Chapter 1

GEOLOGIC HISTORY OF MAUI

John M. Sinton
Hawaii Institute of Geophysics
University of Hawaii
Honolulu, Hawaii 96822

INTRODUCTION

Maui is the second largest of the Hawaiian Islands, and covers about 730 square miles. Named after a Polynesian demigod, it is now commonly known as "The Valley Isle" in reference to its many deeply-incised canyons, most notably those of the West Maui Mountains.

The first non-polynesian visitor to Maui was Capt. James Cook, who visited the island in 1778, during his second voyage to the Hawaiian Islands. He was followed shortly thereafter by the French Explorer, La Perouse, who anchored off the southwest shore of Haleakala in 1786 in the bay that now bears his name.

American missionaries established the Lahainaluna School near Lahaina in 1831. Lahaina prospered as a whaling port in the mid-1800's. Although nearly decimated by modern whalers, Humpback whales can sometimes still be seen from January to late-April in their winter mating grounds off Lahaina. Sugar and pineapple cultivation formed the economic base for Maui in the early years, but the island's economy is currently undergoing diversification with the establishment of hardwood forests, cattle ranching and a winery on East Maui, along with a growing tourist industry on the south and west coasts. Kula onions from upland Haleakala and Maui potato chips produced in Kahului are special treats for residents of, and visitors to this unique and beautiful island.

Geological Exploration

J. D. Dana (1849) provided the first physiographic description of Maui, based mainly on notes made by members of the Wilkes Expedition while sailing past it on their way to the island of Hawaii. Dana (1889, 1890) spent a few days on Maui in 1887 and subsequently published his observations. Other early physiographic observations were made by Brigham (1868) and Dutton (1884). Early contributions to the petrology of rocks from Maui were made by E. S. Dana (1889), Cross (1915), Powers (1920) and Washington and Keyes (1928). The single most substantial contribution to deciphering the geology of Maui was made by Stearns and Macdonald (1942) following intensive field and petrographic studies. Macdonald (1963, 1968; Macdonald and Katsura, 1964) added significantly to this earlier work and gave special emphasis to Haleakala in later years (Macdonald, 1978; Macdonald and Powers, 1946, 1968). In addition he supervised M.S. theses on Haleakala (Brill, 1975; Horton, 1977). Fodor and co-workers (Fodor et al, 1972, 1975, 1977; Keil et al., 1972) provided detailed mineralogical data on rocks from Maui; a review of these studies is contained in Chapter 2 of this section. Much of the present chapter draws heavily on the work of Stearns and Macdonald (1942) and on subsequent reviews (e.g. Macdonald and Abbott, 1970).

Geologic History

Maui is part of a large volcanic massif that includes the islands of Molokai, Lanai and Kahoolawe. At times this massif was emergent as a single island with an area of about 2000 square miles (Stearns and Macdonald, 1942). Maui itself consists of two separate volcanoes. The West Maui volcano is probably the older of the two, but both may have been concurrently active over part of their histories. East Maui (Haleakala) was last active about 1790, whereas activity on West Maui is wholly pre-historic.

Both volcanoes share with other Hawaiian volcanoes a common evolution through three principal petrological stages (Fig. 1). Basaltic, mostly tholeiitic shield-building eruptions dominate the history, followed by a discontinuous covering of differentiated alkalic lavas. Following a profound period of quiescence, each volcano then had a brief history of post-erosional volcanism. In other respects, however, the two volcanoes are distinct and hence are treated separately below.

West Maui

Stearns and Macdonald (1942) distinguished three separate volcanic series in West Maui (Fig. 1). The Wailuku Volcanic Series comprises about 97% of the volume of the volcano (Macdonald, 1963). This series consists mainly of thin pahoehoe and aa flows of tholeiitic olivine basalt with minor plagioclase basalt. The exposed section is at least 1700 meters thick. In the uppermost section, the lavas became more alkalic, grading to alkali olivine basalt, and locally to ankaramite. For the most part, Wailuku Series eruptions were generally quiet; explosive pyroclastic deposits are rare. Tuff beds are increasingly more abundant near the upper parts of this series and can be seen separating tholeiitic basalt and alkalic basalt along Route 30, north of McGregor Point (see Chapter 3, Field Trip Stop 4).

