

# **FIRE REGIMES AND FIRE HISTORY: IMPLICATIONS FOR OBSIDIAN HYDRATION DATING**

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## **Abstract**

*That fire can alter the hydration bands of obsidian specimens and thus affect the accuracy of dating is well known. It is also well known that before the 20th Century, fires were generally frequent (intervals of 5-20 years were common) in most forest, woodland, grassland, and shrub ecosystems of the western United States and especially California. Thus, it is likely that obsidian material that has been unprotected for more than a few decades on or near the soil surface has been exposed to fire. Only material that was buried and remained so after it was no longer used is likely to have escaped being influenced by fire. Fire intensity and duration of burning are highly variable and dependent upon the nature of the available fuels and weather. Thus, high variability in dates inferred from hydration rinds should be expected from artifacts that have been exposed to the effects of past fires.*

## **Introduction**

Dating of hydration bands in obsidian artifacts has become an important tool used to help determine dates of archaeological sites, artifacts, and especially intra- site stratigraphy (Friedman and Trembour 1983; Byram 1995). Yet, there are several environmental factors that can confound interpretations of dates due to their effects on the hydration rind development. These factors include (but are not limited to) ambient air temperature, patterns of humidity, exposure to the sun, soil temperature and moisture regime, and fire (the focus of this paper) (Byram 1995).

The ability of fire to alter the hydration bands of obsidian specimens and thus affect the accuracy of dating is well known (Byram 1995). Paleoecological data indicate fire has been interacting with vegetative ecosystems for 350 million years (Clark and Robinson 1993). It is well established that fire has been an important ecosystem process in much of the area that is now California throughout the Holocene. Before the last 100 years, fires were generally frequent (intervals of 5-20 years were common) in most forest, woodland, grassland, and shrub ecosystems (Martin and Sapsis 1992; Agee 1993; Skinner and Chang 1996). Nevertheless, during the 20th Century, fire suppression has been successful in generally minimizing the acres burned by all but the occasional high-severity fires (Skinner and Chang 1996). The success of the fire suppression policy has contributed to a cultural view that fire is unusual or an anomaly in the ecosystem. This view of fire leads to a tendency to ignore the potential long-term influences of fire not only on ecosystems, but also on past cultures and cultural materials.

Fires were frequent before the 20th Century for several reasons. Most important, the Mediterranean climate of California, with warm, dry summers and cool, moist winters, ensures that conditions for fire occurrences are experienced annually in most locations (McCutchan 1977). Thunderstorms cause

many fires annually, particularly throughout the mountainous regions (Schroeder and Buck 1970). The occurrence of fire has often been augmented by human cultures. Ethnographic accounts reveal that Native Americans commonly used fire in many areas of California as a tool to help manage the production of food and necessary materials (Blackburn and Anderson 1993).

Fire intensity and duration are highly variable and dependent upon the condition of available fuels and weather (Rothermel 1983; Agee 1993). The effects of fire on hydration rinds of exposed obsidian are related to the magnitude (and probably duration) of temperatures reached. Thus, investigators should expect high variability in dates inferred from hydration rinds of artifacts that have been exposed to past fires (Byram 1995).

In this paper, we have three objectives: (a) summarize what is currently known about long-term patterns of fire occurrence; (b) summarize what is known about the nature of fire (characteristic behavior and temperatures) for broad vegetation types; and (c) discuss the implications of this information for obsidian hydration dating.

## California Fire Regimes

The Mediterranean climate of California, with its annual warm/dry season, has helped induce vegetative ecosystems where fire has been an important, and often frequent, ecological force for millennia. Some notable exceptions would be extremely dry areas of the deserts, alpine areas above treeline and other areas where fuel accumulates at very slow rates. Several review articles have summarized research on frequency and importance of fire in the more common of California's vegetative ecosystems (e.g., Kilgore 1973; Biswell 1974; Barro and Conard 1991; Martin and Sapsis 1992; Weatherspoon et al. 1992; Agee 1993; Skinner and Chang 1996). Even studies in the moist coastal forests of northwestern California have documented the relatively frequent occurrence of past fires (Stuart 1987; Finney and Martin 1989, 1992; Brown and Swetnam 1994).

