# Numerical Evaluation and Analysis of the Occurrence of Earth Fissures in Faulted Sedimentary Basins

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## ABSTRACT

This dissertation describes the occurrence of pumping-induced earth fissures associated with quaternary faulting using numerical simulations. The Eglington Fault located in Las Vegas valley has been selected as the prototype fault described herein. The finite-element software program ABAQUS is used for the numerical simulations.

The Eglington fault area is chosen because it represents one of the best examples displaying the complex relationship between fissuring, faulting and pumping-induced stress. This fault is known to influence both the vertical and horizontal deformation patterns through the accumulation of stress in its vicinity. The result is that fissures are observed on both sides of the fault and in close proximity to the fault plane. In addition to the complex fault-fissure connection, a thick caliche-rich vadose zone with weak mechanical strength allows for the initiation and propagation of fissures.

The numerical analysis a) investigates the geometrical and hydromechanical features of the zone of influence surrounding the Eglington Fault; b) identifies the zones of accumulated stress on the surface and at depth that can lead to fissuring; and c) simulates the onset and propagation of tensile-induced fissures.

Three-dimensional numerical simulations of this fault indicate that a 100-meter wide fault-zone composed by sand-like material best reproduces the conditions of stress that may lead to fissuring in the vicinity of the fault. Additionally, two-dimensional models reveal that two main mechanisms promote the accumulation of stress in the vicinity of the fault zone: one is the counterclockwise rotation of the unsaturated portion of the fault zone; the other is the differential compaction caused by the difference in the accumulated thickness of compressible layers. Tensile stress is concentrated on the surface in the hanging wall, but maximum shear stress zones are simulated to occur on both sides of the fault at the contact between the saturated aquifer and the vadose zone. A final analysis of the initiation and propagation of tensile-induced fissures demonstrates that fissures commence and propagate only within the vadose zone, and that the propagation path is influenced by the mechanical properties of the medium and the location of the main load, which in this case is pumping.

# DEDICATION

This dissertation and all work behind it is dedicated to two exceptional persons:
My dear Norma, and loved Mother.

Mother, I am sure you are always taking care of me
in whatever part of heaven you are now.

Norma, thanks for every little thing you do for me and
for every little moment you spend with me.

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# ATTRIBUTIONS

This dissertation consists of three journal papers. Chapter two was published in the Hydrogeology Journal (DOI 10.1007/s10040-009-0501-8), "Hernandez-Marin, M., and Burbey. T.J., The role of faulting on surface deformation patterns from pumping-induced groundwater flow (Las Vegas Valley, USA). The concept of the project, model simulations and interpretations, writing and figure preparations were performed by M. Hernandez-Marin. T.J. Burbey clarified text and reviewed the manuscript.

Chapter three was submitted for publication to the Journal of Hydrology: "Hernandez-Marin, M., and Burbey. T.J., Fault-controlled deformation and stress from pumping-induced ground-water flow in a hydrogeologic setting. The concept of the project, model simulations and interpretations, writing and figure preparations were performed by M. Hernandez-Marin. T.J. Burbey clarified text and reviewed the manuscript.

Chapter four is being prepared for submission to the Hydrogeology Journal. "Hernandez-Marin, M., and Burbey. T.J., Controls on initiation and propagation of pumping-induced earth fissures: insights from numerical simulations". The concept of the project, model simulations and interpretations, writing, and figure preparations were performed by M. Hernandez-Marin. T.J. Burbey clarified text, reviewed the manuscript and contributed with the main conclusion.

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# CHAPTER 1

## 1.1 Introduction

The overall objective of this dissertation is to identify the mechanisms leading to pumping-induced earth fissuring and then to simulate the initiation and propagation of tensile fissures in proximity to basin-fill faults (e.g., the Eglington Fault in Las Vegas Valley). The software program ABAQUS is used for the simulations in this investigation. Pumping-induced earth fissures can be defined as cracks occurring in the soil surface with or without vertical offset. Understanding the conditions and locations where these damaging features will form is important in light of the fact that millions of dollars in damage to structures from earth fissures has led to widespread litigation.

This dissertation is composed mainly of three independent manuscripts that will be published in scientific journals

Chapter 2 describes a numerical analysis of the hydromechanical properties of the Eglington Fault in Las Vegas Valley. Two materials, sand-like and clay-like, and 4 widths, 0-meter, 1-meter, 20-meters and 100-meters are evaluated in order to find the characteristics of groundwater flow and deformation most similar to the observed conditions in the vicinity of the Eglington Fault. Simulation results suggest that a 100-meter wide fault zone composed of sand-like material presents the conditions most like those of the Eglington Fault. The results identify the most favorable conditions leading to earth fissuring. This chapter has been published in *Hydrogeology Journal*.

Chapter 3 describes a series of two-dimensional numerical analyses in which the location of fissure initiation is discussed on the basis of stress patterns. The geometrical and hydromechanical properties of the fault zone described in chapter number 2 are used in this numerical analysis. The simulated zones of accumulated tensional and shear stress indicate that fissures can occur in three main zones adjacent to the fault zone: (1) a zone of accumulated tensile stress in the hanging wall with maximum values near the surface; (2) another zone of accumulated shear stress on the footwall at the center of the vadose zone; and (3) a zone of accumulated shear stress on the hanging wall in the vadose zone. This chapter is currently in review in *Journal of Hydrology.*

Chapter 4 contains a descriptive conceptual analysis of the occurrence of fissuring in selected locations around the world. The conditions that lead to fissuring are analyzed. These conditions can be broadly summarized as having (a) a complex hydrostatigraphy containing an exploited aquifer as the lower unit, a compressible aquitard as the middle unit, and a weak vadose zone as the top unit; (b) a 100-meter wide fault zone having properties as described in Chapter 2; and (c) a 25-meter high buried fault scarp at the model base that results in an abrupt reduction in aquifer thickness. Furthermore, a numerical analysis of the evolution of stress is provided, followed by a simulation that reveals the locations for the initiation and propagation of tensile-induced fissures. The conceptual model used in the simulations is based on the main conditions described in the descriptive conceptual analysis. Results of the evolution of stress at different times show an early influence of the fault scarp and a persistent strong influence of the fault-zone on the simulated stress patterns. Both tensile and shear stress accumulate primarily in the fault zone. This result is consistent with the results obtained and presented in Chapter 3. The numerical analysis of the onset and propagation of the tensile-induced fissure shows that the fissure commences close to the land surface on the hanging wall and then migrates sub-vertically downward to the contact with the 60º-dipping fault-zone. Once the fissure reaches the fault zone a horizontal deflection is observed in the direction of the pumping well. This deflection is likely caused by a change in the mechanical properties of the medium and influenced by the location of pumping. This fissure terminates near the saturated/unsaturated interface with a total elongation close to the thickness of the vadose zone (100 meters).

# CHAPTER 2

# The role of faulting on surface deformation patterns from pumping-induced groundwater flow (Las Vegas Valley, USA).

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## Abstract

Land subsidence and earth fissuring can cause damage in semiarid urbanized valleys where pumping exceeds natural recharge. In places such as Las Vegas Valley (USA), Quaternary faults play an important role in the surface deformation patterns by constraining the migration of land subsidence and creating complex relationships with surface fissures. These fissures typically result from horizontal displacements that occur in zones where extensional stress derived from groundwater flow exceeds the tensile strength of the near-surface sediments. A series of hypothetical numerical models, using the finite-element code ABAQUS and based on the observed conditions of the Eglington Fault zone, were developed. The models reproduced the (1) long-term natural recharge and discharge, (2) heavy pumping and (3) incorporation of artificial recharge that reflects the conditions of Las Vegas Valley. The simulated hydrostratigraphy consists of three aquifers, two aquitards and a relatively dry vadose zone, plus a normal fault zone that reflects the Quaternary Eglington fault. Numerical results suggest that a 100-m-wide fault zone composed of sand-like material produces: (1) conditions most similar to those observed in Las Vegas Valley and (2) the most favorable conditions for the development of fissures to form on the surface adjacent to the fault zone.