The shield volcano eventually underwent summit collapse to form a caldera about 3.2 km across (Fig. 3). Lava beds dip outward at about 10° to 20° outside of the caldera. Post-caldera deposits have variable orientation. Lava flows were originally nearly horizontal within the caldera boundaries but talus breccias have expectedly steeper dips. Much of the caldera complex has, however, been disturbed by episodes of later collapse.

The boundary between the Wailuku and Honolua Volcanic Series is marked by a soil horizon up to 2 m thick. However, in many places this soil is notably ashy and, although any eruptive activity marking the transition from Wailuku to Honolua volcanism was probably already restricted, there is no evidence that the volcano was completely inactive at that time. The Honolua Volcanic Series lavas are dominantly differentiated alkalic rocks, ranging from mugearite to soda trachyte in composition.

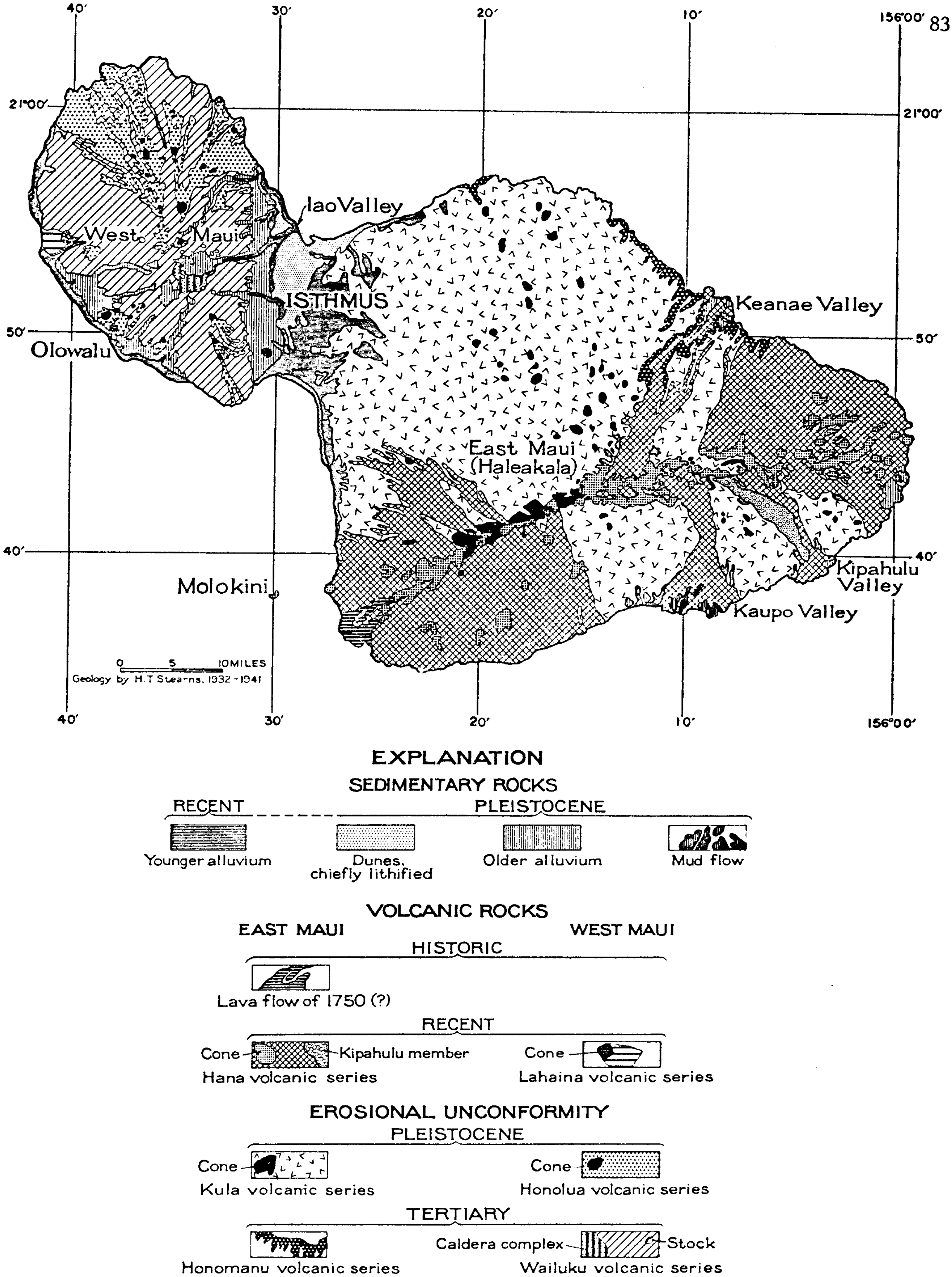

Figure 1. Geologic map of Maui (from Macdonald and Abbott, 1970, after Stearns and Macdonald, 1942).

This series forms an incomplete cap to the volcano, ranging from single flows less than 10 m thick up to several flows with a total thickness of about 230 m on the northeastern slope (Macdonald and Abbott, 1970). Locally, viscous trachytic magma formed domes with steeply dipping flow planes (Fig. 2). Such domes are preserved as hilly landmarks, for example at Mt. Eke, Puu Koae and at Puu Mohanalua Nui.

