, were compiled as features in ArcGIS Geodatabases, which are released here as Shape files and ArcGIS Geodatabases in the XML Workspace Document format (for details, see accompanying documentation that defines the data structure and content). Confidence levels in interpretation of line work, such as faults or geological contacts being identified as defined, approximate, or assumed, have generally been compiled as shown by the original authors, where possible. Note, however, that differences between map vintages, and indeed differences in various authors' usage of these terms, may have resulted in some inconsistencies in the final compilation. Original sources can and should be consulted if necessary.

Published Maps and Page Figures

Published bedrock geology maps in the Chinook West map area that contain primary source data for the Chinook West compilation include: Leech (1958, 1960), Hoy and Diakow (1982), Hoy and Carter (1988), McMechan (1979), and Price (2013). Published page figures incorporated into the map are restricted to Figure 3 of Leech (1962), which contains structural details in the vicinity of the confluence of the Bull River with Dibble and Iron creeks. Incorporation of, or revisions to, these maps are detailed below.

When the Chinook compilation maps were conceived it was anticipated that the digital line work from Price (2013; GSC Map 2200A), then in early stages of production, would be utilized for parts of Chinook South and Chinook North. However, because the compilation base map for Price (2013) is at a scale of 1:250 000, substantial generalizations of the geology were made by R.A. Price in comparison to the original source maps, and there was no discrimination of map confidence level for faults and contacts, Price (2013) was used only for updating structural interpretations in select areas, or where select plotted structural attitudes had not been previously published. With respect to the Chinook West map,

Price (2013) was consulted during compilation but was used as a data source only for Jurassic to Lower Cretaceous contacts east of the Elk Valley (westernmost portion of Fernie Basin), and fault traces, contacts, and one structural attitude, in the vicinity of Wardner, B.C., in the Rocky Mountain Trench.

Unpublished Theses, Guidebooks, and Other Data Sources

Unpublished thesis data and maps incorporated into the Chinook West compilation include: Benvenuto (1978; 1:25 000 scale, with 1:50 000 scale compilation maps), McMechan (1980; 1:50 000 scale), Stretch (1997; 1:20 000 scale), and Larson (2004; 1:20 000 scale); all were supervised by R.A. Price (Queen's University). Unpublished guidebooks used for the annual SIFT (Student-Industry Field Trip) excursion organized by the Canadian Society of Petroleum Geologists have incorporated a map and cross-sections depicting interpretations of the Hosmer Thrust by K.G. Root. His generalized map contains some structural elements that have been incorporated into the Chinook West map.

Sets of original or photocopied field notes, aerial photographs, and hand-coloured field geological maps pertaining to portions of the Chinook compilation map areas were submitted for archival purposes to the GSC by R.A. Price in 2013. This extensive set of material included original aerial photographs, some annotated or with overlays, used by G.L. Benvenuto (Benvenuto, 1978; Ph.D.), G.W. Stretch (Stretch, 1997; M.Sc.), and K. Larson (Larson, 2004; M.Sc.). Photocopies of the field notes of G.W. Stretch were also included. These materials were consulted as necessary during compilation to resolve, as best as possible, discrepancies or oddities between structures interpreted in various map vintages by various authors.

The Traces feature class includes locations of published or publicly available geological cross-sections and seismic lines that were discovered and compiled for the Chinook map project. All publically available cross-sections and seismic lines known at the time of publication are included, with source references (28 traces for Chinook West). In some instances, these were used to inform map interpretations.

Map Compilation Approach

Stratigraphy

The approach taken for the Chinook map series was to preserve, at an appropriate scale, the mapped extents of units as they appear in the primary source maps, but with updated labeling or naming of these units. For the Chinook West map specifically, some groupings of finely sub-divided units mapped by Benvenuto (1978) were made. The bounding lines for all changes in nomenclature are indicated on the Chinook maps, and are distinct features in the databases. These often occur at map boundaries (where they commonly reflect the vintage of mapping), but also occur where there are changes in mapping precision (as along or away from extensive stream exposures), or changes in application of stratigraphic subdivision.

