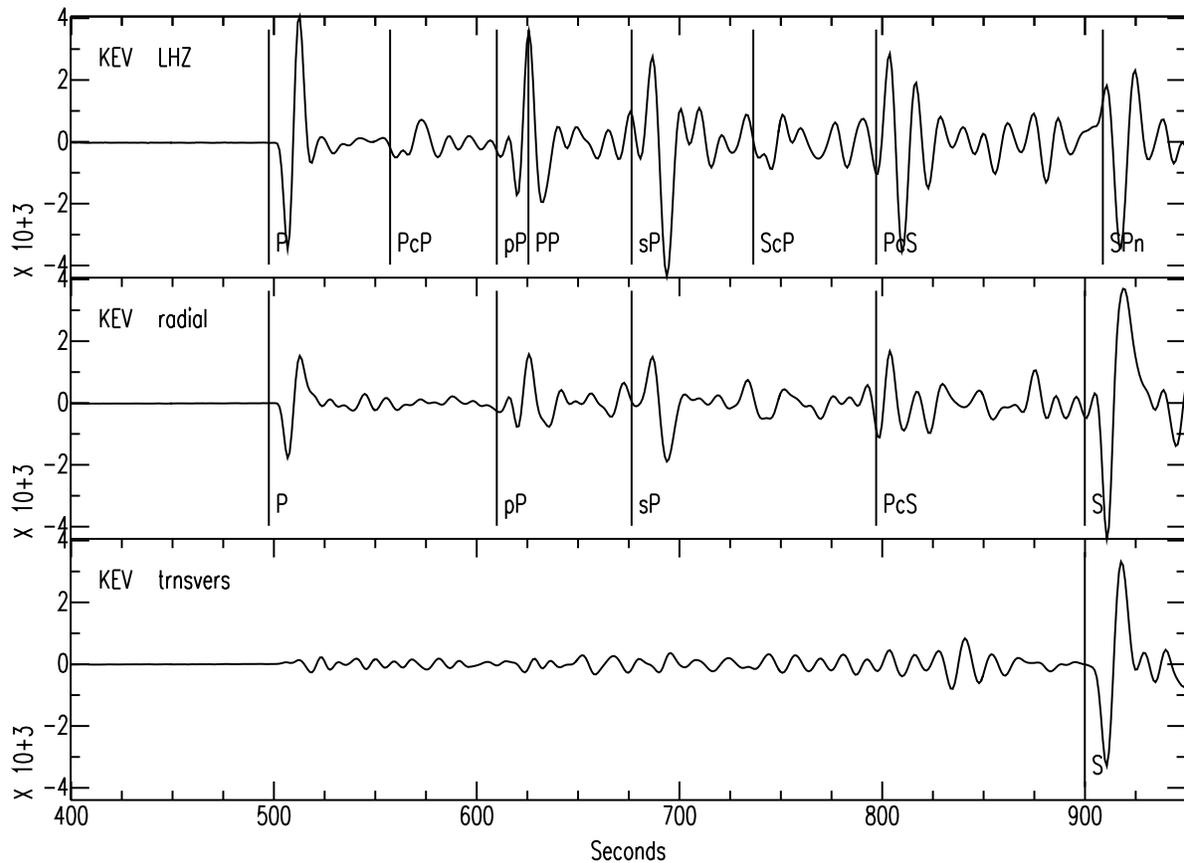


Predicted arrival times for body-wave phases



Shown above are waveforms from the 12 May 1990 $M=6.5$ deep-focus (611 km) Sakhalin Island event recorded at station KEV with an epicentral distance of 52.474° . The waveforms have been instrument-corrected to velocity, and the horizontals rotated to radial and transverse.

This set of seismograms was chosen because of the large number of clear body-wave arrivals. In preparing this figure, predicted arrival times were calculated using program *times* for model *iasp91*. These phases were added to the waveform plot using a SAC (Goldstein *et al.*, 2003) script (see below).

A close examination of the arrival labeled *PcS* shows that care must be taken when interpreting predicted arrival times: A phase that arrives as an *S* should be out-of-phase on the vertical and radial components, and, based on the predicted emergence angle of 7.6° , the amplitude on the radial should be 6.5 times as large as the amplitude on the vertical. Yet as seen from the figure, the arrivals are clearly in phase on the vertical and radial, and the amplitude ratio is 0.4. Hence, this arrival must be a *P* phase at KEV. George Hellfrich (personal communication, 2008) suggested that the arrival might be *sPP*, and he noted that several “depth phases” of interest to him are not included among the calculated phases for the *iaspei-tau* distribution. Phase *sPP* has a predicted arrival time about three seconds before that for *PcS*, so *sPP* is almost certainly the observed phase.

The phase information from program *ttimes* for model *iasp911* for a focal depth of 611 km and an epicentral distance of 52.474° is as follows:

code	time	Take-off ang	dT/dD	dT/dh	d2T/dD2
P	497.464	45.226	7.112	-7.02E-02	-4.51E-03
PcP	557.336	22.482	3.831	-9.21E-02	8.75E-03
pP	609.935	128.993	7.787	6.27E-02	-3.90E-03
PP	625.524	62.192	8.861	-4.65E-02	-1.80E-02
sP	676.419	155.531	7.577	1.66E-01	-4.07E-03
ScP	736.422	13.802	4.364	-1.77E-01	1.75E-02
PcS	797.014	25.934	4.381	-8.96E-02	2.02E-02
S	899.865	46.266	13.217	-1.26E-01	-2.92E-03
SPn	908.766	48.701	13.742	-1.20E-01	-5.85E-02

A SAC script, *phases.m*, is used to produce an annotated plot. One starts SAC and enters

```
m phases.m.
```

The contents of *phases.m* are as follows:

```
r KEV.t
cut 400 950
r
ch t7 899.9
ch kt7 "S"
write KEV-phases.t
r KEV.r
cut 400 950
r
ch t0 497.5
ch kt0 "P"
ch t2 609.9
ch Kt2 "pP"
ch t4 676.4
ch kt4 "sP"
ch t6 797.0
ch kt6 "PcS"
ch t7 899.9
ch kt7 "S"
write KEV-phases.r
read KEV.z
cut 400 950
r
ch t0 497.5
ch kt0 "P"
ch t1 557.3
```

```
ch kt1 "PcP"  
ch t2 609.9  
ch Kt2 "pP"  
ch t3 625.5  
ch kt3 "PP"  
ch t4 676.4  
ch kt4 "sP"  
ch t5 736.4  
ch Kt5 "ScP"  
ch t6 797.0  
ch kt6 "PcS"  
ch t7 908.8  
ch kt7 "SPn"  
write KEV-phases.z  
read KEV-phases.z KEV-phases.r KEV-phases.t  
ylim all  
fileid location ul type list kstcmp  
bd sgf  
p1  
mv f001.sgf zrt_phases.sgf  
sgftoeps.csh zrt_phases  
quit
```

URL <http://www.iris.edu/software/sac/> has information about the current SAC package.