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EVIDENCE OF A HIDDEN HYDROTHERMAL SYSTEM: THE NORTH VALLEY HYDROTHERMAL EXPLOSION CRATERS, WESTERN NEVADA, USA

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John H. Stewart and
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Abstract

Two small craters located about 75 miles northeast of Reno, Nevada, have been considered either meteor impact craters or hydrothermal explosion craters. The crater rims are not elevated as would be expected from ejecta deposited during meteor impact, nor are the crater walls deformed, as is typical of impact craters. On the other hand, the craters are not associated with surface hot spring deposits or Quaternary igneous rocks, factors that would favor a hydrothermal origin. However, the absence of elevated rims and of crater-wall deformation is characteristic of hydrothermal explosion craters, particularly those developed in unindurated, or little indurated material. The craters are in a region of high temperature gradients and very high heat flow, and thus are in a likely region of hydrothermal activity. Our combined observations support the interpretation that the craters were formed by hydrothermal explosions related to a hidden hydrothermal system.

Introduction

In September, 1990, the senior author noted on aerial photographs two small craters located about 75 miles northeast of Reno in western Nevada (Fig. 1). The craters were examined in the field later that year. Since then, speculation has focused on the question of whether the craters were created by meteor impact, or by some kind of hydrothermal explosion. The craters are not associated with hot spring deposits or Quaternary igneous rocks, characteristics that argue against a hydrothermal explosion origin. The impact idea was supported by newspaper reports (Nevada State Journal, 1911) describing a major meteor shower that took place in eastern California and western Nevada on May 25, 1911. The meteors had a trajectory that was consistent with an impact site at or near the North Valley craters. However, a 4.7 kg iron meteor (Grossman, 1997) found in the Hot Springs Range 30 km south-southeast of the craters may be related to the 1911 meteor shower. A further puzzlement is the name Fireball Ridge which is applied to a modest mountain range about 7 km southeast of the North Valley craters. The origin of the name Fireball Ridge is not known, but previous speculation was that the name was derived from the 1911 meteor event and that the supposed impacts were the North Valley craters.

The purpose of this note is to outline evidence that the North Valley craters are hydrothermal explosion craters, not impact craters, and that they are related to a hidden hydrothermal system.