## 2.1. Introduction

Surface deformation in the form of subsidence and earth fissuring resulting from heavy pumping in arid to semiarid regions, has been observed in many valleys and coastal regions around the world. The damage caused by this geologic hazard in urbanized valleys has resulted in enormous economic loss. In Las Vegas Valley (Nevada, USA), for instance, this problem has caused more than 10 million dollars in damage to infrastructures and has led to subsequent litigations (Pavelko et al. 2006).

Long-term overdraft of groundwater causes fluid pressure reduction in the aquifer and adjacent layers, which is responsible for vertical and horizontal tensile stress in the soil mass (Holzer 1984) and increased hydraulic forces leading to strain accumulation and three-dimensional deformation due to the flow of fluid and solids toward the pumping zone, as demonstrated theoretically by Helm (Helm 1984, 1994a) and physically in the field by Burbey (2006). In most of the valleys undergoing surface deformation, the vertical displacement, also known as land subsidence, generally results from the compaction of the low-permeability compressible layers when their effective stress is gradually increased as a result of the slow release of water from their pore structure. Horizontal surface displacement typically results in earth fissuring and can be mechanically controlled not only by the magnitude of the stress applied, but also by the mechanical properties of the upper weak vadose layer. Pumping-induced fissures take place when tensional stress derived from pumping exceeds the tensile strength of the vadose zone. It is assumed that some fissures are initially formed under ground as buried tension cracks, and then migrate upward to the surface as an erosional process (Bell 1981; Helm 1994b). The influence that faults have on deformation and groundwater flow has been widely discussed (Burbey 2002, 2008; Lin et al. 2006; Marler and Ge 2003; Mayer et al. 2007). It is accepted that faults can influence groundwater flow in three different ways: as a barrier, as a conduit, and as a complex barrier-conduit combination (Bredehoeft et al. 1992). The resulting deformation in each of these responses mainly depends on how groundwater flow is locally related to ground deformation. In other words, it depends on how the grains and fluids are displaced toward the discharging zone/well during pumping according to the Darcy-Gersevanov law.

For this research, the arid Las Vegas valley, a region with increasing water demand in which land subsidence and earth fissuring have been occurring for the past half century, has been selected as the prototype basin. In this valley, the recent analysis of satellite imagery (from global positioning systems (GPS), differential InSAR (interferometric synthetic aperture radar) and PS-InSAR (Permanent Scatterer InSAR) has shown that subsidence patterns induced by pumping are mainly controlled by Quaternary faults (Amelung et al. 1999; Bell et al. 2008). However, the relationship between faulting and earth fissuring is not yet well understood, despite the occurrence of fissures in zones adjacent and approximately parallel to these inactive faults (Burbey 2002). The complex patterns of subsidence-induced earth fissuring in Las Vegas Valley are likely the result of several factors including: (1) the complex nature of the fault system and its multifaceted role on surface deformation and groundwater flow, (2) transient storage patterns resulting from long periods of heavy pumping followed by equally long episodes of artificial aquifer recharge from surface water importation to the basin, (3) the variable spatial distribution of the saturated hydrostratigraphic units and their unique properties resulting in contrasting compressibilities as well as their capacity for transmitting accumulated strain and tensile stress from the aquifer to the vadose zone, and (4) the unique tensional strength of the brittle vadose zone and its capacity to propagate fissures from the saturated zone upward to the surface.

Fault-zone width as a potential control of surface deformation has been discussed recently by Burbey (2008) who determined that a high permeability 5-m-wide fault zone with small hydromechanical differences between the saturated and the unsaturated regions resulted in the best simulated representation of the observed displacements in Mesquite, Nevada. In 2003, Marler and Ge (2003) developed a model to determine the permeability of a low-angle reverse fault in South Park, Colorado. They found that a low-permeability 3.04-m-thick (10-ft-thick) fault zone best represented the observed hydraulic characteristics of the zone. Other investigations related to surface deformation made in Taiwan have included the effect of the dip angle of the fault (Lin et al. 2006). Finally, a recent investigation in Desert Hot Springs, California (USA), included the effect of the type of adjacent materials and their distribution in the vicinity of the fault (Mayer et al. 2007).

A series of analyses using numerical models was developed here to mainly focus on developing a better understanding of the hydromechanical processes responsible for the formation and propagation of earth fissures; hence, a series of simulation scenarios are developed to include the characteristics observed in the vicinity of the Eglington Fault zone in the northwest part of Las Vegas Valley. Within the Eglington Fault zone (Figure 2.1), several subvertical normal faults penetrate through the entire sedimentary sequence and play an important role in aquifer-system deformation and possibly on groundwater flow. The focus of this paper is on the analysis of the complex nature of faulting and its relation to surface deformation, especially extensional stresses that lead to earth fissuring. Three different groundwater flow conditions including natural recharge and discharge, heavy pumping and artificial recharge, are used in the analysis of deformation. Moreover, this investigation includes an analysis of the fault-zone width and the type of fault-zone constituent materials that best represent the field conditions leading to fissuring. Four fault zone widths were studied in this work: 100, 20, 1 and 0 m (no fault zone material). In addition, two types of materials were included: a compressible low-permeability material (clay-like), and a low-compressibility high-permeability material (sand-like). Numerical models were developed using the three-dimensional finite-element code ABAQUS.

### 2.2. Las Vegas Valley as a prototype model

Maxey and Jameson (1948) describe the stratigraphy of the Quaternary sequences in Las Vegas Valley on the basis of field observations and well records. Their description included sand and gravel (aquifers) mainly in the western part of the valley and higher concentration of fine material (aquitards) in the eastern part. This distribution of grain size matches the location of pumping wells reported by Maxey and Jameson (1948), Harrill (1976), and Morgan and Dettinger (1996). In other words, most of the high-volume pumping wells are located on the west side of the valley, where the principal aquifer is thickest and contains fewer intervening aquitards. Pavelko (2004) used lithologic and geophysical logs to describe the hydrostratigraphy to a depth of 243 m at the Lorenzi site (Figure 2.1), which is adjacent to the Eglington Fault System (EFZ), a group of several subvertical normal NE–SW trending faults located at the northwest portion of Las Vegas Valley (Bell et al. 2002). The investigation made by Pavelko was focused on estimating the hydraulic parameters of the aquifer system located near the EFZ using a vertical one-dimensional numerical model. Hydromechanically, the zone of the EFZ is remarkable for four main reasons: (1) because more than 1.7 m of vertical differential subsidence has occurred here (Bell et al. 2008) resulting in the deepest subsidence bowl of the entire basin, even though the main concentration of pumping, and the thickest compressible layers, are localized several kilometers from the EFZ; (2) because the EFZ is clearly acting as a mechanical barrier to land subsidence; that is, the EFZ mitigates the surficial horizontal expansion of the subsidence bowl located adjacent to this fault system as observed in recent maps of land subsidence (Amelung et al. 1999; Bell et al. 2002, 2008); (3) because earth fissures have been observed to occur on both sides of the fault trending approximately parallel to the EFZ, even though the principal fissure zone is observed on the hanging wall of the fault (de Polo and Bell 2000); and (4) because it is suspected that the Eglington fault is rotating along a vertically oriented hinge line whose pivot is within the saturated zone as suggested by Helm (1994b) and results in the accumulation of stresses in the vicinity of the EFZ. To the authors' knowledge, no research is being conducted to address the influence of the vadose zone on surface deformation patterns, especially those that lead to earth fissuring. The inclusion of the vadose zone in a stress-strain analysis is important when trying to understand earth fissure generation and propagation because it tends to behave in a mechanically fragile way during the application of pumping-induced stresses, likely due to its low moisture content and high caliche content, a rock-like carbonate-cemented soil (Werle and Luke 2007) widely observed in the Quaternary deposits of Las Vegas Valley.