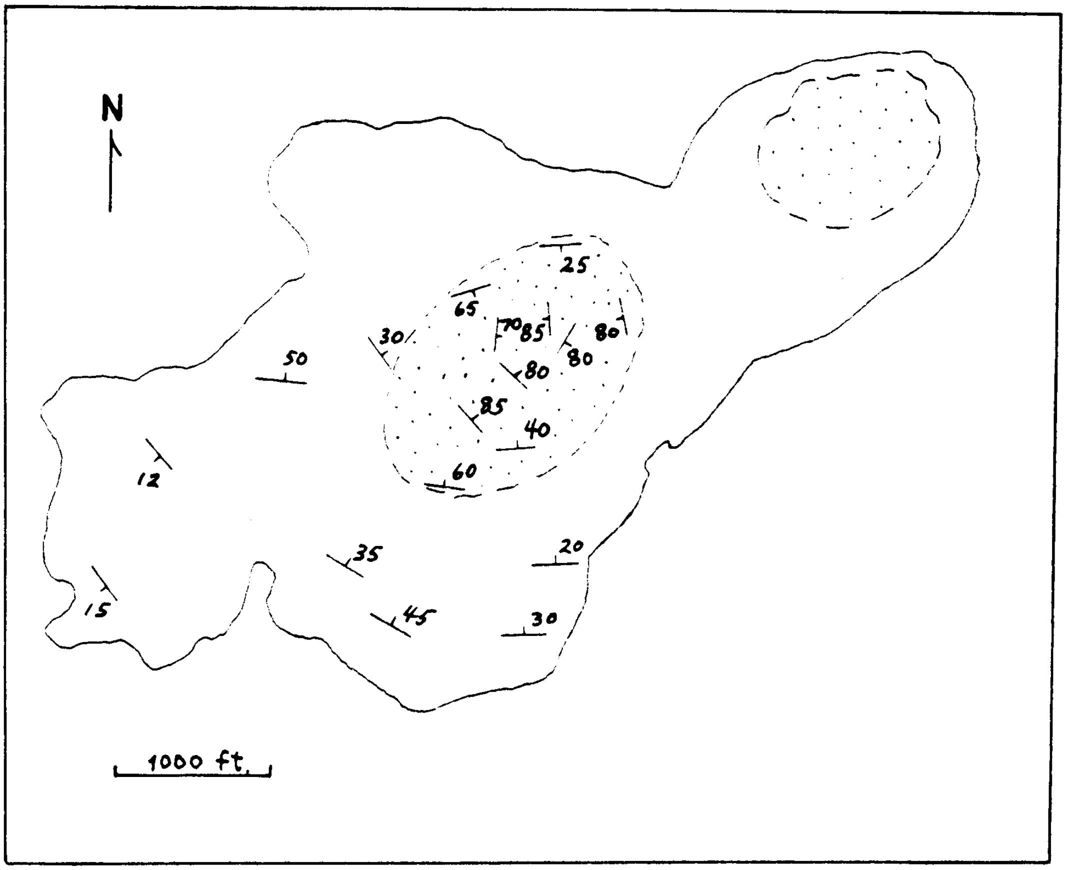

Figure 2. Survey map of flow planes of the Launiupoko dome and flow of Puu Mohanalua Nui, West Maui. Domes are stippled. Survey by G. A. Macdonald (after Stearns and Macdonald, 1942).

The distribution of dikes and vents of the Honolua Volcanic Series is somewhat irregular and the roughly circular plan view of West Maui supports the interpretation that, in contrast to most Hawaiian volcanoes, this volcano had no well-developed rift system. However, several indefinite zones were suggested by Stearns and Macdonald (1942) as shown in Figure 3.