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[1] Deceased

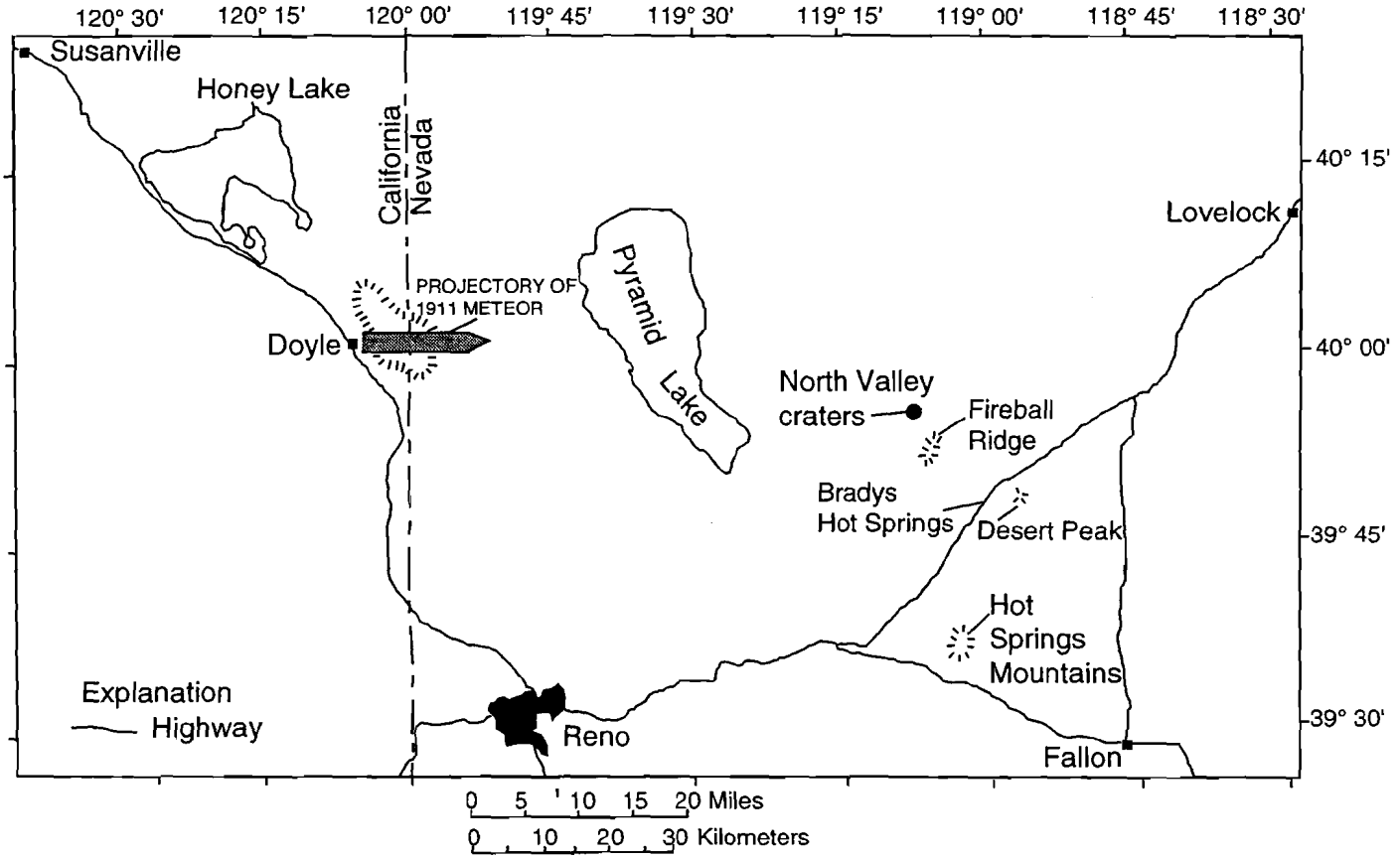

Figure 1. Index map of western Nevada and eastern California showing location of North Valley craters, reported projectory of 1911 meteor, and localities mentioned in text.

Description

The North Valley craters are located at 39°55.7' N., 119°07.7'W. in the northwestern part of sec. 25, T.24 N., R.25 E. in the Black Warrior Peak 7.5', 1:24,000-scale map (U.S. Geological Survey provisional edition, 1986). On this map, only the eastern crater is recognizable. It shows as a 60-m-wide depression in the 4920 ft. contour. The elevation of the craters is about 4,920 to 4,960 ft (1,500 to 1,512 m). They lie about 3 km north of North Valley, from which the name of the craters is here derived (Fig. 1).

Two craters are present (Fig. 2, 3). The eastern crater is well defined, about 80 m across, and about 6 m deep. It has a nearly flat bottom, steep walls, and a well defined rim. The terrain outward from the rim is not elevated. Ejecta from the crater has not been recognized, although recognizing such ejecta is difficult because the crater is in loose Miocene sandstone and clayey sandstone that could have been dispersed when the crater was formed. The top 0. 5 to 1 m of the eastern crater wall consists of alluvial-fan or pediment gravel composed of fragments of black basalt. This pediment gravel does not appear to be structurally deformed, although it is clearly part of the crater wall. The remainder of the crater wall is loose Miocene sandstone and clayey sandstone, mostly covered by a thin veneer of loose sand and silt. The bottom of the crater is loose sand and silt that appears to have been deposited after the crater formed. Post-crater gullies cut the crater's north wall.

The western crater is not easily noted and could have been missed entirely if the conspicuous eastern crater were not present. It is a circular feature about 100 m across and has less well defined walls than the eastern crater. A small area of the western crater is a shallow depression with interior drainage, but this depression is too small to be shown by the 2-meter contours on Figure 2. The western crater probably also formed mainly in unconsolidated silt and sand, and locally in basalt, although much of the area of the western crater is covered by what appears to be colluvium. The western crater may be older than the eastern one, based on the poor preservation of the crater walls.

The craters lie in an area mapped by Willden and Speed (1974) as "younger basalt and andesite" of Pliocene age. Much of this area in and near the craters, however, appears to be interstratified basalt flows and slightly indurated to unindurated sandstone and clayey sandstone. Much of the basalt and sedimentary rock succession probably is of Miocene age, because apparently correlative sedimentary rocks about 4 km to the northeast are Clarendonian in age (middle and late Miocene) based on mammalian faunas (Truckee-Nightingale locality of MacDonald, 1949).