The groundwater flow conditions of Las Vegas Valley have undergone several changes over the past 80 years. Before intensive pumping took place, the natural groundwater flow conditions were from the west and northwest to the east and southeast as observed on maps of potentiometric surfaces in the early stage of pumping development (Harrill 1976). Beginning in the 1950s, the valley underwent perhaps the most significant changes in its developmental history as vastly increased groundwater extraction led to greatly lowered water levels, causing several large cones of depression centered mainly near the center of the valley in the western portion of the urbanized zone. Changes in the water levels significantly affected the effective stress regime in the aquifer system, resulting in high annual rates of land subsidence and the occurrence of earth fissures mainly adjacent to Quaternary faults. Later, at the end of the 1980s, a rigorous aquifer storage and recovery program was implemented in the valley in order to equilibrate the water levels and probably to mitigate the damage caused by surface deformation from overpumping (Coache 2005). This program consisted of injecting imported surface water (artificial recharge) into wells during the season of lower demand (Bell et al. 2002). Figure 2.2 denotes the changes in volumes of groundwater used for human consumption in Las Vegas Valley. Data from before and after the artificial recharge program was implemented are included in the simulations conducted in this investigation.

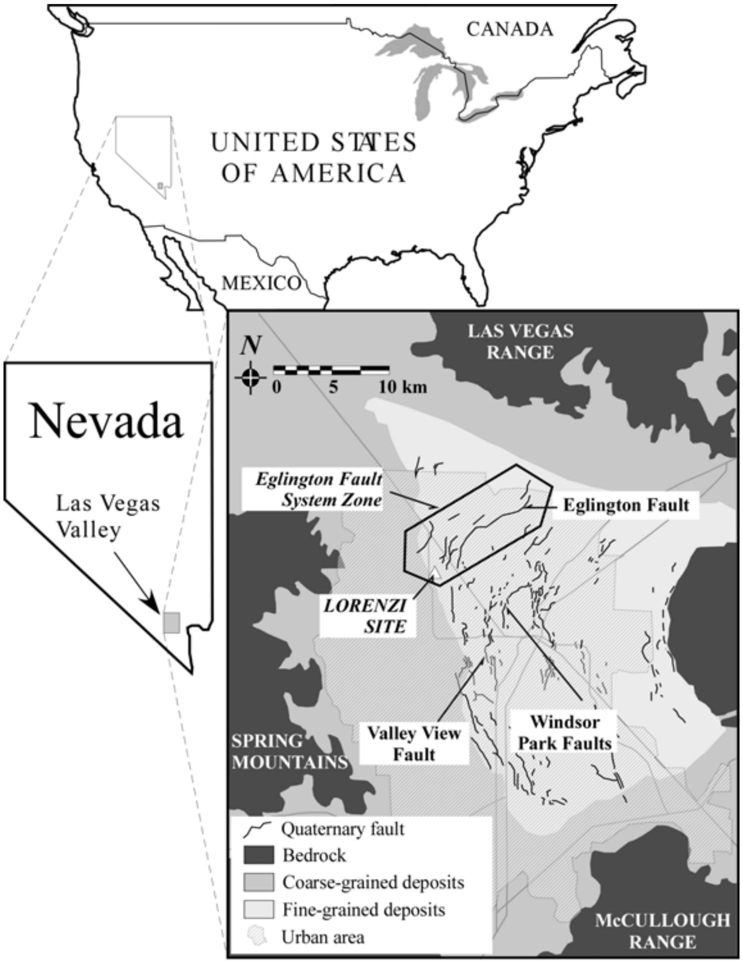

**Figure 2.1. Map of Las Vegas Basin. The Eglington Fault System is depicted as well as are some of the most important normal faults. The Lorenzi site is indicated as a white triangle.**

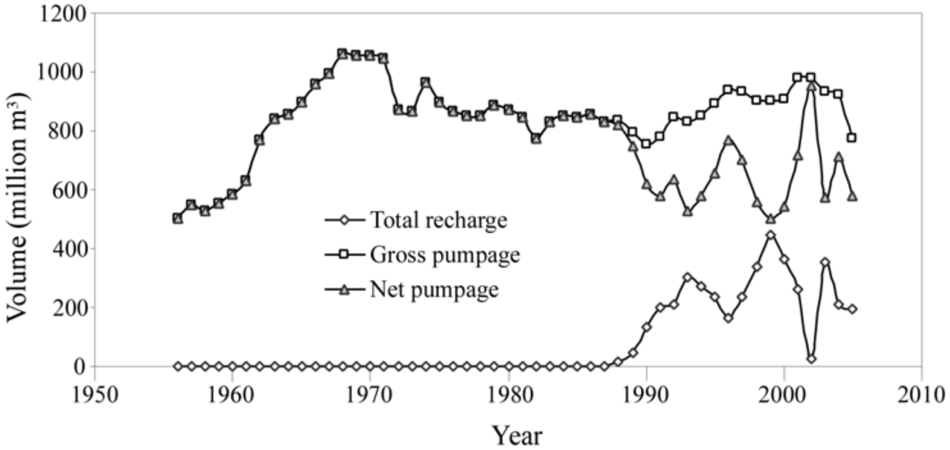

**Figure 2.2. Variation of pumping and recharge volumes over time in Las Vegas Valley. Data from Coache (2005)**

## 2.3. Numerical modeling

### 2.3.1. Conceptual models using ABAQUS

The finite element code ABAQUS (Hibbit 2004) was selected for the numerical simulations conducted in this investigation because it has the capability of simulating three-dimensional variably saturated flow and aquifer deformation with complex boundaries. ABAQUS calculates spatial displacements and pore pressures, as well as strain and stress components. Equations 1and 2 represent a modified form of Biot's (1941) equation that is solved numerically in ABAQUS.

$$G\nabla^2\vec{u}_s + (\lambda + G)\nabla(\nabla \bullet \vec{u}_s) = \alpha\nabla P \qquad (1)$$

$$\frac{\partial}{\partial t}(\nabla^2 \bullet \vec{u}_s) = \frac{K}{\rho_w g}\nabla^2 P \qquad (2)$$

Where $G$ and $\lambda$ are referred to as the Lame's constants and are related to Young's Modulus $E$ and Poisson ratio $\nu$ according to the next expressions $G = E/[2(1+\nu)]$ and $\lambda = 2\nu G/(1-2\nu)$. $\vec{u}_s$ is the displacement field, $P$ is the pore pressure, $\alpha$ is the Biot-Willis coefficient, $K$ is the hydraulic conductivity, $\rho_w$ is the density of the water and $g$ is the gravity.

Another important feature is that ABAQUS is capable of easily adapting different finite-element meshes to represent geometrically complex layered-faulted systems such as that observed in Las Vegas Valley. As mentioned previously, conditions similar to those observed in the one of the Eglington Fault will be used in this analysis. The developed models correspond to a 7×7 km$^2$ area that encompasses the Eglington Fault system and much of the adjacent subsidence bowl. A deformable hexagonal 8-node brick element type with variable degree of saturation was chosen for the pore fluid/stress analysis. The hydrostratigraphy considered in the simulations is composed of aquitards, aquifers and an upper vadose zone (Figure 2.3). Aquitards are considered poorly permeable and highly compressible layers. Conversely, aquifers are permeable and are composed of low-compressibility materials; whereas the vadose zone is considered to be composed of poorly compressible materials. All layers are simulated as elastic materials with the properties indicated in Table 2.1. A subvertical normal fault is simulated to cut through the entire sequence and represents the Eglington Fault zone in the analysis. This fault zone is simulated to (1) be elastic, except when no fault materials are simulated (0 m width); (2)

be homogeneous, because even a small conductive discontinuity in the fault zone would cause enormous changes in the model results; and (3) consist of geologic materials of different hydromechanical properties than the surrounding aquifer/aquitard system.

