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STRATIGRAPHY AND CHRONOLOGY OF QUATERNARY DEPOSITS OF THE PUGET LOWLAND AND OLYMPIC MOUNTAINS OF WASHINGTON AND THE CASCADE MOUNTAINS OF WASHINGTON AND OREGON

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INTRODUCTION

The Pleistocene chronology of the Puget Lowland is based on multiple dating methods, including radiocarbon and fission-track dating, as well as amino acid, paleomagnetic, and tephra correlation techniques. Datable material is abundant and age control is generally good. Radiocarbon dates have been obtained from late Wisconsin deposits in the Olympic Mountains, but older deposits are not well dated. Finite ^{14}C dates from the Cascade Mountains are meager and the chronologic framework there is based largely on relative weathering characteristics with limited K–Ar dating and paleomagnetic measurements.

EARLY PLEISTOCENE (> 788 ka)

Puget Lowland

The Pleistocene deposits in the Puget Lowland were first studied by Willis (1898) and Bretz (1913). Type localities for the Orting Drift, Alderton Formation, Stuck Drift, Puyallup Formation, and Salmon Springs Drift were established by Crandell *et al.* (1958) near the southern margin of the Cordilleran ice sheet, but until recently their ages were unknown.

The oldest finite dates of Pleistocene deposits in the Puget Lowland are fission-track ages of 840 ka BP tephra within the Salmon Springs Drift at three localities (Easterbrook and Briggs, 1979; Easterbrook *et al.*, 1981; Naeser *et al.*, 1984), providing an upper limit for at least two glacial drifts and two interglacial deposits which lie stratigraphically lower. Reversed remanent magnetism of the Salmon Springs and older deposits indicates that they were deposited during the Matuyama Reversed Polarity Chron and thus between 0.7 and 2.48 Ma ago (Roland, 1984; Easterbrook *et al.*, 1985, *in press*).

Because many drift units in the region were designated as Salmon Springs on the basis that they were the next-oldest drift beneath Vashon till, the fission-track dates and paleomagnetic measurements of Salmon Springs and older sediments at their type localities invalidated many 'Salmon Springs' correlations. Deposits previously labeled 'Salmon Springs' are likely to be much younger than the type Salmon Springs Drift. Glacial sediments directly underlying Vashon till in the southern Puget Lowland probably are correlative with Salmon Springs Drift, but farther north, drift directly beneath Vashon till is most likely correlative with much younger drifts, such as the Double Bluff or Possession Drifts. Thus, virtually all previously-mapped Salmon Springs Drift needs to be re-examined to determine if it is indeed correlative with Salmon Springs Drift or is younger.

Orting Drift

The oldest glacial unit recognized in the Puget Lowland, the Orting Drift, occurs in restricted outcrops south of Seattle (Crandell *et al.*, 1958; Crandell, 1963). It consists mostly of deeply oxidized sand and gravel derived from the Cascade Range, interbedded with compact and oxidized till in at least three horizons. The tills contain northern rock types and garnet in the sand fraction, suggesting deposition from Cordilleran ice having a British Columbia provenance. The maximum known thickness of Orting Drift is 79 m, consisting mostly of gravel with till lenses less than 8 m thick.

A thick basal gravel, deposited by westward-flowing streams from the Cascade Range prior to the beginning of volcanism at Mt. Rainier, is overlain by till and gravel of northern Cordilleran provenance. Tills occur at more than one horizon but are interpreted to be oscillations of a single major glaciation because the tills are laterally discontinuous and no major unconformities are evident (Crandell *et al.*, 1958; Crandell, 1963).

Because the Orting Drift is reversely magnetized (declination = 164°; inclination = −31°) (Roland, 1984; Easterbrook *et al., in press*) and is stratigraphically beneath Salmon Springs Drift dated at 840 ka BP (Easterbrook *et al.*, 1981), it is considered to have been deposited during the Matuyama Reversed Polarity Chron between 0.78 and 2.48 Ma ago. Considering its deeply weathered character compared with the Alderton Formation, Stuck Drift, Puyallup Formation, and Salmon Springs Drift, the Orting Drift may well be approximately two million years old.

Alderton Formation

Mudflows, alluvium, lahars, and lake sediments, with interbeds of peat and volcanic ash, comprise the interglacial Alderton Formation, known only in the southern Puget Lowland (Crandell *et al.*, 1958; Cran-

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