# The Putnam Thrust Plate, Idaho—Dismemberment and Tilting by Tertiary Normal Faults

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## INTRODUCTION

The Putnam thrust is one of the major structures of the Idaho-Wyoming fold-and-thrust belt. It is exposed in the northern Portneuf Range, about 25 km northeast of Pocatello (Figs. 1 and 3), a region underlain by a thick sequence of Upper Proterozoic to Mesozoic rocks (Fig. 2). Detailed descriptions of these units are given by Link (1983), Link and others (1987), Kellogg and others (1989), Kellogg (1990), and Hladky and Kellogg (1990). At most localities, the Putnam thrust places Ordovician rocks above Permian and Pennsylvanian rocks of the Meade thrust plate, although near its southeastern extent, the thrust ramps laterally downsection and places Cambrian rocks above Mississippian (Hladky and others, 1992; Kellogg, 1992). The total stratigraphic offset across the thrust is as great as about 3,700 m. Hanging wall rocks include the oldest and most deeply buried sedimentary and volcanic rocks known in the entire Idaho-Wyoming-Utah thrust belt, brought up in the core of a major thrust culmination centered in the Bannock and Pocatello ranges near Pocatello (Fig. 1) (Trimble, 1976; Burgel and others, 1987; Rodgers and Janecke, 1992). These relationships require that the Putnam thrust ramp steeply downsection in the footwall somewhere to the west and south of Pocatello.

The Putnam thrust has been well known for years (Mansfield, 1920, 1927; Trimble, 1982), but the details of the complex upper-plate structures remained elusive until recent detailed mapping and structural analysis was completed at scales of 1:24,000 or more. (Hladky, 1986; Kellogg and others, 1989; Kellogg, 1990; Hladky and Kellogg, 1990; Hladky and others, 1992; Kellogg, 1992; Rodgers and Othberg, in press; McQuarrie and others, in press; Riesterer and Link, in press).

The age of movement on the Putnam thrust can only be inferred. The north end of the Paris thrust system, which is not shown on Figure 3, is about 40 km southeast of the eastern exposed trace of the Putnam thrust and is probably connected to the Putnam thrust by a thrust-transfer system (Kellogg, 1992; Rodgers and Janecke, 1992). This suggests that the age of movement on the Putnam thrust is probably coeval with that on the Paris thrust system. The Paris thrust is no younger than Early Cretaceous (Aptian) (DeCelles and others, 1993), and may be as old as Late Jurassic (Armstrong and Cressman, 1963). These ages most likely also constrain the age of the Putnam thrust and, by a somewhat more tenuous projection, contractional structures in its hanging wall.

### Hanging Wall Structure of the Putnam thrust

Three subplates comprise the hanging wall of the Putnum thrust in the Pocatello Range and northern Portneuf Range (Figs. 3 and 5), although Neogene extension has profoundly modified the thrust geometry by block faulting and tilting. (The term *subplate* is used