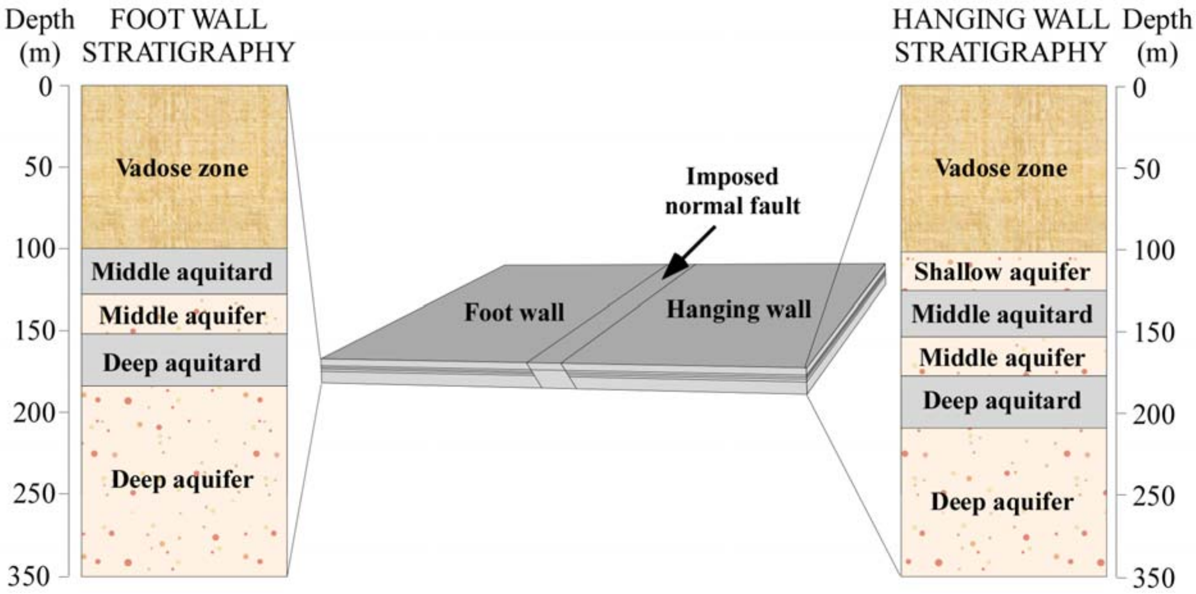

**Figure 2.3. Stratigraphy used in the simulations based on the description of Pavelko (2004). Note that a shallow aquifer layer is included only in the hanging wall as a consequence of the fault offset.**

**Table 2.1. Properties and characteristics of each hydrostratigraphic layer used in the simulations. Chosen properties represent typical average values found in the literature.**

| | **Material type** | **Young's Modulus (N/m$^2$)** | **Poisson Ratio ( v)** | **Hydraulic Conductivity (m/s)** | **Void Ratio (*e*)** | **Density (kg/m$^3$)** |
|---|---|---|---|---|---|---|
| Vadoze zone | Caliche | 1.0E+10 | 0.30 | 1.0E-07 | 0.3 | 1500 |
| Middle aquitard | Clay-silt | 2.5E+07 | 0.30 | 1.0E-08 | 1.8 | 1700 |
| Middle aquifer | Sand | 1.0E+09 | 0.25 | 1.0E-05 | 0.28 | 1600 |
| Deep aquitard | Clay-silt | 5.0E+07 | 0.30 | 1.0E-09 | 1.5 | 1700 |
| Deep aquifer | Sand | 1.0E+09 | 0.25 | 1.0E-05 | 0.25 | 1600 |
| Shallow aquifer | Sand | 1.0E+09 | 0.25 | 6.0E-05 | 0.28 | 1600 |

### 2.3.2. Loads, boundary conditions and time stepping

One of the purposes of this analysis is to define the effective width and property characteristics of the Eglington Fault zone that result in the deformation patterns observed at the land surface, in order to gain a better understanding about the origin of earth fissuring in faulted aquifer/aquitard systems influenced by heavy pumping. Figure 2.4 shows a topographic profile of the EFZ, which is characterized on the surface as a notable elevation decline to the east over a distance of about 500 m. It is therefore suspected that the actual fault zone may range from 0 to at least 100 m in width. Considering that only a portion of Las Vegas Valley was simulated, no directional restrictions to displacements were imposed on the perimeter area of the model. This, however, does not create an under-constrained condition because (1) this study is interested in incremental displacements from a zero-displacement initial condition and (2) because equations 1 and 2 are coupled such that displacements are dependent upon pore-pressure changes and vertical deformations, which are both constrained in the model. The base of the model was prescribed to have zero vertical displacement.

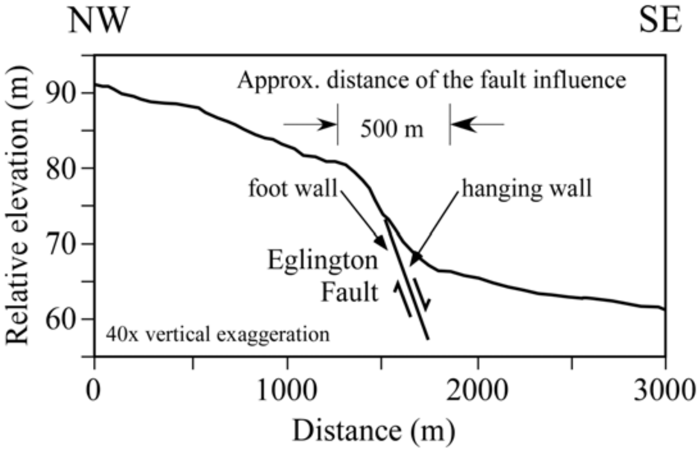

**Figure 2.4. Cross section of the Eglington Fault scarp. From Bell et al. (2002).**

Two different groups of simulations using two different material properties were performed to evaluate the material characteristics of the Eglington Fault zone. The first simulation group involved using a clay-type material. In this scenario, one would expect considerable deformation into and across the fault zone. However, the fault would also be expected to act as a hydraulic barrier because flow would be impeded by the low-permeability fault zone. Hydraulic properties in this scenario include low hydraulic conductivity along with a high void ratio, typical values for clayey unconsolidated sediments. The second simulation group consisted of using a sand-type material in the fault zone, which would result in less deformation in the fault zone because sand is less compressible than fine-grained sediments. The mechanical properties of the sand-dominated fault zone are prescribed as a relatively rigid material with a high Young's modulus and a low Poisson's ratio. It can be expected that the Eglington Fault zone would impede or mitigate the potential deformation as pumping induced stress migrates from one side of the fault to the other. Table 2.2 summarizes the properties of the fault zone in both scenarios.

