CRATERING MOTIONS AND MATERIAL DESCRIPTIONS FOR
PRAIRIE FLAT/DIAL PACK SURFACE-BURST EXPLOSION CRATERS IN WET,
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Terrestrial explosion craters which exhibit flat floors and
central uplifts or multirings suggest comparison with planetary
impact craters or basins having similar morphological and struc-
tural features (4). Understanding the dynamic cratering motions
of the explosion craters hopefully should improve understanding
of the planetary impact structures even though the target mater-
ials and scales are dissimilar.

The Prairie-Flat 500-ton tangent sphere TNT charge was de-
tonated in August, 1968 at the Defence Research Establishment
Suffield (DRES), Alberta, Canada. It formed a large, shallow
crater with a broad central uplift surrounded by a multiring
structure on a flat-floor with steep sides. The site stratigra-
phy consisted of layered alluvial, lacustrine, and glacial till
deposits overlaying sandstone bedrock. The water table was at
approximately 6.7 meters and the bedrock at 65 m. The apparent
crater was 61 m wide and 4.4 m deep. The event was heavily in-
strumented with velocity gages and sand column marker cans.
Detailed geologic cross sections were also made after the event.
Dial Pack was an identical 500-ton tangent sphere TNT event over
the same geology. Together the Prairie Flat/Dial Pack data pro-
vide a detailed picture of a large aspect ratio cratering event
with which to compare the results of computer simulations.

The well-documented data and extensive post-shot analysis
provide a coherent picture of the crater development and sequence
of cratering motions involved. This makes Prairie Flat an ideal
event to verify the adequacy of computational techniques and
material modelling efforts for cratering applications and speci-
fically to calculate larger aspect ratio craters than has been
done previously.

Within the first several seconds Prairie Flat formed a
broad flat-floored crater with overturned flap and downfolded
rim (5,6). Simulations of Prairie Flat address the cratering
motions of large transient uplift of material and rebounding of
the crater floor as well as the terminal deformations. Specific
features which calculations attempt to simulate are: (i) the
sequence of rim deformations and motions resulting in a down-
turned rim and overturned flap, (ii) the crater shape and large
aspect ratio, specifically the formation of the broad, flat floor,
(iii) the central uplift and surrounding multiring structure,
(iv) the role played by the layering, including the shallow water
and the alluvium-bedrock interface, and (v) the time se-
quence and mechanisms involved in these. At early times as the
large transient cavity expands, a large part of the flow field
can be described by a simple modified Z-Model (1). But as the
rebound and inward motions occur the flow field description
becomes much more complicated and requires resolution into
several different phases.
The basic data needed for the calculations are the compressibility and shear strength of the various layers of material at DRES (3,8). The basic material models are augmented by an effective stress rule (2) which requires an input relation of pore pressure as a function of applied mean stress or volumetric strain. The basic idea of the effective stress rule is based on the observations that if the pore pressure and hydrostatic stress are increased by the same amount, then there is negligible change in the volume of the material; and there is no increase in the shear strength if both the stress and pore pressure are increased by the same amount, but if the applied stress alone is increased there is a large increase in shear strength. To apply effective stress concepts to a material, the material needs to have high porosity, be nearly saturated with a not too viscous fluid, and be permeable. The first order effects of the pore pressure are to make the material less compressible and lower in shear strength than it would otherwise be. But the difference in material behavior introduced by the presence of a nonzero pore pressure are not just quantitative, they are qualitative. When the effective stress replaces the mean stress in the relations for compressibility and shear strength, qualitatively as well as quantitatively new possible stress-strain paths are introduced.

The effective stress model provides a particular kind of strain softening of the fluid saturated material during unloading at constant axial strain (the approximate condition of most of the cratering flow field behind the outgoing shock). In a parameter study in which two cratering calculations were done varying only the material strength in a somewhat arbitrary way, it was shown (7) that reduction in the low pressure failure strength of the material after passage of the shock wave leads to larger aspect ratio, larger volume, and longer formation time. Where applicable, a reasonable effective stress model provides just such a real physical mechanism for material strength reduction on unloading. An effective stress material model can thereby lead to the calculation of larger aspect ratio craters.