The expanded Map Legend (Sheet 2) accompanying each Chinook open file map is designed to assist the user in understanding both the changes in nomenclature and changes in mapping precision where they

occur explicitly on the maps, as discrete bounding lines, and also the changes that occur implicitly where units may be grouped or subdivided from one structural slice to another. Note that a few formation-level units in the expanded Legend are shown without an associated colour. These are units that do not occur as discrete polygons on the maps, but are included for completeness, showing the user all formation-level units that are represented by grouped units.

As noted in the Descriptive Notes on the Chinook West map PDF, this area encompasses dramatic along-strike changes in Cambrian stratigraphy. These changes are accompanied by the abrupt northwestward appearance, principally across the Dibble Creek Fault, of both older and younger strata (see section "Sub-Devonian stratigraphy and associated structures", below). The Dibble Creek, Bull Canyon, Boulder Creek, and other associated faults have complex histories including reactivation (e.g., Price, 1972a; Benvenuto and Price, 1979; McMechan and Price, 1982).

Structural Geology

Structural geology interpretations from Chinook West source maps were incorporated into the compilation by georeferencing and digitizing, in ArcMap, scanned high-resolution images. All features were digitized directly into appropriate geodatabase feature classes, and scientifically and topologically edited. The principal changes made to source map interpretations during compilation are listed below.

For the Chinook West map, compilation of the detailed 1:25 000 scale mapping of Benvenuto (1978) and Stretch (1997) required some simplifications or generalizations locally. Although the positions of stratigraphic contacts were generally followed as mapped, numerous tightly spaced fold hinge surfaces were excluded or otherwise generalized. Similarly, not all closely spaced minor faults are included in the compilation. Structural attitudes from all source maps were selectively chosen for the compilation to be representative of the mapped structure, and to indicate to the user those areas where direct observations were made. The user should refer to the original source maps for comparison.

PRINCIPAL CHANGES – CHINOOK WEST

Principal changes made to source maps during compilation of Chinook West are detailed below. They are generally organized in an east-to-west order and by the principal structural or stratigraphic elements that are bounded by major faults or detachments. These details are intended to assist the user in determining where the compilation maps differ substantially from the source maps (users should also refer to the Sources feature class in the database). These changes and their justifications will be addressed in greater detail elsewhere.

Numerous revisions to named features were made during the compilation exercise. In some cases this involved major changes to or even elimination of these features in some areas. The names of features that were changed or eliminated appear below in quotation marks and italic font (e.g., *"Lizard segment"*) to distinguish them from named features on the Chinook West compilation map.

Note that there were numerous instances where faults or contacts were modified to varying degrees to better conform to the compilation base maps, or to better match aerial photo or Google Earth™ imagery

observations. These modifications generally reflect: (1) differences in topographic bases of original source maps and the most current bases; (2) errors discovered during the compilation process where the most recent source maps did not honour firm observations or other details of earlier source maps or field observations; or (3) instances where the dip of strata across the topography were not well represented on the source maps, as confirmed by consulting aerial photographs or Google Earth™ imagery. In most instances, those contacts or faults that were modified include a statement to that effect in the "Remarks" feature attribute.

Fernie Basin, east of Elk River

Price (2013) was used as the source of stratigraphic contacts of Jurassic to Early Cretaceous units east of the Elk River Valley, with very minor modification to accommodate the 1:50 000-scale topographic base. In addition to these contacts from Price (2013), the Chinook West compilation map shows the inferred trace of a foreland-directed thrust, the Natal Lookout Thrust (see trace through 49°29'00"N, 115°02'26"W), which thickened the Fernie Formation in accordance with the interpretation shown on the Chinook South map (see brief discussion in the Chinook South background document). West of but sub-parallel to the trace of the Natal Lookout Thrust is a concealed detachment fault (see trace through 49°29'00"N, 115°04'01"W) that is inferred to also thicken the Fernie Formation and be associated with the Fernie Detachment (see next).

Fernie Detachment

A principal reinterpretation of previous maps involves the Fernie Detachment, which is inferred to lie within the Fernie Formation along the west flank of the Fernie Basin (see trace through 49°30'00"N, 115°05'39"W). A similar detachment feature, bounding the gently synclinally folded Jurassic-Cretaceous strata of the Fernie Basin above from the tight overturned folds and folded thrusts within the underlying Paleozoic rocks (see the Broadwood, Bighorn, and other unnamed overturned fold pairs west of the Howell Creek Structure on the Chinook South map), was previously suggested by Root et al. (2000), Jones (2004), and Root (2004). See also the Chinook South and Chinook North maps and accompanying documentation for related discussions.

