The condition for stability against deformation is that the bracket be positive, that is:

$$\frac{Z^2}{A} < 44.7 \qquad (8\text{-}10)$$

For uranium Z^2/A is 36, while for lower elements its value is even smaller, indicating that the foregoing condition for instability is too stringent.

Actually, instability will occur for lower values of Z^2/A than the limiting value given by equation (8-10). For potential curves of the shape shown in Figure 52, the barrier is rather transparent, and one could expect appreciable spontaneous fission. The probability of leakage through the barrier will be finite, so that the decay constant with respect to fission will not be zero. Even for U^{238}, there are ~ 20 fissions per gram per hour spontaneously (corresponding to a "fission half-life" of about 10^{18} years), so that for heavier atoms this may soon become a prominent phenomenon.

Our principal interest is not in spontaneous fissions but in fissions brought about by neutrons. Neutrons can cause fissions by contributing their kinetic energy and their binding energy to the nucleus. This energy is at least 5 or 6 Mev (the binding energy of the neutron) and may raise the energy of the nucleus high enough within the barrier for a fission to take place before the excess energy is lost by gamma radiation. Because of the fact that the binding energy of neutrons to nuclei with an odd number of neutrons is larger than it is to those with an even number of neutrons (see equation (8-6)) it is reasonable to expect fission for thermal neutrons to be more prevalent for those nuclei with an odd number of neutrons. This is confirmed by experiment. U^{238} is not fissioned by thermal neutrons whereas U^{235} is. Moreover the other "fissionable" materials, U^{233} and Pu^{239}, each have an odd number of neutrons. From facts such as these and photofission thresholds, one can estimate that for uranium the height of the fission barrier is of the order of 5 Mev.

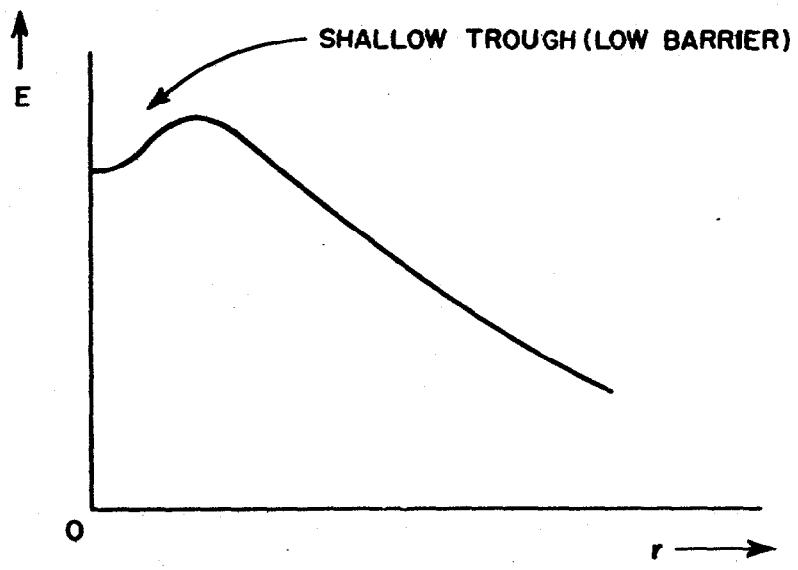

Figure 52. Possible potential barrier in spontaneous fission.

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