**Table 2.2. Properties of the fault zone. Unsaturated conditions were based exclusively on pore pressure variations during the simulation. Initial conditions included a prescribed 0.1 saturation index. Values obtained from literature.**

| | **Young's Modulus ($N/m^2$)** | **Poisson Ratio** | **Hydraulic Conductivity (m/s)** | **Void Ratio** | **Density ($kg/m^3$)** |
|---|---|---|---|---|---|
| Fault (saturated part) | | | | | |
| Clay-type | 5.0E+07 | 0.30 | 1.0E-09 | 1.0 | 1600 |
| Sand-type | 1.0E+09 | 0.30 | 1.0E-05 | 0.3 | 1500 |
| Fault (unsaturated part) | | | | | |
| Clay-type | 1.0E+08 | 0.30 | 1.0E-09 | 1.0 | 1600 |
| Sand-type | 1.0E+10 | 0.30 | 1.0E-05 | 0.3 | 1500 |

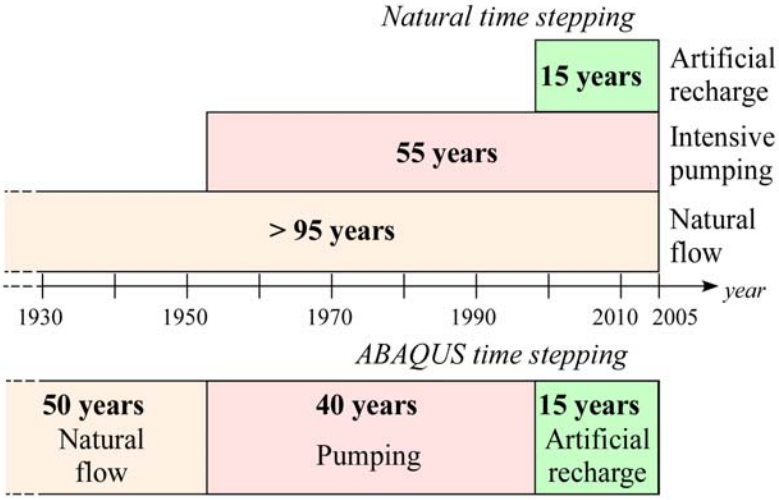

**Figure 2.5. Schematic representation of time stepping used in all model simulations.**

A 95-year simulation of transient groundwater flow was distributed in three time steps (Figure 2.5) based on the pumping history in the basin. In ABAQUS, properties and pumping load can remain constant in a time step, which is equivalent to stress periods in other types of modeling software such as MODFLOW 2000 (Harbaugh et al. 2000). In addition, hydraulic boundaries are prescribed by pore pressures instead of hydraulic heads. Therefore, the prescription of constant pore pressures allow for the simulation of constant inflows and outflows representing natural recharge and discharge. The first time step is designed to represent the natural flow system prior to pumping by prescribing a positive constant pore pressure on the zone of natural recharge (inflow) and a zone of zero pore pressure on the opposite side, located on the lateral face of the shallow aquifer layer (outflow). The positive pore pressure applied is estimated according to the hydrostatic pressure. In other words, the variation of the pore pressure is dependent on the elevation. The location of anticipated prescribed pore pressures, positive (zone of inflow) and zero (zone of outflow) are indicated in Figure 2.6.

No flow boundaries are prescribed along the NE face of the model domain. The second step simulates the heavy pumping that occurred in Las Vegas Valley from the 1950s through the 1980s. Initially, a pumping zone was simulated by establishing a flow discharge area through the entire side, indicated in Figure 2.6 (perpendicular to the imposed fault). However, after this second step, simulated vertical deformation patterns did not accurately reflect the observed conditions of the EFZ because pumping likely only significantly affects the region to the west of the EFZ. As a result, the discharge zone is limited to the south facing foot wall block (where most of the large municipal pumping wells are located), which produces results more in line with observed conditions. In addition, a pumping well is included on the center of the foot wall block in order to better reflect the observed conditions and impose more vertical deformation on the foot wall side of the fault. These imposed pumping patterns result in simulated vertical deformation patterns that best reflect the observed subsidence patterns of Las Vegas Valley. In all simulation scenarios, outflow from the deep aquifer occurs only through pumping. The third time step simulates the period of artificial recharge and consists of reducing the net pumping rate from both the south facing foot wall block and the pumping well in the middle of the foot wall block. Since it is very difficult to estimate the actual pumping rates that affect only the region involved in the simulation, the rate of discharge used in the simulations is apportioned based on area and net municipal pumping rates (Coache 2005). In addition, the location of the pumping wells is based on the work of Bell et al. (2002). Table 2.3 lists the pumping rates for the second and third time steps. It is important to note that ABAQUS requires velocity as an input stress and is derived from flow instead of volumetric rates. The conversion to velocities, *v*, is given by the relations:

$$v = \frac{Q}{2\pi r n \ell} \tag{3}$$

$$v = \frac{Q}{An} \tag{4}$$

where $Q$ is the volumetric pumping rate, n represents the porosity, $\ell$ is the length of the well screen and r is the radius of the well in Equation (3). Equation 3 (Burbey 2008) is used to simulate pumping from a well and Equation 4 is used to simulate pumping from the south foot wall block where the variable $A$ indicates the area from which water flows in or out of the model.

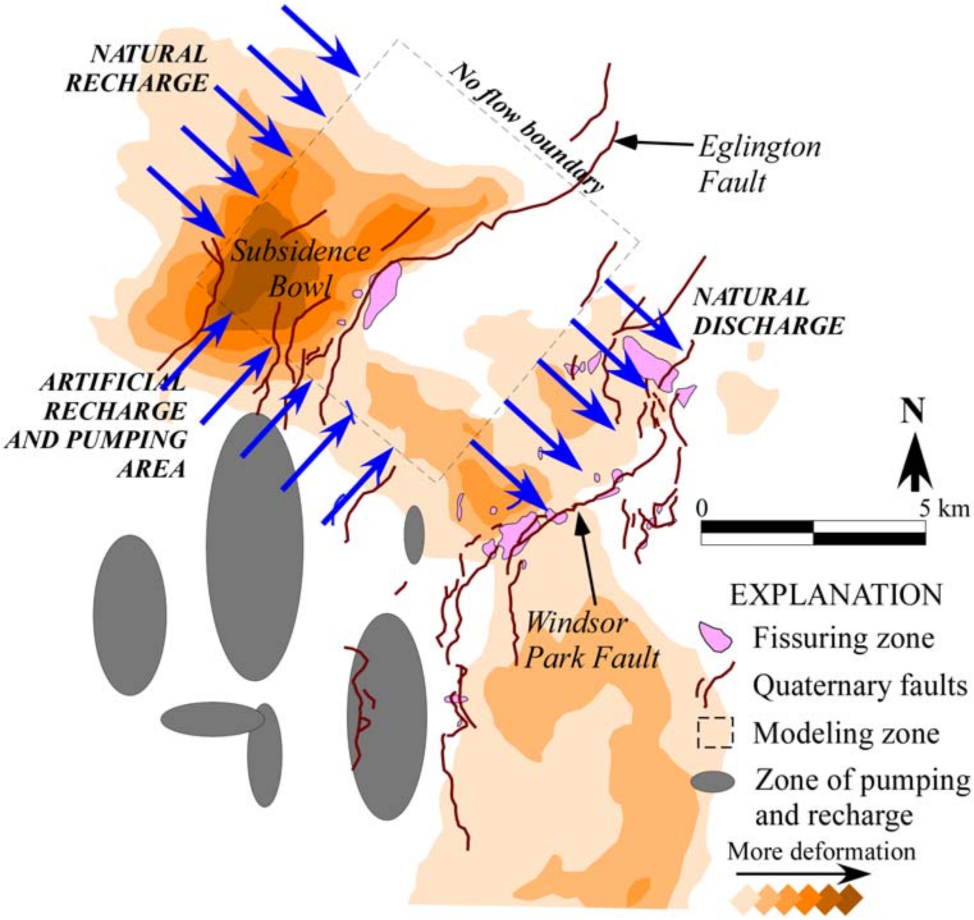

**Figure 2.6. Relative magnitude of observed surface deformation in the northern part of Las Vegas Valley. The Eglington Fault system is located in the northwest. Subsidence bowls and fissuring zones are also shown. The color scale indicates the magnitude of land subsidence. The zone of pumping in the main municipal well field is shown as gray ovals to depict both location and relative magnitude (from Bell et al. 2002).**