The *"Hosmer Thrust"* and *"Hosmer Nappe"*

The influential paper by Henderson and Dahlstrom (1959), which included interpreted oblique aerial photographs, identified a "first-order nappe" carried above a gently dipping and folded (but continuous) fault they named the *"Hosmer Thrust"*. This thrust sheet was interpreted to carry Middle Proterozoic through Triassic and Jurassic strata over the Jurassic Fernie Formation, where the sinuous fault trace, including two klippen, laid dominantly on the western slopes of the Elk River Valley. They identified three discrete topographically expressed segments of this single interpreted thrust sheet, disrupted by two interpreted tear faults. The southern segment, the *"Lizard segment"*, is dominated by the steeply overturned eastern ridge of the Lizard Range (centred at approximately 49°28'00"N, 115°10'00"W); it was interpreted as separated from the middle segment by the *"Lizard tear fault"*. The middle segment, the *"Trinity segment"*, is named for the Trinity Range along its southeastern edge (Mount Fernie – Three Sisters – Mount Procter; centred at approximately 49°33'30"N, 115°06'30"W); it was interpreted as

separated from the northern segment by the now fully eroded *"Hartley Creek tear fault".* The northern segment, the *"Hosmer segment"*, is centred on Mount Hosmer (at 49°36'50"N, 115°00'41"W).

The Chinook West compilation map closely follows the detailed mapping of Benvenuto (1978) with respect to lithological and well-constrained structural interpretations. However, it departs significantly from all previous interpretations of the Hosmer structure with respect to the natures and linkages of some of the less-well-constrained structural boundaries. The three structural segments of a single thrust sheet identified by Henderson and Dahlstrom (1959) and adopted by Price (1972b, 1972c), Benvenuto (1978), and Benvenuto and Price (1979), among others, are interpreted on the Chinook West map as related but distinct structural slices of a blind thrust stack underlying the Fernie Detachment. Each of these formerly defined segments and their inferred bounding features are discussed in turn below, with brief justifications for the compilation interpretation.

The "Lizard segment"*, and the footwall of the Sand Creek Fault*

The Chinook West compilation follows the interpretation of Leech (1958, 1960), as modified in detail by Benvenuto (1978), for the southwest dipping but overturned eastern ridge of the Lizard Range and underlying structures to the south, which include the folded Sand Creek and Wigwam faults (see locations below), and the Broadwood Anticline (see the Chinook South map to better appreciate the extent and nature of the slightly faulted Broadwood Anticline). As explained below, the Chinook West map shows no foreland-directed thrust cropping out east of the Lizard Range, in contrast to the interpretation of Henderson and Dahlstrom (1959), and most subsequent interpretations.

Southern trace of the *"Hosmer Thrust"*

The trace of the *"Hosmer Thrust"* mapped by Henderson and Dahlstrom (1959), around the southern end and to the west of the eastern ridge of the Lizard Range, corresponds to the trace of the Sand Creek Fault (see trace through 49°22'55"N, 115°04'16"W) as mapped by Leech (1958). Although Leech (1960) retained the name 'Sand Creek Fault', Leech (1962) adopted the name and general interpretation of Henderson and Dahlstrom (1959) for the *"Hosmer Thrust"*, including their interpreted tear faults. Subsequently, the regional work of Price (1972b, 1972c) and the detailed analyses of Benvenuto (1978) and Benvenuto and Price (1979) largely followed the interpretation presented by Henderson and Dahlstrom (1959).

Although the interpretive structural cross-sections of Benvenuto (1978) clearly illustrate the conceptualization of the *"Hosmer Thrust"* as a continuous surface, disrupted by tear faults in the hanging wall, his objective 1:25 000-scale detailed maps indicate that the trace of the *"Hosmer Thrust"* east of the eastern ridge of the Lizard Range is inferred along the entire extent of this ridge. The *"Hosmer Thrust"* trace is not mapped as defined or approximate anywhere south of the interpreted *"Lizard tear fault"* except where it coincides with the trace of the Sand Creek Fault as mapped by Leech (1958, 1960). This wholly inferred segment of the former *"Hosmer Thrust"* is excluded from the Chinook West compilation map. Instead, the Sand Creek Fault, which carries the Lizard Range in its hanging wall, is interpreted to feed into the Fernie Detachment.