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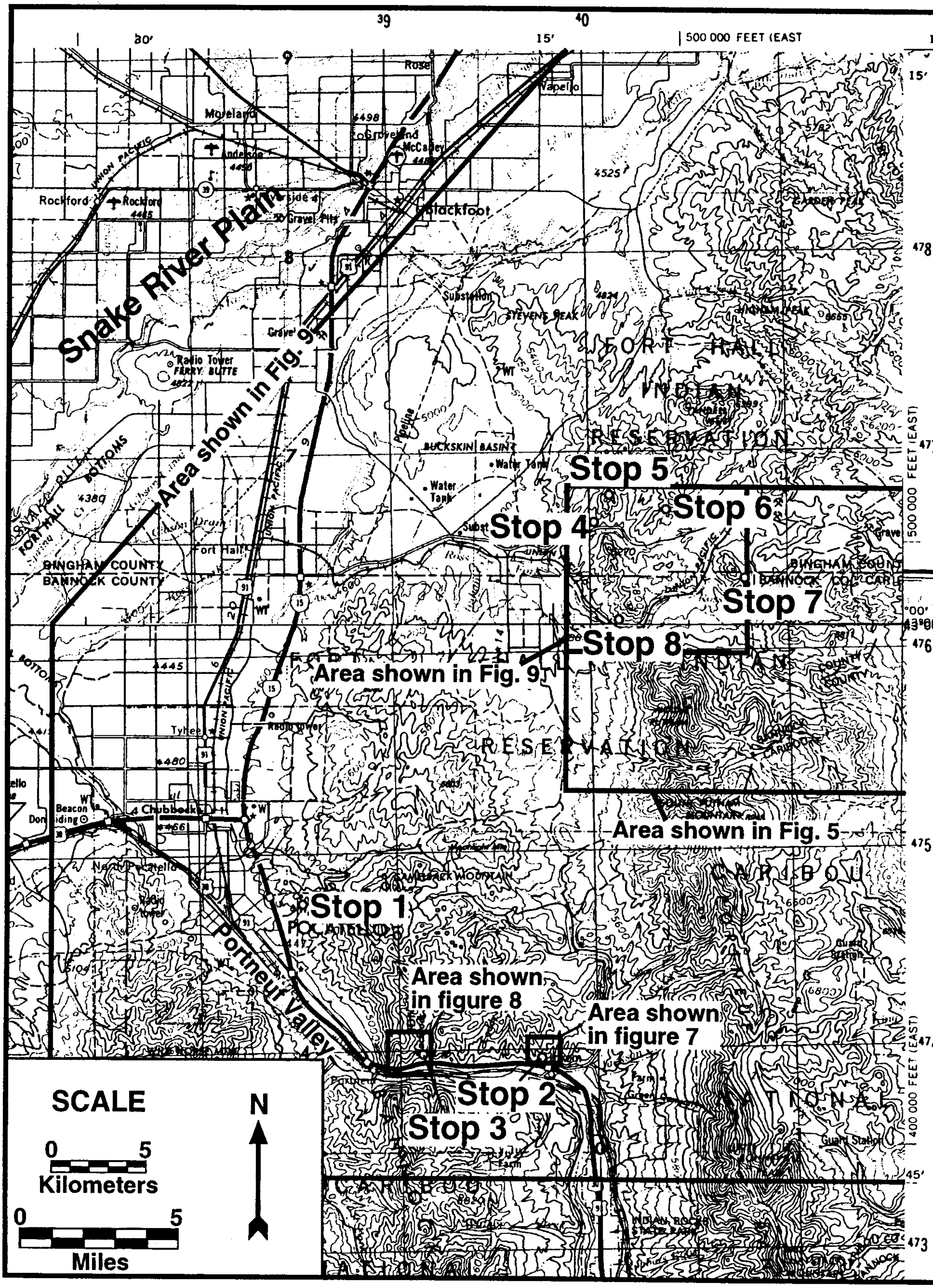



Figure 1. Location map of Pocatello region, showing areas of Figures 3, 5, 7, 8, and 9, and fieldtrip Stops 1-8.

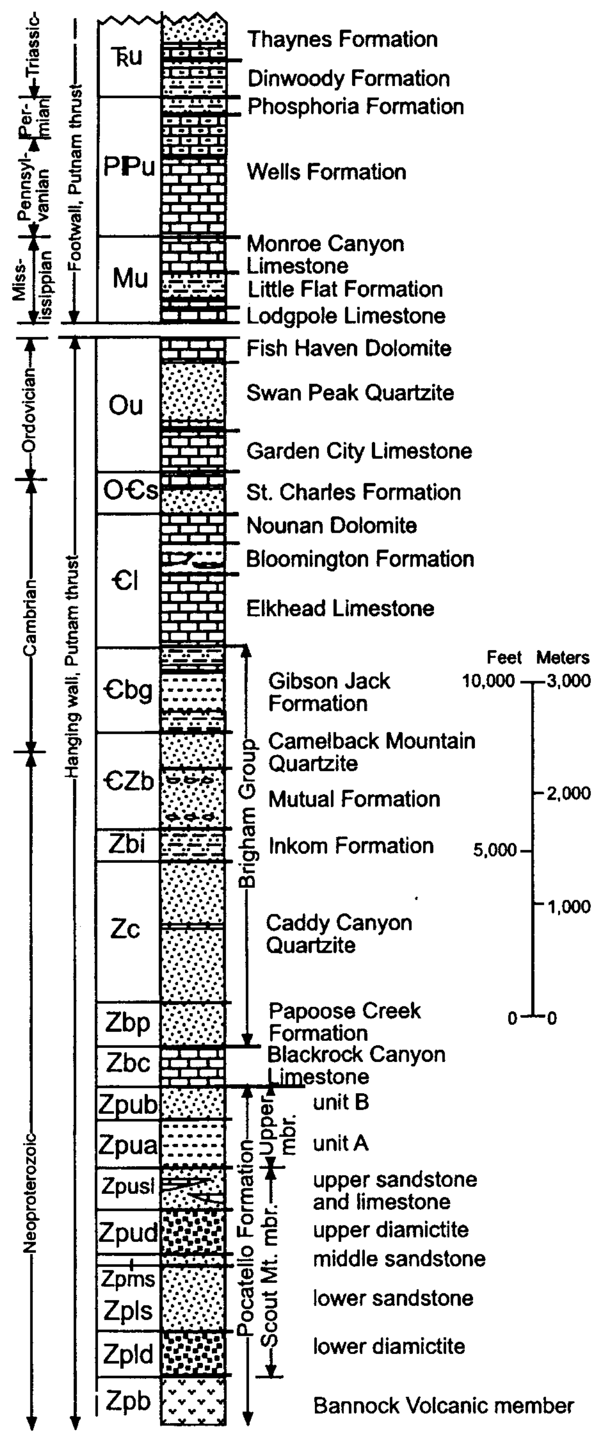



*Figure 2. Stratigraphic column of rocks exposed in the northern Portneuf, Pocatello, and Bannock Ranges. Adapted from Kellogg (1992) and McQuarrie and others (in press).*

