Klondike Basin—late Laramide depocenter in southern New Mexico

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Abstract

The Klondike Basin defined in this paper occurs mostly in the subsurface of southwestern New Mexico, north of the Cedar Mountain Range and southwest of Deming. The basin is asymmetric, thickening from a northern zero edge in the vicinity of Interstate 10 to a maximum preserved thickness of 2,750 ft (840 m) of sedimentary strata about 3 mi (5 km) north of the southern basin margin. The southern basin margin is a reverse fault or fault complex that bounds the Laramide Luna uplift, also defined here. The uplift consists of Paleozoic strata overlain unconformably by mid-Tertiary ash-flow tuffs and andesitic volcanics.

The principal sedimentary unit of the Klondike Basin is the Lobo Formation. It was deposited in alluvial-fan, fluvial, and playa environments adjacent to the Luna uplift. Conglomerates in the lower part of the section were derived from nearby sedimentary strata of the uplift; volcanic arenites in the middle and upper part of the section were derived from older volcanic rocks, including the Hidalgo Formation, lying to the west and northwest, and possibly to the north as well.

The age of the Lobo Formation and development of the Klondike Basin are bracketed as early to middle Eocene. The Hidalgo Formation, which occurs as dats in the Lobo, has an upper fission-track age of 54.9 ± 2.7 Ma (Marvin et al., 1978). The overlying Rubio Peak Formation in the Victorio Mountains is 41.7 Ma (Thor and Drewes, 1980). The Klondike Basin is thus a member of a group of late Laramide basins developed in and adjacent to the foreland in Paleogene time.

Introduction

In southwestern New Mexico and southeastern Arizona, the Laramide orogeny created a broad belt of northwest-trending faults and folds during the approximate time span of 75–55 Ma (Davis, 1979; Drewes, 1988). In contrast with Laramide deformation of the Rocky Mountain region, extensive volcanism accompanied shortening in Arizona and New Mexico. This volcanism has been interpreted as subduction related (Coney and Reynolds, 1977; Keith, 1979). The deformation itself has been attributed to underthrusting of the Farallon plate beneath North America (Seager and Mack, 1986). Sedimentary basins formed in association with Laramide deformation. Laram...
ide sedimentary units include an assemblage of strata that range in age from Late Cretaceous to middle Eocene (Fig. 1), although ages of the Paleogene units are as yet poorly constrained. Improved interpretation of the timing and style of Laramide deformation hinges on our understanding of the ages and distribution of these syntectonic units. The objective of this report is to describe the evidence for a newly discovered Laramide basin, here named the Klondike Basin, in southwestern New Mexico and to discuss its significance. The Klondike Basin takes its name from a small range known as the Klondike Hills immediately north of the Cedar Mountain Range (Pearce, 1965).

Stratigraphic correlations of sedimentary formations deposited as a result of Laramide deformation suggest that at least two generations of Laramide basins exist (Fig. 1). The older generation, ranging in age from Campanian through late Maastrichtian, encompasses the Fort Crittenden Formation in Arizona, the Cabullona Group in Sonora, and the Ringbone and McRae Formations in New Mexico (Dickinson, 1981; Bilodeau, 1982; Mack et al., 1986; Dickinson et al., 1989).

Methods

The Klondike Basin was defined largely through subsurface analysis (Clemons and Lawton, 1991). Cuttings from three wells (Fig. 2) were prepared as thin sections and examined petrographically. Gamma-ray and sonic logs of the wells were correlated, and formation tops picked from cuttings were depth adjusted to match lithologic changes indicated by the well logs. Surface sections of Paleozoic, Mesozoic, and Tertiary strata were examined in the Victoria Mountains, Cedar Mountain Range, Klondike Hills, and West Lime Hills in order to compare lithologies seen in cuttings with the variability of interbedded lithic types observed in outcrops. The thicknesses of units depicted in Fig. 3 were reconstructed using dips indicated by dipmeter logs for the Saltys and Bisbee Hills wells. Fig. 3 was constructed by projecting the sections on to a line of azimuth 20° located midway between the Saltys and Bisbee Hills wells.