Generally, grass dominated ecosystems (including woodlands with fairly continuous understories of grass and herbs) are thought to have had the most frequent fires. These areas are able to carry fires often with annual fires not uncommon. Shrub fields and closed-cone conifer stands are not well studied in California in terms of fire frequencies. This is because most fires in these types are severe and remove evidence of previous fires. These types appear to have quite variable fire return intervals ranging from ~10 years in coastal sage scrub to more than 100 years in some areas. The conifer forests of the ponderosa pine, mixed conifer, and upper montane areas generally have median fire return intervals of approximately 5 to 40 years with considerable variation possible. Subalpine environments are little studied in California. Nonetheless, these areas have a high incidence of lightning. The characteristic fire regime appears to be of frequent, small, smoldering fires that usually do not spread well because of the compactness of the fuelbed and the slow accumulation of fuel.

Martin and Sapsis (1992) provide a California-wide perspective of what our knowledge of historical fire frequency implies in terms of annual area burned. They estimate that, of the 30 million hectares of flammable vegetation in California, between 2.3 (7.7%) and 5.3 (17.8%) million hectares burned annually under historical fire regimes. Of this total, tree dominated ecosystems (9.7 million ha.) accounted for between 0.5 and 1.0 million ha., shrub ecosystems (7.7 million ha.) accounted for 0.3 to 0.9 million ha., and grass/herb ecosystems (12.7 million ha.) accounted for 1.6 to 3.5 million ha.

Clearly, fire was historically a major ecosystem process that frequently affected vast areas. With few exceptions, it was rare for areas to escape the influence of fire for long periods of time.

## **Fire Characteristics in Various Fuel Types**

Potential fire behavior expressed as magnitude and duration of heating is of interest. Most experiments that have studied the effects of fire on obsidian hydration rinds have found that high temperatures are more likely to cause alterations than are low temperatures (Friedman and Trembour 1983; Green et al. 1997). One study showed that temperatures above 200°C for short periods affected the hydration rinds (Green et al. 1997). Thus, the potential for fire affecting the ability to use hydration rinds for accurate dating is related to both the frequency of and the temperatures reached by the many fires that have occurred over years past.

Fire behavior, even within a relatively homogeneous landscape, can be quite variable. The rate of spread and intensity changes with variation in humidity, air temperature, wind speed, fuel moisture, fuel arrangement and fuel quantity (Rothermel 1983). Fires in grasslands will have very different characteristics than fires in shrub or forest environments.

All temperatures given in the following discussion are those recorded at the soil surface. Temperatures within a fire vary greatly from those at the soil surface depending upon the position of measurement in relation to the burning fuel (Woodmansee and Wallach 1981).

### **Grass and Herb Dominated Fuel Types**

Surface temperatures in grasslands have been found to vary from 100°C to over 680°C depending upon fuel loading. The highest surface temperatures are probably associated with local accumulations of loosely compacted litter (Wright and Bailey 1982). Fires usually move rapidly through grasslands and the heating is of short duration. Surface temperatures recorded in fires in annual grasslands range from 80°C to 160°C. Slow moving fires recorded lower peak temperatures than did faster moving fires (Woodmansee and Wallach 1981). However, others have found backing fires to reach higher temperatures than forward spreading fires (Wright and Bailey 1982).

### **Shrub/Chaparral Dominated Fuel Types**

The surface temperatures recorded for chaparral and shrub fires show extremes of over 700°C with temperatures over 500°C remaining for more than 10 minutes (DeBano et al. 1979). DeBano et al. (1979) characterized temperatures in fire described as light intensity, moderate intensity, and high intensity to average 260, 430, and 685°C respectively. Average soil surface temperatures in shrublands were reported to run 350 to 370°C by Woodmansee and Wallach (1981).