Sand Creek and Wigwam faults

As mapped and illustrated in cross-section by Price (1972b), Benvenuto (1978), and Benvenuto and Price (1979; see cross-section 5-5' in their figure 2), the Sand Creek Fault (which these authors identified as the *"Hosmer Thrust"*), the underlying Wigwam Fault (see trace through 49°20'46"N, 115°03'11"W), and a smaller intervening but unnamed thrust fault form a folded thrust stack above the Broadwood Anticline. Together, these fault slices are interpreted to form the structurally lowest horses in a complex inferred blind thrust stack that includes all three segments of the former *"Hosmer Thrust"* sheet. This inferred blind thrust stack has a roof thrust (a back-thrust) localized in the Fernie Formation (the Fernie Detachment), and a pair of overlapping and partially linked floor thrusts: one in the south beneath the former *"Lizard segment"*, probably localized in and ramping upward from the Aldridge Formation, and the other in the north beneath the former *"Trinity segment"* and *"Hosmer segment"*, localized in the informally termed "basal Devonian" succession (Cedared, Burnais, and Harrogate formations; see discussion of the Gypsum Fault, below).

Northwest end of the Lizard Range

At the northwest end of the overturned Lizard Range, south and west of the confluence of Iron Creek and East Iron Creek (see area centred on 49°32'30"N, 115°16'30"W), Benvenuto (1978) mapped a closely faulted and tightly folded structure that outlines a contorted and partly overturned syncline-anticline-syncline fold train within the Devonian and Mississippian succession that is detached above underlying Proterozoic rocks along the Oveson Fault. The Chinook West compilation map generally follows the interpretation of Benvenuto for these complex structures, with modifications based on Stretch (1997) and examination of Google Earth™ imagery. Note the broadly folded "Core Fault" (see trace at 49°32'40"N, 115°16'09"W), which is coincident with the hinge surface of the overturned anticline. The overturned southeast limb of this anticline also forms the northwest limb of the second syncline, of which the southeast limb is also overturned resulting in a fully inverted antiformal syncline (see antiform trace at 49°31'49"N, 115°14'19"W).

The "Trinity segment"*, the Hosmer Thrust, and the Gypsum Fault*

Structurally above and northeast of the contorted set of folds discussed immediately above, the Chinook West compilation map shows the shallowly northeast-dipping Hosmer Thrust, which here follows the fault mapped by Benvenuto (1978) as the northwest-to-southeast-trending *"Lizard tear fault"* (see trace through 49°33'35"N, 115°15'56"W). The *"Lizard tear fault"*, named and mapped in a general way by Henderson and Dahlstrom (1959), was mapped in detail by Benvenuto (1978). With respect to confidence level, he showed this fault as an approximate trace (centred on the coordinates above) over a distance of less than 1.5 km, and inferred elsewhere.

To the northwest, Benvenuto (1978) inferred the *"Lizard tear fault"* to link into the Gypsum Fault (discussed below). To the southeast, he inferred the tear fault to link at a high angle with the *"Hosmer Thrust"* along East Iron Creek, at 49°32'44"N, 115°14'04"W. In the Chinook West compilation, the Hosmer Thrust is interpreted to follow the combined traces of the "*Lizard tear fault"* and the *"Hosmer Thrust"* as mapped by Benvenuto (1978), similar to the interpretation of Root (2006). As mapped by Benvenuto (1978), with confidence ranging from defined to inferred (see defined trace segment through

49°33’13”N, 115°12’18”W, for example), the circuitous trace of the shallowly dipping Hosmer Thrust follows the rugged topography northeast of East Iron Creek, southeast of the Trinity Range, and northwestward along Sulphur Creek.

The Hosmer Thrust is interpreted on the Chinook West compilation map to splay structurally upward (toward the foreland) from the Gypsum Fault detachment (see below). This interpretation requires a slight modification of the inferred trace of the Hosmer Thrust as mapped by Benvenuto (1978) along Sulphur Creek near its confluence with the Bull River (see merger of the traces of the Hosmer Thrust and the Gypsum Fault at 49°40’19”N, 115°09’41”W). The portion of the Hosmer Thrust sheet referred to by Henderson and Dahlstrom (1959) as the *“Trinity segment”* will be referred to here as the Trinity block.