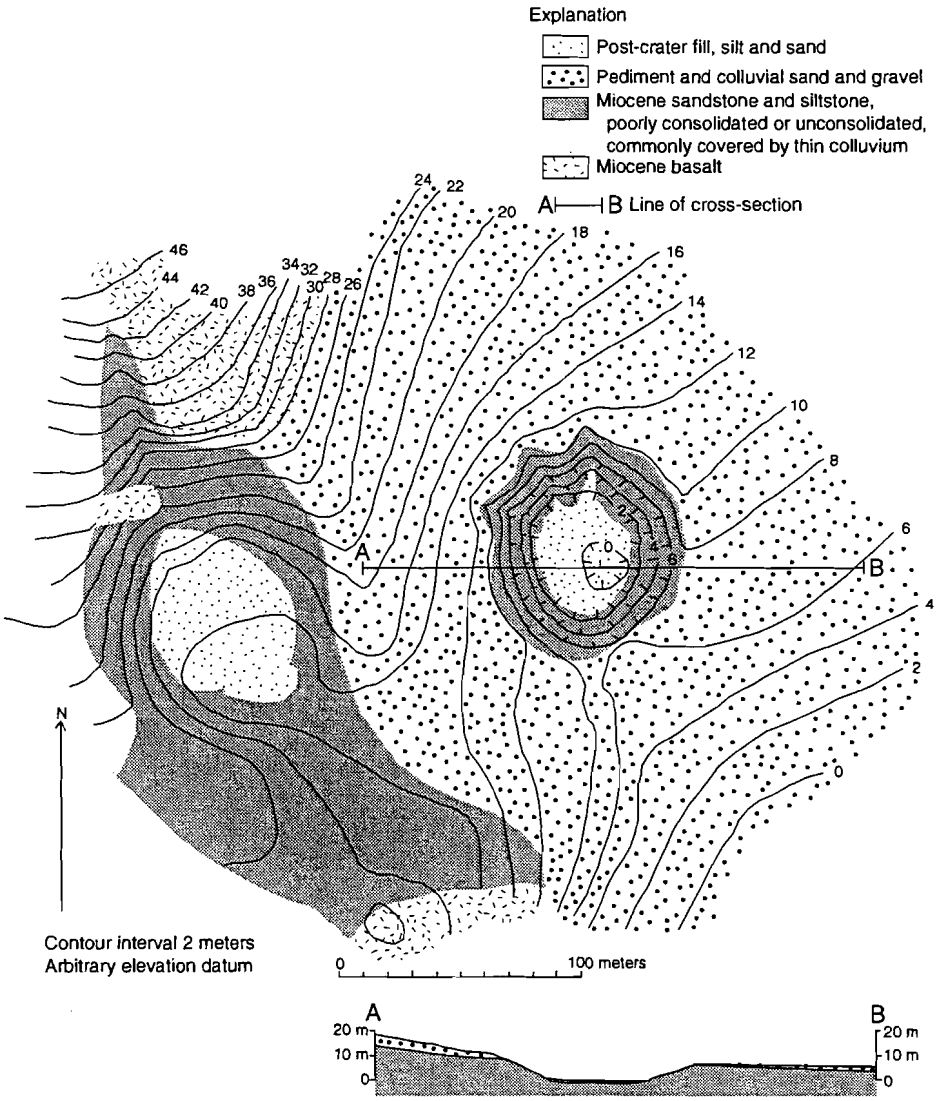

Figure 2. Contour and geologic map of North Valley craters. Surveyed by plane-table methods by J. H. Stewart and R.W. Kopf in 1992. Arbitrary elevation datum

Figure 3. Low altitude, oblique aerial photograph of North Valley craters. Line of sight is about S45E. Main (eastern crater with a diameter of 80 m is in the center of the photograph. Second (western) crater is to the lower right of the main crater at the prominent white area. Note northeast-dipping basalt in upper left of photograph, and gullies on the north and northeast side of eastern crater.

Hydrothermal Explosion Versus Impact Origin

The North Valley craters are considered here to be hydrothermal explosion craters, rather than impact craters. The absence of an elevated rim formed by impact ejecta and the apparent absence of deformation on the crater walls themselves are the most important factors in this interpretation. Impact craters are characterized by elevated rims and by crater-wall deformation, whereas hydrothermal explosion craters that form in unindurated, or little indurated material, are characterized by non-elevated rims and no crater-wall deformation (Marini and others, 1993). We also noted an absence of an elevated rim and the possible absence of crater-wall deformation at a "phreatic explosion crater" (considered here to be a hydrothermal explosion crater) associated with the Steamboat Springs hydrothermal system, south of Reno, in western Nevada (Bonham and Rodgers, 1983). As outlined by Marini and others (1993), ejecta from hydrothermal explosion craters consist of relatively thin water-dominated debris-flow deposits that spread out moderate distances from the crater and are easily eroded. Such debris-flow deposits have not been recognized at the North Valley craters and apparently have been eroded away. Some remnants may be present, but have not been recognized because they resemble the pre-crater alluvial deposits (in part debris-flow deposits) that characterize the area.

The North Valley craters lie within the Battle Mountain high, a region of high temperature gradients and very high (>100mW m^{-2}) heat flow (Lachenbruch and Sass, 1978; Blackwell, (1978, 1983; Sass and Walters, 1999; Sass and others, 1999). The craters are 18 km northwest of Bradys Hot Spring and 20 km northwest of the Desert Peak geothermal field (Fig. 1) (Benoit and others, 1982). The North Valley area is a likely place for blind hydrothermal systems that could have produced the North Valley hydrothermal explosion craters.

In conclusion, small craters that might be interpreted as impact craters can in truth be hydrothermal explosion craters. In addition, hydrothermal explosion craters can be isolated features exhibiting no other surface evidence of hydrothermal activity. The craters described here are 18 km northwest of Bradys Hot Springs, the closest surface indication of a hydrothermal system. When combined with drill-hole heat-flow measurements, hydrothermal explosion craters like those described here are a potential guide to the location of hidden geothermal fields.

Acknowledgments

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