DISCRIMINATION CRITERIA FOR SOURCES OF T PHASES RECORDED IN FRENCH POLYNESIA

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ABSTRACT

We use a dataset of 150 digital records of T phases from 71 sources obtained on seismometers of the Polynesian Seismic Network to define a discriminant separating earthquake and explosion sources. It uses the maximum amplitude of recorded ground velocity, measured on its envelope (e_{Max} ; in microns/second), and the duration of the phase measured at 1/3 of maximum amplitude ($tau_{1/3}$; in seconds). Earthquake sources and man-made explosions are effectively separated in a log-log space by the straight line

(1) $\log_{10} (e_{Max}) = 4.9 * \log_{10} (tau_{1/3}) - 4.1$

We are motivated by the observation that other criteria, both in the time and frequency domains, fail to reliably separate the populations of the various kinds of events. In particular, we define a class of intraplate earthquakes, mainly located in the vicinity of active centers of volcanism, whose T phases feature many characteristics reminiscent of explosions, rather than of plate boundary earthquakes.

In the frequency domain, we studied systematically such parameters as mean frequency of the signal, maximum frequency of the signal, and width of spectrum, as well as the ratio of energy contained in the lower and higher parts of the seismic spectrum. In most instances, we observe that the highest and lowest values of the properties investigated indeed belong to different classes of sources. However, there is a field of average values where no discrimination is possible, in particular because intraplate earthquakes tend to exhibit properties typical of explosions (notably higher-frequency spectra). Thus the parameters listed above cannot be used as reliable discriminants.

In the time domain, we similarly investigated the rise time and fall time of the envelope of the signal, as well as its total duration, with very similar conclusions, namely that the longest signals, and those rising fastest were indeed generated by explosions, while the slower-rising or longer-lasting ones were generated by plate boundary earthquakes. However, there are intraplate earthquakes occupying an intermediate field and making the use of such discriminants unreliable. We also tested the higher statistical moments -- skewness and kurtosis -- applied to the envelope of the waveshapes, with totally similar conclusions, namely they discriminate efficiently between the end-members of the populations, but cannot resolve the center field, which is occupied by a mixture of explosions and intraplate earthquakes.

On the other hand, we find that the discriminant (1), when applied to T phases recorded at atoll stations, successfully separates explosions, which plot above the straight line (1), from earthquakes (both plate boundary and intraplate), which plot below the line. The only exception is a small earthquake at the volcanic island of Mehetia in Polynesia, which is marginally misidentified, and a record of a Hawaiian earthquake at one Polynesian station, which is correctly identified at another station. An important aspect of the performance of (1) as a discriminant is that it misses no explosion in our dataset. We emphasize that the performance of (1) as a discriminant can be degraded if records are taken at stations located on high islands, rather than on atolls. The reason is that the propagation of the converted seismic wave from the conversion point to the station can significantly affect the time domain characteristics of the waveshape of the final T phase. Also, T phases recorded from episodes of volcanic activity cannot be reliably discriminated from man-made explosions; this is probably due to the explosive nature of some volcanic sources. We will present a possible interpretation of the origin of the discriminant (1) in terms of scaled properties of seismic and explosive sources.

Key words: T-phases, hydroacoustics, explosions, discriminants

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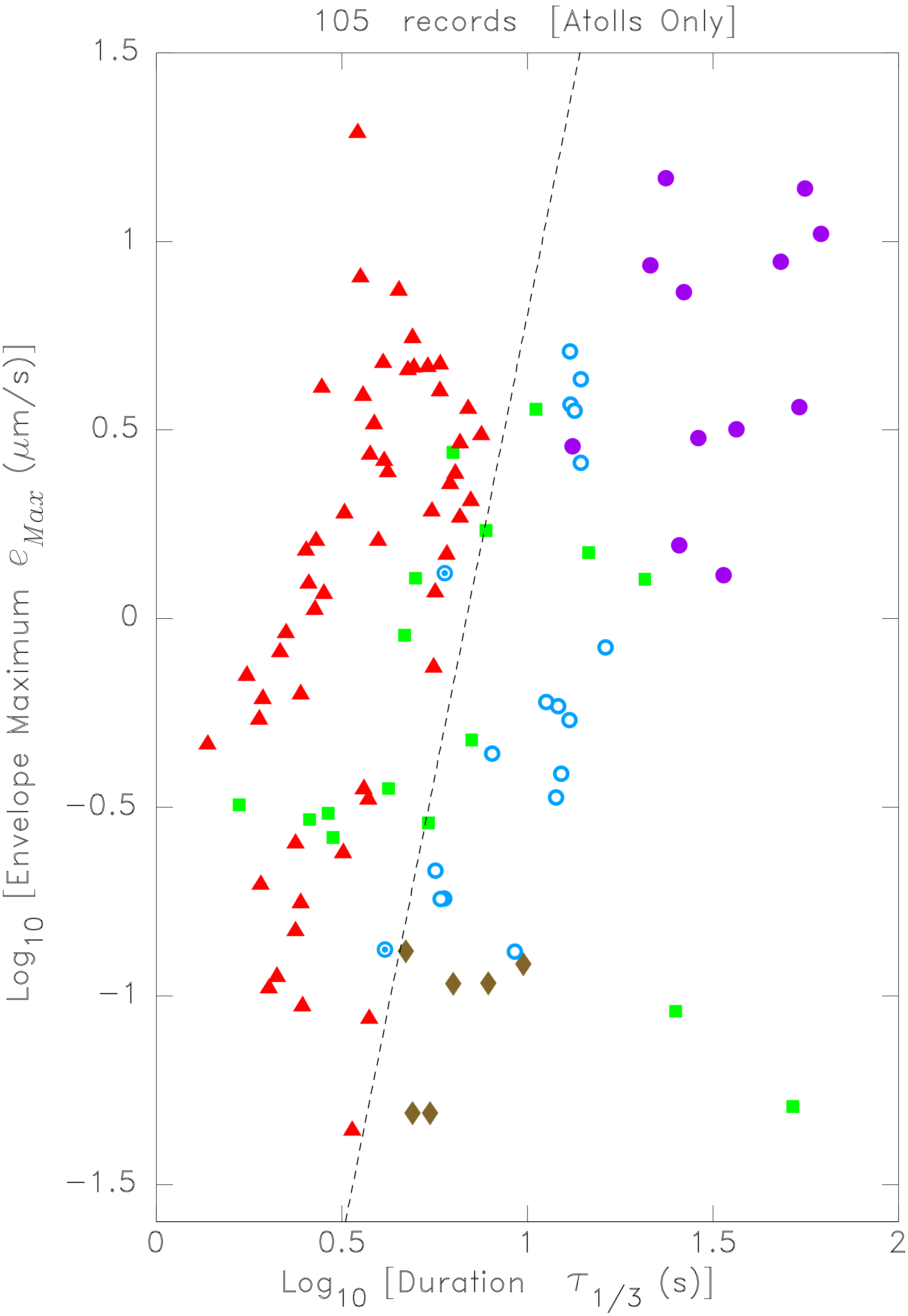

The duration-amplitude discriminant. This figure plots the envelope maximum e_{Max} as a function of signal duration measured at 1/3 of maximum, $\tau_{1/3}$. The following symbols are used to differentiate the various sources: *Solid circles:* Subduction earthquakes; *Open Circles:* Midplate earthquakes; *Solid squares:* Explosive volcanic events; *Triangles:* Man-made explosions; *Diamonds:* Presumed firing of missiles. The two bull's eye symbols showing the only misidentified midplate earthquakes The dashed line is the proposed separator. This figure includes only records obtained at atoll stations.