**Table 2.3. Pumping rates used in each model simulation. Values correspond to the 0 meter fault zone case. The area of pumping is very similar for all cases ($1.06\times10^6$ $m^2$ for cases 0, 1 and 20 m. and $1.05\times10^6$ $m^2$ for the 100 m case). Q is the volumetric pumping rate and v is the flow velocity entering the screened interval of the well.**

| | values of the 0 m fault zone case |
|---|---|
| Before artificial recharge | |
| Q ($m^3$/d) | 26,500 |
| Q ($m^3$/s) | 0.3067 |
| v (m/s) | 1.15E-6 |
| During artificial recharge | |
| Q ($m^3$/d) | 18,650 |
| Q ($m^3$/s) | 0.2159 |
| v (m/s) | 8.10E-7 |
| From Pumping well | |
| Q ($m^3$/d) | 10,000 |
| Q ($m^3$/s) | 0.1157 |
| v (m/s) | 1.79E-3 |

## 2.4. Modeling results and discussion

### 2.4.1. Distribution of vertical displacements at the land surface

Evaluation of parameters and analysis of model results at the end of the third time step (95-year simulation period) suggest that spatial deformations are likely to be mainly controlled by Young’s modulus. Hydraulic conductivity, however, appears to control mainly pore-pressure distributions and consequently other hydraulic parameters such as hydraulic head. The trial-and-error method was used to calibrate the parameters shown in Tables 2.1 and 2.2 through comparison of simulated vertical deformations with observed subsidence patterns near the EFZ at the end of 2000. In other words, the final selected parameters used in the simulations were the values that produced vertical deformations on the order of 1.7 m (± 0.5 m). Although this approach does not constitute a rigorous calibration method, it is sufficient to obtain acceptable parameter values. At the end of the 95-year simulation period, the equivalent observed maximum vertical displacement in the northwest subsidence bowl for the same time period was slightly greater than 1.7 m (Bell et al. 2008). Even though the simulations conducted here are by nature hypothetical, the comparisons to observed values in Las Vegas Valley are useful for obtaining adequate parameter values for the model simulations. The maximum simulated vertical deformation ranges between 1.54 and 2.05 m. This maximum always occurs within the area of the northwest subsidence bowl located on the foot wall block. For the case of 0 m fault width, no relevant influence of the fault was experienced on the modeled deformation patterns (Figure 2.7a). That is, the expansion of the subsidence bowl on the surface was only minimally inhibited by the fault. This indicates that the system, and especially the vadose zone, is behaving close to a laterally homogeneous system when no fault width is implemented, even though the vertical distribution of hydrogeologic units changes across the fault (Figure 2.3). Consequently, the resulting maximum vertical deformation in this scenario is the lowest of all simulations and implies that the fault does influence vertical deformation patterns. Conversely, the highest simulated vertical deformation occurs when the fault width is 100 m with clay as the constituent fault material (Figure 2.7d). This simulation is discussed later.

Figures 2.7 and 2.8 show the simulated vertical deformations for fault-zone widths of 0 (no fault zone), 1, 20, and 100 m for clay and sand as infill fault-zone material, respectively. The results indicate that the wider the fault zone the greater the vertical deformation occurring on the foot wall block. In other words, the surficial expansion of the subsidence bowl located on the foot wall is hindered by the sediment-filled fault zone, from the foot wall to the hanging wall as the fault width is increased. This result is expected and is likely caused by equilibrium pore pressures achieved across the fault zone. However, as can be seen in Figure 2.7, the surficial expansion of the subsidence bowl toward the hanging wall is not only mitigated by the fault but is completely terminated, as observed in Figure 2.7d (100-m-wide zone). The large differential subsidence that occurs over a small linear distance perpendicular to the fault zone is evidence of this occurrence. However, when a sand-like material is used in the fault zone (Figure 2.8), the vertical deformation is propagated across the fault zone even as its width is increased. This result implies that, (1) a 100-m-wide clay-filled fault zone is necessary to completely inhibit expansion of vertical deformation bowls from occurring on the hanging wall, and (2) the expansion of vertical deformation on the surface from the foot wall to the hanging wall can be linked to groundwater flow, since clay is significantly less permeable than sand (2–4 orders of magnitude). This observation is relevant if this result is compared with the recent subsidence patterns observed in Las Vegas Valley, where the EFZ is acting as a barrier to the eastward migration of vertical deformation, but does not completely halt its eastward migration as observed in Figure 2.6. On the other hand, if one considers that the main outflow in the simulations is due to the zone of pumping and is only imposed on the lateral face of the foot wall, one can then hypothesize that the entire EFZ may also be constraining the flow induced from the main pumping zone located at the center of the Valley as observed in Figure 2.6.

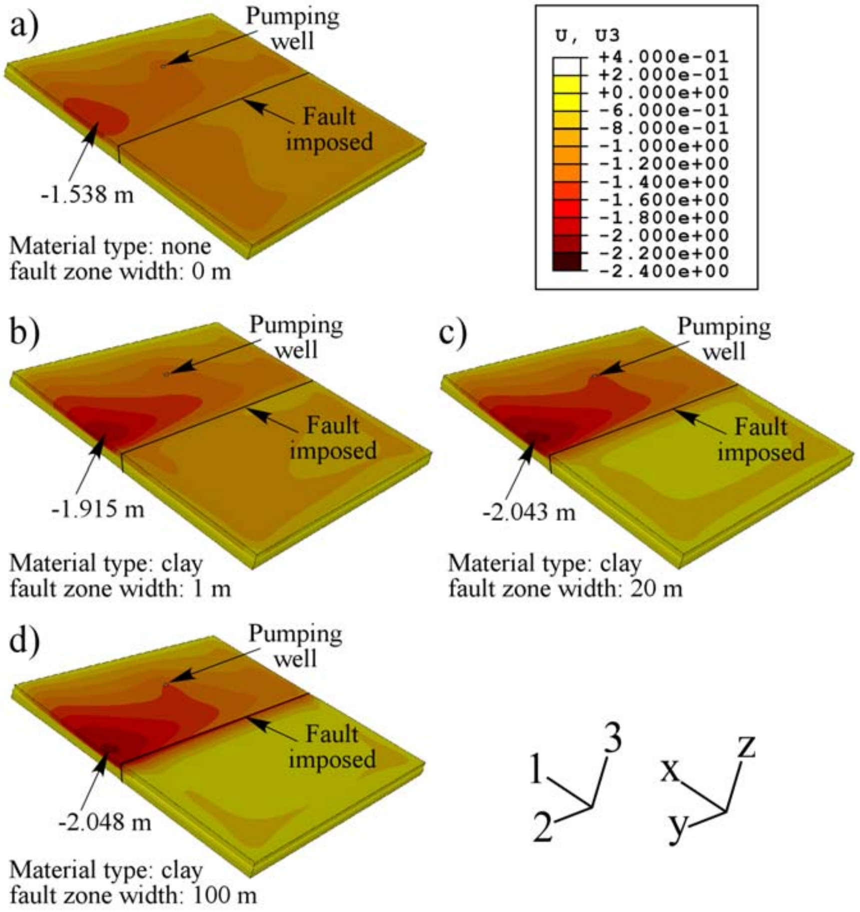

**Figure 2.7. Land subsidence (vertical deformation) for all clay-type cases. Points of maximum and minimum deformation are indicated in each simulation (a–d). Units of vertical displacement (U3) in the scale bar are meters.**