The “Hosmer segment”*, the* “Hartley Creek tear fault”*, and the footwall of the Hosmer Thrust*

The *“Hosmer segment”* of the *“Hosmer Nappe”* of Henderson and Dahlstrom (1959) comprises two klippen carried on the Hosmer Thrust. The larger klippe is centred on Mount Hosmer (located at 49°36’50”N, 115°00’41”W) and a much smaller klippe lies to the north (main peak within this klippe is at 49°40’43”N, 115°00’58”W). Note that the larger Mount Hosmer klippe spans the boundary between the Chinook West and Chinook South compilation maps. The portion of the Hosmer Thrust sheet referred to by Henderson and Dahlstrom (1959) as the *“Hosmer segment”* will be referred to here as the Hosmer block.

The *“Hartley Creek tear fault”* was proposed by Henderson and Dahlstrom (1959) to account for a structural offset between the *“Trinity segment”* and the *“Hosmer segment”*. The structure of the Mount Hosmer klippe is similar to that of the eastern margin of the Trinity block to the south, where Devonian through Triassic rocks are steeply overturned. Despite the structural similarities, the offset of dipping strata between Mount Hosmer (49°36’50”N, 115°00’41”W) and Mount Procter (49°33’55”N, 115°04’42”W) requires an intervening but now-eroded structure, for which there is no other evidence. The permissible strike of this inferred structure is constrained by the preserved traces of the Hosmer Thrust, which encompass the Trinity and Hosmer blocks, to be approximately 140°-175° Az, similar to the regional strikes of thrust faults in the southern Canadian Rockies. Alternatives to the tear fault interpretation of Henderson and Dahlstrom (1959) include a foreland-dipping duplex structure, where the Trinity and Hosmer blocks are distinct thrust slices, or large coherent gravity slides (Root, 2004, 2006).

The northeast corner of the Chinook West map area, located in the footwall of the Hosmer Thrust, closely follows the mapping of Benvenuto (1978), with minor adjustments using Google Earth™ imagery. The Barrier Thrust (see trace through 49°43’53”N, 115°05’59”W) places kilometre-scale east-vergent but recumbent folds within the Devonian succession onto overturned Upper Devonian and Mississippian strata. These spectacular recumbent folds (see hinge surface traces at 49°44’13”N, 115°06’32”W, and 49°44’13”N, 115°07’49”W) lie east of and structurally above the inferred sub-vertical Gypsum Fault detachment, which lies in Middle Devonian (“basal Devonian”) strata that are embedded in an east-facing and stratigraphically intact succession from upper Cambrian to uppermost Paleozoic. Relative to the now steeply dipping Gypsum Fault, these east-vergent recumbent folds appear to be true

detachment-style folds that were subsequently rotated toward the foreland during transport on underlying structures.

The Gypsum Fault detachment

On the Chinook West compilation map, the extents of Middle Devonian outcrop associated with what Leech (1958, 1960) and others refer to as the "basal Devonian", which consists of the Cedared, Burnais, and Harrogate formations, closely follow the mapping of Leech (1958, 1960), Benvenuto (1978), McMechan (1979), and Stretch (1997). Where these sources differ in interpretation, Google Earth™ imagery was used for assessment and guidance for the compilation. Where exposures exist, this basal Devonian succession is everywhere overlain conformably to paraconformably by the Middle to Upper Devonian Fairholme Group. Within the Chinook West map area, the basal Devonian lies unconformably on rocks as young as the Upper Ordovician to Lower Silurian Beaverfoot Formation (e.g., at 49°43'00"N, 115°09'34"W) and as old as the Mesoproterozoic Kitchener Formation (e.g., at 49°33'45"N, 115°19'11"W).