Geologic setting

In the Cedar Mountain Range south of the Bisbee Hills well, lower Paleozoic strata are overlain by conglomerate with clasts derived dominantly from Lower Cretaceous strata. The conglomerate and Paleozoic strata are overlain by mid-Tertiary ash-flow tuffs (Bromfield and Wrucke, 1961); no Lower Cretaceous rocks are exposed in the range. Southeastward, along the general trend of the northern flank of the Cedar Mountain Range, the West Lime Hills contain a series of northeast-vergent reverse faults, the southwesternmost of which emplaces Permian carbonates (Thompson, 1982) above conglomerates composed of Paleozoic carbonate clasts.
1. VICTORIO MTNS. (FROM KOTTLOWSKI, 1960)

2. BISBEE HILLS UNIT #1 (11-26S-11W)

3. COCKRELL STATE #1 (14-25S-16W)

4. SALTY S UNIT #1 (33-25S-15W)

QUATERNARY DEPOSITS

SILICIC ASH-FLOW TUFFS

RUBIO PEAK FORMATION

LOBO FORMATION

Fault zone in Pe limestone

Paleozoic rocks faulted over Lobo formation

Ritchie of Lobo in vicinity of 6-3b onto Laramide Burro uplift of Seager and Mark (1986)

Lobo Formation

Laullo bedded over Lobo Formation

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The conglomerate may be Hell-to-Finish Formation (Lower Cretaceous) or Lobo. The conglomerate is faulted against metamorphosed and overturned Ordovician through Mississippian strata, which are in turn thrust over the Hell-to-Finish Formation. This system of faults trends northwestward toward the Cedar Mountain Range and illustrates the structural complexity created by Laramide deformation in the area.

In the Victorio Mountains, a thin (790 ft; 240 m) Lower Cretaceous section (Kottlowski, 1960) overlies Ordovician and Silurian strata. The Lower Cretaceous section is overlain unconformably by 690 ft (210 m) of reddish-brown conglomerate, sandstone, and siltstone (Kottlowski, 1960) that we consider to be Lobo Formation. The Lobo in the Victorio Mountains is overlain conformably by hornblende-andesite flows and breccias of the Rubio Peak Formation.

Ages on the Rubio Peak Formation range from 44.7 to 32.6 Ma in the Cooke's Range to the north (Loring and Loring, 1980; Clemons, 1982). A zircon fission-track age of 41.7 ± 2.0 Ma was reported from a flow breccia in the Victorio Mountains (Thorman and Drewes, 1980).

Subsurface relations

Three wells southwest of Deming penetrated thick sections of Lobo. The thickness of the unit is 2,750 ft (840 m) in the Bisbee Hills Unit #1, 1,800 ft (550 m) in the Cockrell State #1, and 1,050 ft (320 m) in the Saltys Unit #1 (thicknesses of intrusive rocks have been removed from the sections). In the Saltys well, the Lobo is truncated beneath a reverse fault with Ordovician through Permian strata in the hanging wall (Fig. 3).

In the Saltys and Cockrell wells the Lobo rests on a sequence of glauconitic marine sandstones and shales that we interpret as the upper part of the Mojado Formation (Albian-Cenomanian?). These marine beds at the top of the Mojado overlie a thick interval of nonmarine strata consisting of fine-grained sandstone, siliceous siltstone, and silty mudstone. Palynomorphs from this nonmarine interval in the Cockrell well include Cricotricosisporites spp. and Quadripollis krempli, which are both long-ranging Cretaceous forms (S. N. Nelson, written communication June 14, 1990).