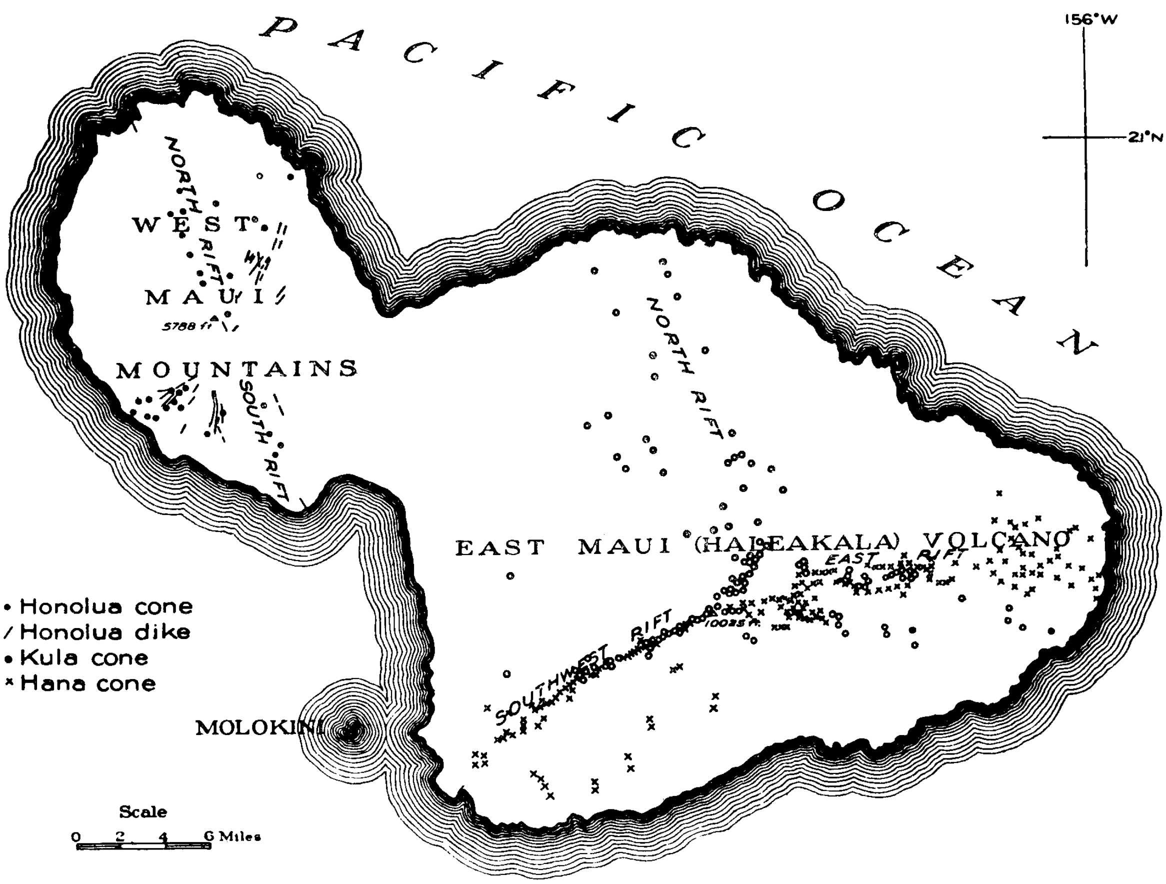

Figure 3. Rift zones of Maui as defined by the distribution of cones and dikes of the Honolua, Kula and Hana volcanic series. (From Stearns and Macdonald, 1942.)

Since the cessation of Honolua volcanism at least 500,000 years ago, West Maui has undergone profound erosion, continuing to the present day. The volcano was again briefly active during a short interval during which four small eruptions occurred on the southwestern slope. These lavas, centered at Puu Hele (now completely quarried away for cinder), Puu Kilea, Puu Laina and Kekaa Point (see Chapter 3, Fig. 1 for localities), form the Lahaina Volcanic Series. They are all silica undersaturated basanitoids or basanites.

West Maui is presently in the early maturity stage of stream erosion. Broad alluvial fans are distinct along the eastern and southwestern sides of the mountain. Lithified to semi-lithified calcareous sand dunes rest on alluvium near Kahului Bay (see Chapter 3). Locally, these dunes are as much as 62 m high, and a test drill hole indicates that they extend below sea level. Macdonald and Abbott (1970) suggest that they formed during the -40-foot stand of the sea. Unconsolidated dunes are still forming today in this region.

East Maui

East Maui Volcano is now almost wholly covered by post-shield-building stage alkalic lavas. The shield-building lavas of East Maui are designated as the Honomanu Volcanic Series (Stearns and Macdonald, 1942) and are restricted to exposures of tholeiitic olivine basalt to oceanite along the northern sea wall and valleys. This series is lithologically similar to the Wailuku Series tholeiites of West Maui, but generally has gentler dips, less aa and thicker beds (Stearns and Macdonald, 1942). Content of pyroclastic deposits is generally comparable to that of the Wailuku Series.