### **Tree Dominated Fuel Types**

Fires in forested environments vary considerably depending upon the nature of the fuelbeds. Where fires run through regularly there is little fuel and lower temperatures are reached. Where fires are infrequent, considerable duff and litter can build up, generating much higher temperatures. The highest temperatures, ranging from 620 to 1000°C, are usually associated with burning of heavy logging debris as in clearcuts (Wright and Bailey 1982). Stark (1977) found in Douglas-fir/larch stands that soil surface temperatures ranged from less than 180°C where little duff and litter were consumed to over 300°C where most duff and litter were consumed. Weatherspoon (unpublished data on file PSW Redding, California), in mixed-conifer stands of northern California, found surface temperatures ranging generally from 90°C to over 250°C. Temperatures exceeded 150°C about 50% of the time.

## Implications for Obsidian Hydration Rind Dating

Obsidian exposed to fires with peak temperatures of more than 200°C for short duration may have significant alterations of their hydration rinds (Green et al. 1997). It is clear from the above discussion that many different fuel conditions can produce surface temperatures exceeding this critical level. The existence of conditions necessary to exceed the critical temperature is especially true for shrub fields and forests where fire is less frequent and in productive perennial grasslands where greater amounts of fuel accumulate. Areas of lighter fuels - annual grasslands and herb dominated understories of woodlands - are probably less likely to reach the critical temperatures as often as areas with heavy fuel concentrations. It is also clear from studies of fire history that obsidian material that has been unprotected for more than a few decades on or near the soil surface has likely been exposed to fire. Indeed, considering the frequency of fire in most California environments, it is likely that exposed material has been affected by fire several times. Only material that was buried and remained so after it was no longer in use is likely to have escaped the influence of fire.

Fire intensity and duration of burning are highly variable and dependent upon the nature of the available fuels and weather conditions. The variable nature of fire across the landscape and from ecosystem to ecosystem is well known. It has been found that the degree that hydration rinds have been altered by fire varies from place to place, even within a local site (Green et al. 1997). This variation appears to be related to the nature of the fire as it is affected by fuel and weather conditions. Thus, high variability in dates inferred from hydration rinds should be expected from artifacts that have been exposed to the effects of past fires.

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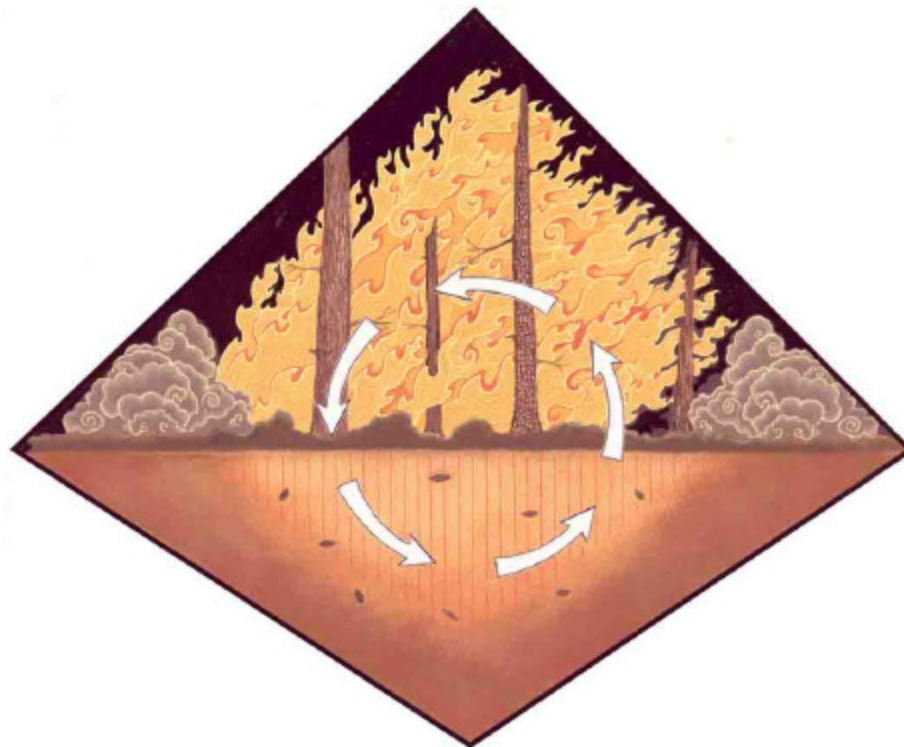
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