BACKGROUND
Pyramid Lake is the site of some of the Earth’s most spectacular tufa deposits. Tufa is a rock composed of calcium carbonate (CaCO₃) that forms at the mouth of a spring, from lake water, or from a mixture of spring and lake water. The explorer John C. Fremont (1845) wrote about the tufas during his 1843-44 expedition and named the lake after the pyramidal-shaped island that lies along the east shore of the lake (fig. 1). The Paiute name for the island is Wono, meaning cone-shaped basket. The Paiute name for the lake is Cui-Ui Panunadu, meaning fish in standing water.

The U.S. Geological Survey, in cooperation with the Pyramid Lake Paiute Tribe, has obtained radiocarbon ages of many of the tufa deposits that border Pyramid Lake in order to obtain a record of lake level change for the past 35,000 years (Benson, 1994).

THE FORMATION OF TUFAS
Most of the tufas formed between 26,000 and 13,000 years ago when the climate was much wetter, and Pyramid Lake was joined to lakes in nearby subbasins. Pluvial lakes, such as Lake Lahontan, formed during this wetter climate. These lakes are transitional in nature, and today, many are gone or exist only as remnants. Pyramid Lake is one of seven water bodies that coalesced to form pluvial Lake Lahontan (fig. 2). At its highstand, Lake Lahontan was 281 m deep (compared to 106 m in 2004) and covered 22,800 km², a surface area slightly larger than present-day Lake Ontario.

Tufas in the Pyramid Lake subbasin were first mentioned in scientific literature by Fremont (1845), who erroneously believed they had formed above water. Tufa mounds formed when springs discharged from the bottom of Pyramid Lake, supplying calcium that combined with carbonate dissolved in lake water to form the mounds. The thickest tufa deposits formed near lake-bottom sites of ground-water discharge, and at overflow elevations where the lake was held at near-constant levels for long periods of time.

TUFA VARIETIES AND FORMS
Russell (1885) was the first to suggest that there were three tufa varieties, including lithoid (dense), thinitolitic (crystalline) and dendritic (branching) (figs. 3, 4, 5). Two other varieties have been noted in the Pyramid Lake area: a fine-grained carbonate that cements sand and gravel forming beachrock (fig. 6), and a thin white porous carbonate that coats the outer surfaces of older tufas (fig. 7).

Tufa varieties combine to become tufa forms. Common forms include: (1) tufa pillows (fig. 8), composed of branching tufa and dense tufa nodules (fig. 5); (2) tufa tubes, composed of dense or branching varieties of tufa that sometime surrounded a thinitolitic crystal mesh (fig. 4); (3) tufa sheets and drapes, which are primarily composed of branching tufa; and (4) tufa spheres or barrels, commonly composed of one or more layers of thinitolitic crystals. In some situations, tufa forms combine to create tufa megaforms, such as tufa mounds (fig. 7) and tufa reefs (figs. 8, 9). The largest collection of mounds occurs at the north end of Pyramid Lake at the Needles Rocks site. The locations of tufas depicted in this fact sheet are shown in Figure 10.
THE ELEVATION OF TUFA DEPOSITS AND THEIR RELATION TO OVERFLOW POINTS (SILLS)

Because tufts form in lake water, it follows that their vertical growth is limited by lake level. In the Pyramid Lake subbasin, the elevations of the tops of many tuft mounds correspond to elevations of intersubbasin overflow points, or sills (fig. 2). When the level of Pyramid Lake was held constant by overflow to an adjacent subbasin, erosion of tufta and sediment occurred at and slightly above the overflow level, and deposition of tufta occurred below the overflow level. Terraces were created by both erosional and constructional processes. In addition, many other reef-like tufta deposits formed on rocky headland areas when the level of Pyramid Lake was kept relatively constant by overflow to adjacent lake subbasins.

Many of the tuftas illustrated in this and other reports (Benson, 1994; Benson, 2004) have been dated using the radiocarbon method (Benson and others, 1995). The elevations and ages of the tufta allow us to construct a lake-level history for the last 35,000 years. The data indicate that Lake Lahontan rose sharply about 26,000 years ago and was maintained at about 1,265 m for the next 7,000 years by overflow to the Carson Desert. After a brief fall to less than 1,250 m, Lake Lahontan rose rapidly to its highstand (1,335 m) about 15,000 years ago and then fell rapidly between 14,000 and 13,000 years ago.

—Larry Benson

REFERENCES

Fremont, J. C., 1845, Report of the exploring expedition to the Rocky Mountains in the year 1843 and to Oregon and north California in the years 1843-44: Washington D.C.

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