The Honomanu Volcanic Series is overlain by alkalic lavas of the Kula Volcanic Series. Locally the contact is marked by the presence of a thin layer of red ashy soil up to 15 cm thick, but elsewhere tholeiitic Honomanu Series lavas are interbedded with Kula alkalic olivine basalts over a transition zone 15 to 60 meters thick. Hawaiite is the predominant lithology of the Kula Volcanic Series, with lesser amounts of ankaramite and alkalic olivine basalt. Explosive eruptions were apparently fairly common at this time as large cinder cones are abundant in the Kula Series. The total thickness varies from about 770 m near the summit of the mountain to as little as 15 m in some places near the coast.

Kula eruptions were generally localized along three well-defined rift zones (Fig. 3). Whether or not these rift zones were active during production of the Honomanu Series is not known, nor is it obvious whether or not East Maui ever had a definite caldera.

A prolonged period of erosion marks the end of Kula volcanism. Formation of some of East Maui's more spectacular valleys--Keanae, Kipahulu and Kaupo--began at this time. The present crater of Haleakala ("House of the Sun") is primarily an erosional feature, formed at the heads of the Keanae and Kaupo valleys as they cut down and back into the mountain during this erosional period (Stearns, 1942).

East Maui's post-erosional volcanism stands in marked petrologic contrast to post-erosional volcanism of other Hawaiian volcanoes. Compared to the nephelinite-basanite-dominated lavas of the Honolulu Series of Oahu, or even the basanite-dominated Lahaina Series of West Maui, the post-erosional Hana Volcanic Series of East Maui is less silica-undersaturated (Macdonald and Powers, 1968). Although still alkalic, the Hana Volcanic Series mainly consists of alkalic olivine basalts and basanitoids.