A continuous belt of the basal Devonian has been mapped from the north edge of the Chinook West map (49°45'00"N, 115°09'10"W), southward along the Bull River Valley to Sulphur Creek (49°41'02"N, 115°09'36"W), along the west side of Dooley Creek south of Sulphur Creek to approximately 49°37'25"N, 115°11'54"W, and then southwestward toward the confluence of the Bull River and Lime Creek (near 49°33'25"N, 115°18'34"W). This belt is inferred to host the Gypsum Fault structural detachment, which is considered to be principally foreland-directed. The Hosmer Thrust underlying the Trinity block, described above, is inferred to splay upward from (i.e., merge structurally downward with) the Gypsum Fault. Although not similarly expressed on the Chinook West map due to the level of erosion, the Hosmer block may represent a thrust slice that originated from the trailing edge of the Trinity block. This possible geometry of the Trinity and Hosmer blocks would form a foreland-dipping blind duplex stack with the Gypsum Fault below and the Fernie Detachment above.

Northeast of the confluence of the Bull River and Dibble Creek, Leech (1962) mapped a series of splay faults involving the basal Devonian and the underlying Cambrian and Ordovician succession (see area centred on approximately 49°36'10"N, 115°15'35"W). The Chinook West interpretation shows these faults as merging structurally upward with the Gypsum Fault detachment. Leech (1962) speculated that these splays are related to the intersection of the Dibble Creek Fault with the Paleozoic succession.

Dibble Creek, Bull Canyon, and Oveson faults, and the "veritable sinkhole of disappearing faults"

Leech (1958, 1960) and McMechan (1979) mapped basal Devonian strata everywhere in the immediate footwall of the Dibble Creek Fault (which follows Dibble Creek and portions of Sunken and Horseshoe creeks from approximately 49°34'15"N, 115°20'05"W, to 49°35'31"N, 115°30'00"W, within the Chinook West map area), where these strata unconformably overlie Mesoproterozoic rocks as young as Nicol Creek Formation and as old as Kitchener Formation. Near the eastern end of The Steeples ridge,

between Dibble Creek and the Bull River and approximately 4600’ above the lowest exposures along Bull River to the east, McMechan (1979) mapped a patch of basal Devonian strata overlying the faulted contact between the Van Creek and Kitchener formations (centred at 49°32’10”N, 115°21’59”W). This suggests that if the Dibble Creek Fault follows the basal Devonian strata in its footwall, then it may have flattened to the southwest, where it would now be eroded. The relationship between the Dibble Creek Fault, first mapped by Leech (1958), and the inferred Gypsum Fault detachment is not well constrained, but their apparent merger occurs where Dibble and Iron creeks flow into the Bull River (see area centred on 49°34’00”N, 115°18’50”W).

Leech (1962) describes the Bull River Valley between Dibble and Lime creeks as a “veritable sinkhole of disappearing faults”, where, in addition to the Dibble Creek and Gypsum faults, the traces of both the Oveson Fault (noted above as forming the detachment for the strongly deformed fold train at the northwest end of the Lizard Range) and the Bull Canyon Fault converge. In this area, the Chinook West compilation map accommodates all firm observations and interpretations of Leech (1958, 1960, 1962), Benvenuto (1978), McMechan (1979), and Stretch (1997), with minor adjustments of inferred structures.

Leech (1962; p. 403) states: “A critical outcrop of Precambrian rock occurs at the confluence of the middle and north forks of the [Lime] creek. This outcrop, discovered by T.L. Thompson, consists of quartzites and argillite that could belong to either the Gateway or Creston formation. Its contact relations are unknown.” This outcrop, mapped by Benvenuto (1978) as “Gateway?”, is located at 49°34’10”N, 115°17’28”W. In part following Benvenuto (1978), it is shown on the Chinook West compilation map as Gateway Formation (the ambiguity in identification by both Leech, 1962, and Benvenuto, 1978, is noted in the ‘Remarks’ field of Station GLB-1978-140), lying in the immediate hanging wall of the Gypsum Fault detachment and overlain unconformably by basal Devonian. Its structural context suggests that it may well be a slice of the Creston Formation rather than Gateway Formation.

South of the “veritable sinkhole”, basal Devonian strata are well exposed along and adjacent to the Bull River near 49°32’00”N, 115°19’19”W. The Oveson Fault closely follows along or very near the unconformity between the Kitchener Formation and the Fairholme Group, and may be localized in part in the “basal Devonian”. The Chinook West map shows an inferred thinning and disappearance of the Middle Devonian Cedared, Burnais, and Harrogate unit in the hanging wall of the Oveson Fault (49°31’44”N, 115°18’02”W) at approximately the same latitude as the most southerly observation of Leech (1962) along the nearby Bull River, as noted above.