to distinguish large thrust slices within the Putnam thrust plate.) The three subplates are, from structurally lowest to highest (and generally north to south), the Lone Pine subplate, the Narrows subplate, and the Bear Canyon-Toponce subplate (Fig. 5).

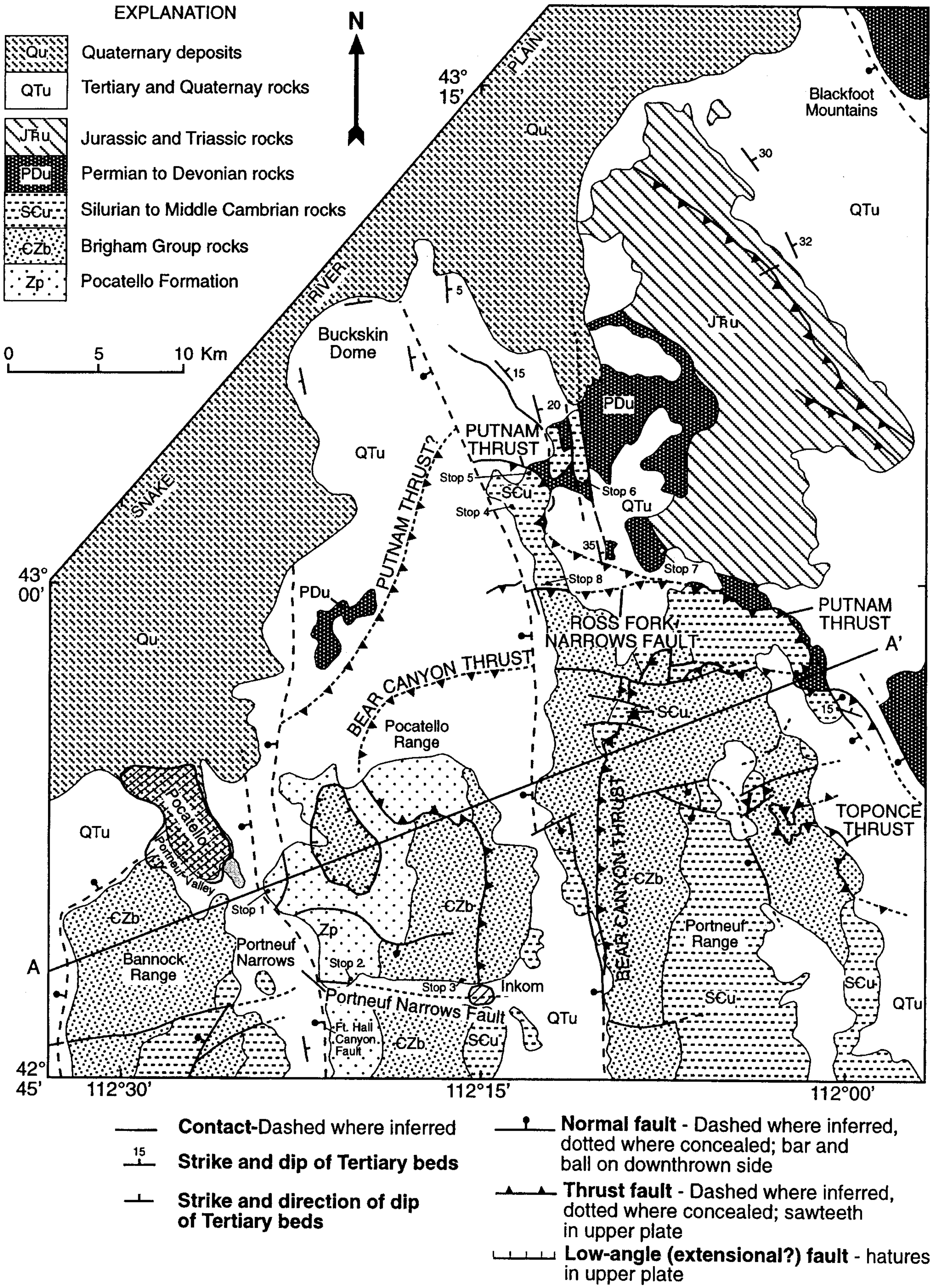
The Lone Pine subplate, composed of Ordovician and Cambrian rocks, and the Narrows subplate, composed mostly of Upper Proterozoic Brigham and Pocatello Groups (but locally containing rocks as young as Silurian), are juxtaposed across the steeply south-dipping Ross Fork Narrows fault, which is viewed as a steep lateral ramp (Kellogg, 1992; Trimble [1982] called it a "tear fault") although this interpretation may be a topic of lively discussions on the trip. Overlying the Narrows subplate and underlying the Bear Canyon-Toponce subplate is the Bear Canyon thrust, which dips eastward along the west side of the Portneuf Range and places mostly lower Brigham Group quartzite (Caddy Canyon Quartzite) above Cambrian limestone and upper Brigham Group rocks. The strongly folded Toponce thrust, on the east side of the Portneuf Range (Fig. 3), is believed to be an eastward extension of the Bear Canyon thrust (Kellogg, 1992). This thrust geometry is further complicated by (1) steep thrust ramps, both frontal and lateral, (2) numerous east-striking tear faults (compartmental faults of Brown, 1984), which accommodated different styles of shortening on either side of the fault (see Kellogg, 1990 for good examples), and (3) locally developed, tight S- and Z-shaped folds, each containing one gently-dipping overturned limb and a near-horizontal axial plane, which are particularly well developed in the Narrows subplate.