Hana Series lavas cover much of the southeast and western part of the volcano; apparently the north rift zone, active during Kula time, was not a locus of Hana volcanism (Fig. 3). The Hana Volcanic Series realizes a maximum thickness of over 900 m in the summit depression, but the presence of many inter-flow soil horizons and local unconformities indicates that Hana volcanism has been intermittent. The small tuff cone of Molokini Islet and the 1790 basanitoid flows of LaPerouse Bay have petrological affinity with other Hana Series lavas, and East Maui must be considered dormant; the potential for further eruptions is quite reasonable.

Summary and Absolute Ages

The isthmus separating the two Maui volcanoes is mainly underlain by East Maui lavas that banked against those of West Maui. This observation led Stearns and Macdonald (1942) to the conclusion that activity on West Maui ceased before that on East Maui. This has largely been borne out by further studies. McDougall (1964) dated nine samples from Maui by the K-Ar method. These results are summarized below and in Figure 4.

Three alkali basalts from the uppermost part of the Wailuku Series yielded ages of 1.29 ± 0.02 m.y. This time probably denotes the last stages of Wailuku volcanism; the inception of Wailuku activity remains uncertain. Four areally dispersed samples of the Honolua Volcanic Series gave practically identical ages of 1.16 m.y. This indicates that the petrology of West Maui changed markedly from dominantly basaltic in Wailuku time, to highly differentiated mugearitic through trachytic in a period of about 0.13 m.y. Lahaina series samples have not been dated, but their post-erosional character indicates that they must be quite young. They overlie Pleistocene alluvial deposits along the southwestern side of West Maui.

A sample of Kula Series alkalic lava near the base of this East Maui series is 0.84 m.y. old and probably approximates the beginning of Kula volcanism. This date indicates that the shield-building-alkalic cap transition occurred about 0.32 m.y. later on East Maui than on West Maui. A sample of lava from considerably higher in the Kula section is about 0.45 m.y. old, indicating that Kula volcanic activity lasted at least 0.4 m.y. and that Hana Series volcanism is confined to less than the last 400,000 years. Samples of Hana Series lavas have not been dated radiometrically but the youngest flow is known to have been erupted about 1790 (Oostdam, 1965).

Macdonald and Katsura (1964) distinguished Hawaiian volcanoes in which the principal alkalic lava is mugearite (Kohala type" from those