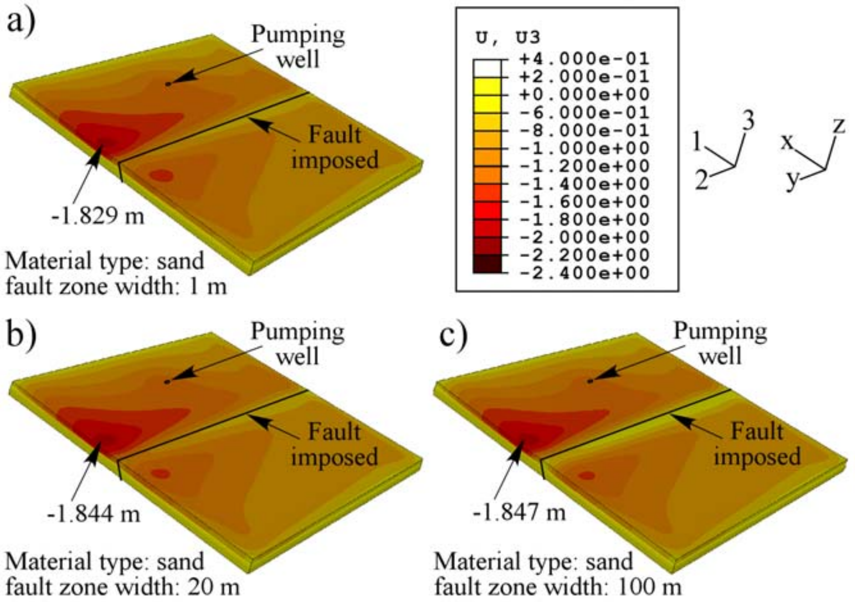

**Figure 2.8. Land subsidence (vertical deformation) for all sand-type cases. Points of maximum and minimum deformation are indicated in each simulation (a–c). Units of vertical displacement (U3) in the scale bar are meters.**

When evaluating differences between sand and clay as materials used in the fault zone (Figure 2.7b with Figure 2.8a, Figure 2.7c with Figure 2.8b, and Figure 2.7d with Figure 2.8c), a larger vertical deformation occurs when clay-like material is used and a much larger vertical differential subsidence occurs across the fault. This is likely the result of the fact that the highly compressible (deformable) clay-like material is able to significantly accumulate more strain along the fault. The sand-like material however, being poorly compressible (greater stiffness), readily transfers part of the imposed strain across the fault into the hanging wall. In addition, the fact that sand is more permeable than clay may have implications on the distribution of hydraulic head in the vicinity of the fault. Using hydraulic head measurements from wells within 2 km of the EFZ, Burbey (2002) suggested that a change in hydraulic head of no more than 2 m likely occurs locally across the fault. In this work, hydraulic head variations can be observed based on simulated pore pressure distributions since both variables are directly related through the expression $h=P/\rho_w g$, where h is the hydraulic head, P is the pore pressure, $\rho_w$ is the density of the water and g is the gravity. Observations made on several cross sections along the fault from each simulation indicate that an abrupt and large hydraulic-head transition occurs when clay-like material is used as the fault material. Conversely, sand-like material results in a more modest transitional variation in head across the Eglington Fault. The scenario with 0 m width (no fault zone material) results in no head change, as expected. The highest hydraulic head change of nearly 20 m corresponds to a 100 m width fault zone using the clay-like material. On the other hand, an almost imperceptible hydraulic head change occurs when sand-like material is used, and likely represents a good approximation to what is occurring in the field.

On the basis of a semi-quantitative comparison of simulated vertical deformation patterns as the fault zone width is increased from 0 to 100 m (Figures 2.7 and 2.8), it can be concluded that sand-like material likely constitutes the main material type at the Eglington Fault zone. The width of the fault zone that best represents field conditions is still largely unknown and a more in-depth analysis that includes field observations of horizontal deformation and extensional stress zones must be carried out to more thoroughly understand the processes leading to fissuring as observed in Las Vegas Valley.

### 2.4.2. Distribution of magnitudes of horizontal displacements at the land surface

The investigation of horizontal deformation in an aquifer system may be significant for the analysis of the origin and propagation of earth fissures. Buried cracks that migrate to the surface as earth fissures are believed to be at least partly the result of horizontal aquifer displacement (Helm 1994b; Lofgren 1978). Previous analyses of aquifer movement during pumping indicate that the magnitude of horizontal displacements in the aquifer undergoing groundwater extraction is directly related to the time and rate of pumping, aquifer thickness, and hydraulic diffusivity (Helm 1994a). Burbey (2002) used numerical simulations to conclude that the type of boundary (mechanic or hydraulic) and the distance to the pumping zone are important factors contributing to differential horizontal deformation.

Based on conceptual models, Helm (1994b) defines the active and passive zones on the basis of the deformation patterns that occur in response to fluid withdrawal. The passive zone usually rides or is dragged over the active zone as pumping causes deformation in the active zone. According to the simulated deformation patterns, the vadose zone and shallow aquifer in the hanging wall and the vadose zone in the foot wall (Figure 2.3) are equivalent to the passive zone because these units deform differently and passively ride over the underlying active zone; in fact, this motion causes the upper units to be dragged horizontally toward the pumping zone and pumping well in the foot wall and toward the center of the hanging wall block. Hence, the passive zone rides over the compressible and mobile middle aquitard in both blocks. In other words, the plane between the active and the passive zones may correspond to the limit between the middle aquitard and the layer located immediately above it, and implies that this plane is related to the mechanical properties of the materials involved and to their degree of saturation. Figures 2.9 and 2.10 show the distributions of simulated horizontal displacements. In most cases, a noticeable variation of the horizontal deformation contours is observed in the vertical direction (observed in cross section along the lateral faces of the model), which can be used to identify the limit between the active and passive zones.

Simulated horizontal deformation patterns reveal that the relative motion of the passive zone over the active zone can occur between two regions in the vertical direction (such as between these two zones), or in the horizontal direction at the land surface (such as is occurring between a fault zone and its adjacent materials). In the former case, potential cracks (referred to here as buried fissures) may be created in a horizontal plane between the active and passive layers. For example, assuming an initially undisturbed horizontal stratigraphy, these cracks will theoretically commence in a horizontal direction, but because of the imposed strain on the overlying brittle vadose zone, tensile failure will occur at the base of the vadose zone and migrate upward toward the land surface over time. In the second case, cracks will be perpendicular (or nearly perpendicular) to the surface, just as they are initially observed in the real world. Additionally, in the second case, it would be mechanically easier for a crack to migrate vertically to the surface due to its orientation. The initiation of a fissure in this second case can occur in one of two ways: the first is when a sudden change in direction of displacement occurs such as from imposed stress changes in the system (e.g., pumping rate change). In the most extreme case, the displacements are changed suddenly in an exact opposite direction (e.g., from pumping to injection). The second case occurs when there is a large contrast in the magnitude of the horizontal displacement, even if the direction of the displacement is in the same orientation. It should be pointed out that zones with large magnitudes of horizontal displacement are not necessarily the most favorable localities for fissures to occur, but only those localities where changes in either the direction or magnitude are greatest; that is, where strains accumulate or abruptly change direction over time (i.e., large strain rates). Faults represent natural discontinuities and for this reason they represent obvious localities for the genesis of fissures. This explains, at least in part, why fissures are positioned mainly in the vicinity of faults in places such as Las Vegas Valley.