The basal contact of the Lobo is somewhat anomalous in the Bisbee Hills well. Although the unit appears to contain a basal conglomeratic interval, the Lower Cretaceous section is absent and the Lobo directly overlies Silurian Fusselman Dolomite (Clemons and Lawton, 1991). In the other two wells, Lower Cretaceous strata overlie the Fusselman. Two possible interpretations are: 1) the Lower Cretaceous section was eroded prior to Lobo deposition in the Bisbee Hills well; 2) the Lower Cretaceous section is absent in the Bisbee Hills well as a result of faulting. Presently
available data do not permit us to reject either of these possibilities; however, the Lobo section is thickest in the Bisbee Hills, indicating that subsidence was greater there than at the other studied localities. This observation favors omission by faulting because it obviates the need for major post-Early Cretaceous uplift and erosion followed by major Paleogene subsidence. The Lobo Formation in the Bisbee Hills well consists of interbedded reddish-brown silty mudstone, siltystone, and very fine to medium-grained calcareous sandstone (Fig. 4; Clemons and Lawton, 1991). The basal 140 ft (43 m) is conglomerate containing clasts of silty shale and mudstone, calcareous fine-grained sandstone, silty limestone, dolostone, chert, and lower Paleozoic limestone. Angular to subangular quartz grains, carbonate and volcanic rock fragments, chert, plagioclase, potassium feldspar, and traces of biotite are present in the sandstone beds. Conglomerates of the middle and upper parts of the Lobo section are dominantly volcanic arenites (Fig. 5).

In the Cockrell well, the lower 40 ft (12 m) of the Lobo Formation is conglomerate containing clasts of silty shale, calcareous medium-grained sandstone, and siliceous sandstone. The lower part of the Lobo in the Bisbee Hills well, sandstone in the Cockrell well contains angular to subrounded grains of quartz, chert, plagioclase, minor potassium feldspar, biotite, and carbonate rock fragments. The upper 1,110 ft (339 m) of the formation in the Cockrell well is fine grained and consists of interbedded red-brown mudstone, chert, calcareous siltstone, and claystone. The Lobo in the Salts well is similar to that in the Cockrell well, but it contains more sandstone. The lower 180 ft (55 m) of Lobo in the Salts well is probably conglomerate with mixed lithologies that include globigerinid-like forams and mollusc fragments. Interpretation of cuttings indicates that the basal conglomerate of the Lobo contains abundant clasts of Lower Cretaceous strata. The siliceous sandstones, globigerinid-bearing clasts, and silty shales probably represent Mojave lithologies. Lower Paleozoic clasts are also present and may have been derived from both lower Paleozoic strata and the Hell-to-Finish Formation, which contains abundant lower Paleozoic clasts elsewhere in the region (Mack et al., 1986). Sandstones of all three wells likewise indicate a sedimentary source terrane, although the volcanic arenites of the Bisbee Hills well suggest an increasingly important volcanic provenance with time. Mack and Clemons (1988) noted a similar upsets increase in volcanic arenites in the Lobo Formation at two localities in the Florida Mountains. The northward-fining trends demonstrated between the Salts and Cockrell wells suggest that the sedimentary source terrane lay to the south.

Victorio Mountains

The Lobo Formation of the Victorio Mountains consists of conglomerate, sandstone, and red-brown siltstone. It rests upon a sequence of siltstone and subordinate fine-grained sandstone similar to the nonmarine strata of the Mojave encountered in the subsurface. The basal conglomerate is poorly sorted boulder and cobble conglomerate with clasts of sandstone, limestone attributable to the Lower Cretaceous U-Bar Formation, and siltstone. In addition to these sedimentary clast types, the basal conglomerate contains andesite clasts that resemble andesite of the Hidalgo Formation of the Little Hatchet and Pyramid Mountains. These volcanic clasts become increasingly abundant upsection in the Lobo. The conglomerates and sandstones of the Lobo are arranged in several upward-fining sequences several hundred feet thick. Conglomerates are crudely bedded to flat bedded, with angular, poorly sorted clasts. They grade to flat-bedded reddish-brown sandstones overlain in turn by interbedded red-brown siltstone and sandstone that form intervals several tens of feet thick. We interpret these associated facies as alluvial fan-braided fluvial-plaay depositional environments arranged in retrogradational sequences. The uppermost siltstone and sandstone interval of the Lobo is overlain by flow breccia of altered hornblende andesite. We regard this breccia as the base of the Rubio Peak Formation.