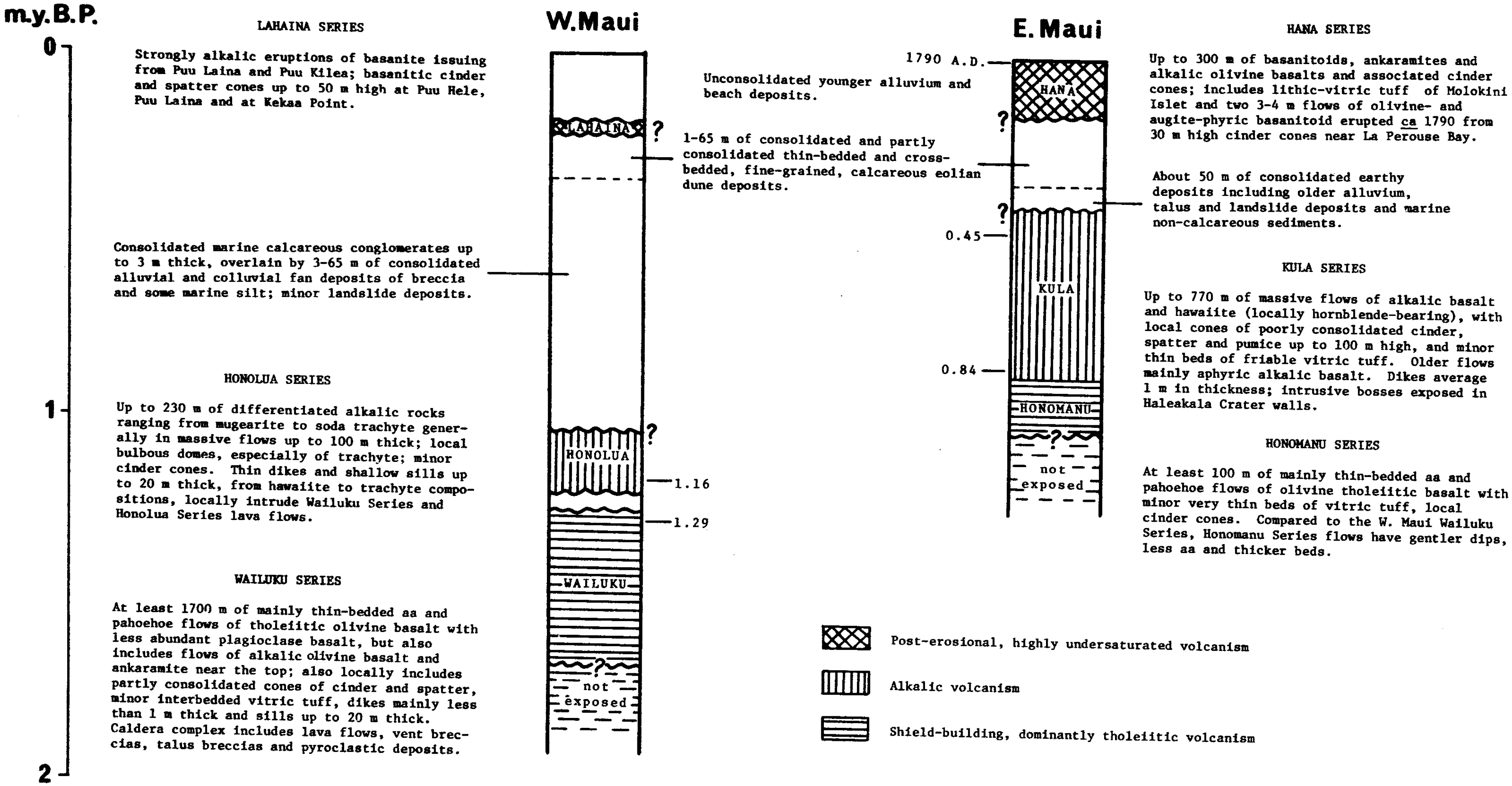

Figure 4. Generalized time-stratigraphic section of Maui volcanic series. Lithologic data mainly from Stearns and Macdonald (1942). Geochronologic data from McDougall (1964) and Oostdam (1965). Question marks denote age uncertainties. Vertical scale is in millions of years before present (m.y.B.P.).

in which it is hawaiite ("Haleakala type"). In this scheme, West Maui is a "Kohala type" volcano and the contrast between the two Maui volcanoes is greatest in their second-stage alkalic volcanism (Honolua versus Kula). Other obvious contrasts can be made with respect to the comparative relative proportions of shield-building lava to later differentiates (greater volume percentage of shield-building lavas at West Maui) and to the volume and character of post-erosional products (much higher volume but less undersaturated at East Maui). The extent of the erosional period before onset of post-erosional volcanism is not well established on either volcano, but Macdonald and Powers (1968) suggest that this interval may be relatively short on East Maui (see also Fig. 4).

In summary, both volcanoes of Maui contain features that have come to be recognized as characteristics of Hawaiian volcanism. Although they may well have been concurrently active over part of their respective histories, they have apparently evolved quite separately. Maui is indeed blessed with two distinctive volcanic monuments. Together they typify Hawaiian volcanoes in general. But individually, they maintain their own unique characteristics--features that provide evidence for more fully understanding the origin and evolution of one of the most beautiful and fascinating island chains in the world.

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