Although not clearly labeled by Benvenuto (1978), the Oveson Fault is shown on the Chinook West map as continuing to the southeast, following the unconformable contact between the Kitchener Formation and the Fairholme Group, to where Benvenuto (1978) shows an inferred thrust cutting up-section in its footwall to place Fairholme Group onto itself. This thrust, identified as the Oveson Fault on the compilation map, is shown by Benvenuto (1978) as becoming overturned and merging at 49°30’31”N, 115°14’59”W, with a partly overturned thrust that is folded across the complex antiform at the northwest end of the Lizard Range.

Sub-Devonian stratigraphy and associated structures

As discussed extensively elsewhere (e.g., Price, 1972a; Benvenuto and Price, 1979; McMechan and Price, 1982), there are profound changes in sub-Devonian stratigraphy, particularly the Cambrian succession, and also preservation of Mesoproterozoic to Silurian strata, from southeast to northwest in the area encompassed by and surrounding the Chinook West compilation map. These dramatic changes are associated with a series of faults, including the Bull Canyon, Dibble Creek, and Boulder Creek faults, among others, which are inferred to have protracted and complex histories of reactivation.

Southeast of where the Oveson Fault cuts up-section to place Fairholme Group onto itself (as noted above), at 49°30'49"N, 115°15'46"W, in the Lizard Range, the Middle Devonian Fairholme Group lies unconformably on Mesoproterozoic Kitchener Formation, and then approximately 5 km farther southeast it lies on Mesoproterozoic Gateway Formation (Benvenuto, 1978). A thin succession of the "basal Devonian" is mapped by Benvenuto (1978) between the Gateway Formation and the Fairholme Group, in a 4 km-long belt centred at approximately 49°25'49"N, 115°07'07"W.

South of Sand Creek Fault

In the southeast corner of the Chinook West map area (e.g., 49°18'51"N, 115°06'21"W, and 49°15'42"N, 115°00'05"W) a thin succession of Middle Cambrian platformal strata, similar to equivalent strata near the leading edge of the Lewis Thrust sheet in the Chinook South map area, appears beneath the sub-Fairholme Group unconformity. Here, these Middle Cambrian units overlie the uppermost unit of the Mesoproterozoic Purcell Supergroup, the Roosville Formation, which in turn overlies the Phillips and Gateway formations. The Chinook West map here follows the mapping of Leech (1958, 1960) and Benvenuto (1978), with minor new interpretation to accord with the Chinook South compilation map.

North of Bull Canyon Fault

In contrast to the situation in the Lizard Range described above, north of the Bull Canyon Fault (but south of Hungry Peak Fault) the Kitchener Formation is overlain by the Mesoproterozoic Van Creek and Nicol Creek formations, all of which are overlain unconformably by the "basal Devonian". Here, the Chinook West compilation map follows the mapping of McMechan (1979), which clearly demonstrates significant pre-Devonian faulting and consequent differential erosion.

North of Dibble Creek Fault

The influence of pre-Devonian faulting on the accumulation and preservation of pre-Devonian stratigraphic units is even more pronounced north of Dibble Creek Fault where, stratigraphically above the Nicol Creek Formation, Leech (1958, 1960) and McMechan (1979) map Mesoproterozoic Sheppard, Gateway, and Phillips formations, and Lower Cambrian Cranbrook and Eager formations (e.g., see area centred on 49°35'35"N, 115°22'20"W). Stretch (1997) extended detailed mapping of the Cranbrook and Eager formations, as well as the overlying Tanglefoot Unit, to the east and north, to encompass the entire area underlain by the Tanglefoot Unit. The somewhat enigmatic Tanglefoot Unit, a shaly deep-water succession that resembles the Chancellor Formation to the north and contains oligomictic carbonate breccias interpreted as debris flow deposits (Stretch, 1997; p. 40-47), is overlain by and may grade laterally northward into the McKay Group. The Chinook West compilation largely follows the

mapping of the Tanglefoot Unit by Benvenuto (1978) and Stretch (1997), with some modifications to accommodate observations or interpretations of McMechan (1979).