Like the upper sandstone in the Lobo of the Bisbee Hills well, the sandstones of the Lobo in the Victorio Mountains are rich in volcanic lithic grains. A lower Lobo lacking in volcanic grains is absent in the Victorio Mountains. These observations indicate that the volcanic influence was greater to the north than to the south during Lobo deposition or that Lobo deposits did not onlap the area of the Victorio Mountains until late in the history of the basin. Volcanic arenites occur in the upper part of the Lobo north of the Laramide Burro uplift (Fig. 7) and likewise indicate the importance of a volcanic provenance to the north of the study area (Mack and Clemons, 1988).

In the Victorio Mountains, the Rubio Peak Formation is 1,400 ft (430 m) thick. In the Bisbee Hills well, Rubio Peak flows, breccias, and volcanicslides are 1,800 ft (549 m) thick. In the Cockrell well, 1,900 ft (549 m) of Rubio Peak are truncated beneath basin-fill gravel (Clemons and Lawton, 1991). Thus, the Rubio Peak Formation, like the Lobo, thickens somewhat from north to south in the areas studied.

Klondike Basin—a late Laramide depocenter

The Lobo Formation between the Victorio Mountains and the Cedar Mountain Range forms a southwestward-thickening wedge of nonmarine clastic strata. The wedge is bounded to the southwest by a dominantly reverse fault that emplaced Paleozoic units above the Lobo. The Lobo overlies Lower Cretaceous strata with only slight discordance. In the Bisbee Hills well, Lower Cretaceous strata are missing beneath the Lobo because of either faulting or erosion. Conglomerates with Lower Cretaceous clasts that overlie Paleozoic strata and underlie mid-Tertiary volcanic units in the Cedar Mountain Range may indicate that Lobo strata lapped onto the southern uplifted block; however, the correlation of the conglomerate of the Cedar Mountain Range remains uncertain. North of the Victorio Mountains, the Lobo thins and pinches out onto Precambrian rocks of the Laramide Burro uplift (Seager and Mack, 1986). To the southeast, we speculate that the Lobo continues south of the Florida Mountains, as depicted by Seager and Mack (1986). The uplifted region that lies south of the Lobo depocenter consists of complex faulted and elevated Paleozoic and subordinate Mesozoic strata. The uplift is partly exposed in the West Lime Hills, the Cedar Mountain Range, and the Klondike Hills immediately northeast of the Cedar Mountain Range. A northwestward extension of the uplifted terrace was penetrated in the Salts well. This uplift is termed the Luna uplift (Fig. 7) because of its extensive presence in Luna County. The Klondike Basin (Fig. 7), defined by the thick wedge of Lobo, was initiated by deposition of conglomerates dominated by Lower Cretaceous and Paleozoic clasts. Volcanic clasts were present at northern
localities. The sedimentary rock types that contributed to the conglomerate are present in modern ranges along the Luna uplift; known sources for volcanic clasts lie to the southwest in the Little Hatchet Mountains (Zeller, 1970) and to the west and northwest in the Coyote Hills (Thorman, 1977) and Pyramid Mountains (Thorman and Drewes, 1978). Dominance of sedimentary grain types in sandstones of the wells and volcanic grain types in distance and pinch out above older strata has been synchronous with formation of the Klondike Basin. Basin development might have been contingent on activation of the volcanic pile of the Rubio Peak Formation in middle to late Eocene time.

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