The Bear Canyon thrust is somewhat unusual in the Cordilleran thrust belt because it dips eastward. At least three explanations may account for this: (1) the thrust is a back thrust above the Putnam thrust and was west-directed, (2) the thrust, prior to Neogene extension, dipped west and was east-directed, but was subsequently tilted by down-to-the-east block tilting along large down-to-the-west normal faults, or 3) the thrust forms the roof of a large foreland-dipping duplex and was arched during duplex formation, so that its foreland side dips eastward.

We will present evidence that the latter two explanations both contributed to the eastward dip of Bear Canyon thrust and that the thrust is, indeed, an east-directed structure. The evidence is based mainly on the observation that the thrust ramps up-section to the east, both in the hanging wall and (particularly) in the footwall.

Eastward tilting of parts of the Portneuf, Pocatello, and Bannock Ranges by as much as 45° during Neogene extension certainly accounts for a large component of eastward dip of structures, but leaves room for an additional component of eastward dip induced by formation of the foreland-dipping duplex (Fig. 6; see Kellogg [1992] for a detailed discussion of this structure). The Narrows subplate is viewed as a large horse in the duplex, in which the Bear Canyon-Toponce thrusts define the roof thrust and the Putnam thrust defines the floor thrust. At the eastern end of the duplex, the roof thrust is nose down on the Putnam thrust and dips east. Beds are tectonically thickened and thinned within the Narrows subplate, reflecting a combination of bedding-plane slip, small-scale duplex stacking and thrust imbrication, and ductile flow. Outcrop- to map-scale, steeply overturned S- and Z-shaped folds, and a fanning of axial-plane cleavages by rotation during thrusting are common features in the Narrows subplate. In marked contrast to the foreland-dipping-duplex structure of the Narrows subplate, the Lone Pine and Bear Canyon-Toponce subplates contain mostly a moderately east-dipping sequence of relatively unsheared rocks.

Cambrian and Upper Proterozoic Brigham Group rocks and older rocks of the aerially extensive Narrows subplate were buried as deeply as about 15 km during Mesozoic contraction. The


EXPLANATION
Qu
Quaternary deposits
QTu
Tertiary and Quaternay rocks
JTRu
Jurassic and Triassic rocks
PDu
Permian to Devonian rocks
SCu
Silurian to Middle Cambrian rocks
CZb
Brigham Group rocks
Zp
Pocatello Formation
N
0
5
10 Km
43° 15'
43° 00'
42° 45'
112°30'
112°15'
112°00'
SNAKE RIVER PLAIN
Blackfoot Mountains
Buckskin Dome
PUTNAM THRUST
PUTNAM THRUST?
Stop 1
Stop 2
Stop 3
Stop 4
Stop 5
Stop 6
Stop 7
Stop 8
ROSS FORK-NARROWS FAULT
BEAR CANYON THRUST
Pocatello Range
TOPONCE THRUST
Pocatello
Portneuf Valley
Bannock Range
Portneuf Narrows
Portneuf Narrows Fault
Ft. Hall Canyon Fault
Inkom
Portneuf Range
A
A'
Contact-Dashed where inferred
Strike and dip of Tertiary beds
Strike and direction of dip of Tertiary beds
Normal fault - Dashed where inferred, dotted where concealed; bar and ball on downthrown side
Thrust fault - Dashed where inferred, dotted where concealed; sawteeth in upper plate
Low-angle (extensional?) fault - hatures in upper plate