Approximately 1.5 km north of the confluence of the Bull River and Dibble Creek, centred near 49°34’52”N, 115°19’55”W, Leech (1962) mapped a small exposure of “basal Devonian” unconformably overlying the lower part of the McKay Group strata. Benvenuto (1978) mapped a similar exposure in the same location, perhaps relying on original field notes by G.B. Leech, where “the sub-Devonian unconformity has apparently cut through the lower part of the McKay Group into the ‘Tanglefoot unit’” (Benvenuto, 1978; p. 85). Without explicit explanation, Stretch (1997) mapped the basal Devonian as an exposure in a structural window through a very flat-lying thrust carrying the Tanglefoot Unit. Examination of roadside, hillside, and creek exposures in this area in 2013 by the compilers revealed no support for a thrust window interpretation. Four outcrop observations of encompassing Tanglefoot Unit exposures constrain the extent of the basal Devonian outcrop, which was only observed by the compilers along the Bull River Forestry Service Road. The Chinook West compilation map shows this small patch of Cedared, Burnais, and Harrogate formations as lying unconformably on the Tanglefoot Unit.

North of Boulder Creek Fault

North of the Boulder Creek Fault, which is coincident with Tanglefoot Creek for most of the extent of this fault within the Chinook West map area, the compilation map closely follows the mapping of Benvenuto (1978) and Stretch (1997), with slight modifications supported by Google Earth™ imagery. In the northwest corner of the map area, observations and some interpretations of Larson (2004) are also incorporated, with the principal exception being new reinterpretation of the Ruault Lake and Bear Lake faults of Larson (2004) northwest of the Mount Haley Stock. As discussed more fully in the background documentation for the Chinook North compilation map, the Bear Lake Fault is reinterpreted as a hinterland-directed back-thrust, which is distinct from the foreland-directed Ruault Lake Fault.

Rocky Mountain Trench and Purcell Mountains

The southwest quadrant of the Chinook West compilation map includes the Rocky Mountain Trench and the easternmost slopes of the Purcell Mountains. Southwest of the normal-sense Rocky Mountain Trench Fault (concealed beneath Quaternary deposits; see trace through 49°25’00”N, 115°16’05”W) and the associated Murray Lake Fault (see trace through 49°27’50”N, 115°18’14”W) the Chinook West map melds the plotted observations and mapping of Leech (1958, 1960), Benvenuto (1978), Hoy and Diakow (1982), Hoy and Carter (1988), and Price (2013). Precedence was given to primary observations where apparent, or to more recent interpretations where reasonable. This included both bedrock contacts and the interpreted limits of Quaternary cover.

Of particular note in this area are two inferred thrust faults that repeat the basal Devonian through Mississippian succession in the vicinity of Wardner, B.C. (see traces through 49°25’22”N, 115°26’25”W, and 49°24’19”N, 115°28’32”W). These were first interpreted as normal faults by Price (1972a; see his generalized regional page-figure map, p. 78), and later as thrust faults (in part) by Benvenuto and Price (1979; again in a generalized page-figure map, p. 363). Hoy and Carter (1988) incorporated the

interpretation of Benvenuto and Price (1979), apparently using the generalized 1:500 000-scale page figure of Benvenuto and Price (1979) as the source for their 1:100 000-scale compilation map, with the result that their placement of these features is not supported by the observations of Leech (1958, 1960).

The Chinook West map traces these two thrust faults approximately where shown by Price (2013), with adjustment to accommodate the observations of Leech (1958, 1960) and guidance from Google Earth™ imagery. Price (2013) was also used as the source for the inferred basal Devonian strata in the immediate hanging walls of each of these thrusts, apparently supported by a structural observation on the west shore of Lake Koocanusa at approximately 49°23’44”N, 115°25’17”W, which is incorporated into the Chinook West map.

References

References below are cited in the GIS databases as well as in this document. Each is accompanied by a code in **[Square Brackets and Bold Font]** denoting one or more of the following categories:

- **[MS-CW]** = Map Source, Chinook West;
- **[CS/SS-CW]** = Cross-Section or Seismic Section Source, Chinook West;
- No code = Additional references cited in this document only.

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