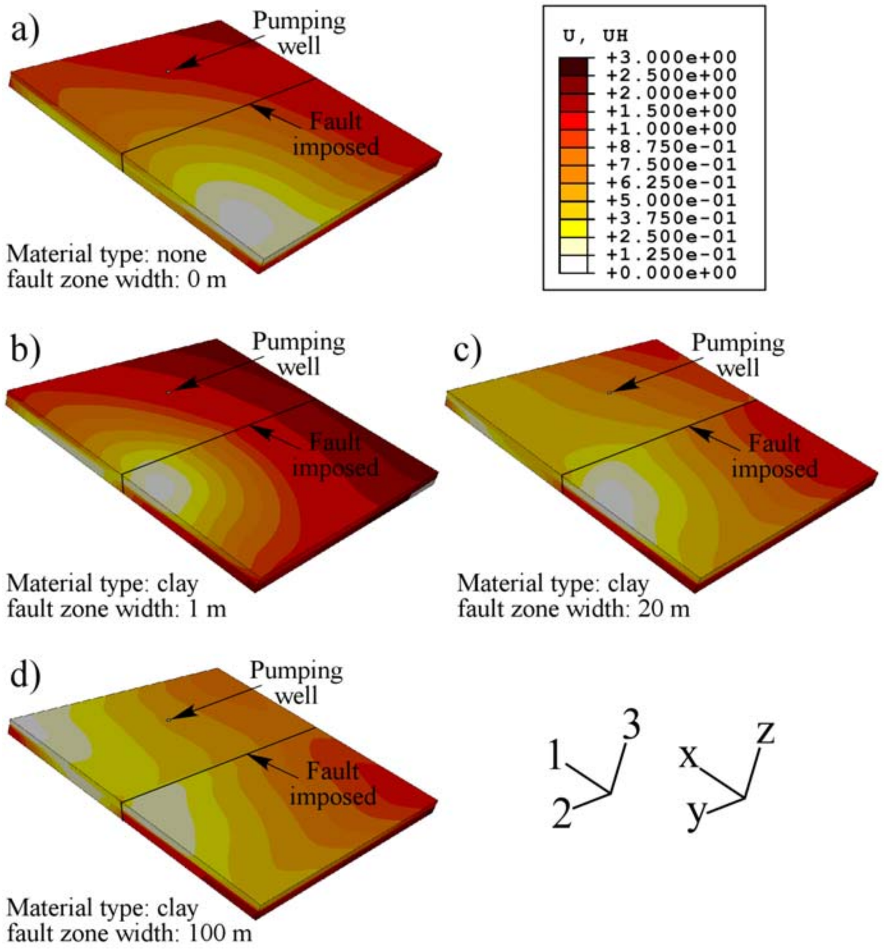

**Figure 2.9. Horizontal deformation for all clay-type cases (a–d). Units of horizontal displacement (UH) in the scale bar are meters.**

Surface fissures occur on both sides of the EFZ and indicate that processes directly related to horizontal displacements and potentially leading to fissuring must exist at the surface adjacent to the fault. Simulated horizontal deformations (Figure 2.9) indicate that when clay is simulated as the fault-zone material, the smaller displacement values are located mainly on the hanging wall block. Maximum values of surface horizontal displacements are perhaps higher than expected field values (on the order of 1–1.75 m). In addition, the imposed fault zone and pumping zones and pumping well, do not appear to influence deformation patterns.

Figure 2.10 represents simulated horizontal deformation patterns with a sand-like fault zone. Results indicate that the deformation response is vastly different than when the fault zone is composed of clay (Figure 2.9). It appears that for the cases with a narrow fault zone (1 and 20 m, in Figure 2.9b,c, respectively), the fault does not significantly impede horizontal deformation. Rather, the zone of compression extends radially outward across the fault zone onto the hanging wall (Figure 2.10b). However, when the fault zone width is increased to 100 m (Figure 2.10c), the translation of deformation onto the hanging wall is greatly reduced. Instead, the pumping induced strain results in large deformations along the northwest boundary on the foot wall.

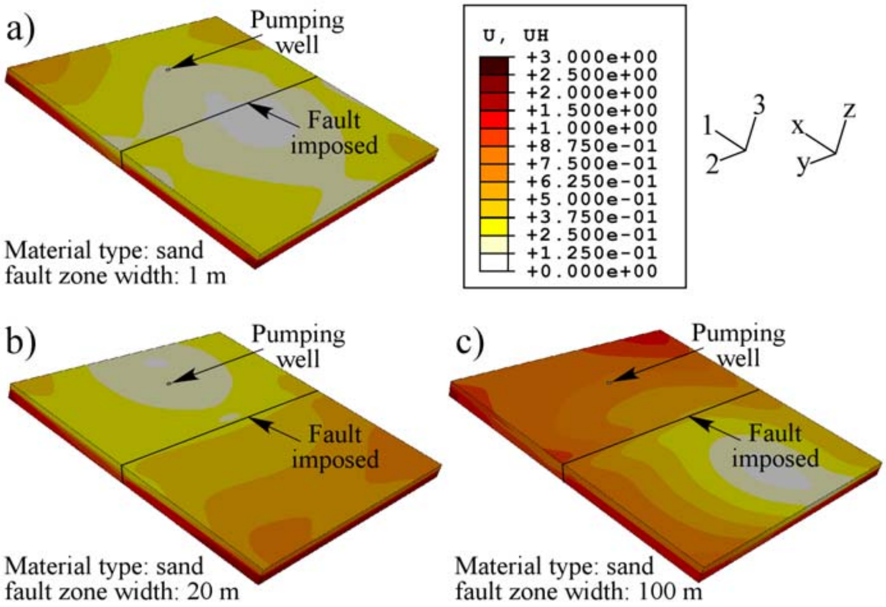

**Figure 2.10. Horizontal deformation for all sand-type cases (a–c). Units of horizontal displacement (UH) in the scale bar are meters.**

### 2.4.3. Direction and evolution of horizontal displacements at the land surface

Figure 2.11 shows the horizontal direction of selected surface points coupled with the magnitude of the displacements as shown in Figures 2.9 and 2.10. Earlier investigations indicate that during pumping, horizontal displacements in the aquifer and surface are directed radially toward the pumping well (Burbey et al. 2006; Helm 1994a; Sheng et al. 2003). Previous studies also indicate that the zone of higher radial compression occurs near to a pumping well (Wolff 1970). In addition, numerical analyses have shown that within the vicinity of pumping, displacements tend to be very small (tending to zero at the well) (Burbey 1999, 2002).

Intuitively, one would expect the direction of the surface displacements to be greatly influenced by the pumping well, the pumping zone and perhaps by the subsidence bowls. However, the displacements appear to be oriented preferentially toward the zones of lowest horizontal displacements, which in most cases do not correspond to the pumping centers or subsidence bowls. Apparently, the complex combination of pumping centers, their locations, pumping rate and total area of water extraction, along with the fault in its different facets of width and constituent material cause the small displacement zones to be positioned mainly in the hanging wall, where groundwater is not pumped. Water extracted from the pumping zone (along the south lateral boundary on the foot wall) represents 72.6% of the total volume of water pumped prior to the inclusion of artificial recharge and 65.1%of the total after the inclusion of artificial recharge. Consequently, the direction of surface motion can be directed away from the pumping centers as observed in several cases in Figure 2.11.

For the case of zero fault width (Figure 2.11a), the direction of the displacements (magnitude $0 - 1.25\times10^{-1}$ m) is unexpectedly not near the zone of pumping. However, the vectors of displacement tends to be displaced initially toward the pumping well and then toward the pumping zone, indicating finally that this last pumping center has more influence on the displacement patterns. Figure 2.11b,d,f represents results of simulations using a clay-like fault zone. In these three cases the tendency of the surface displacements is toward the pumping zone because the zone of small displacements is positioned near this pumping center. Figure 2.11f shows perhaps the greatest influence of the fault on the surface horizontal displacements. However, points on the foot wall are mainly displaced from north to south, while on the hanging wall the motion is primarily east to west converging at the fault zone and resulting in compressional strain in the vicinity of the fault. This result would imply that surface fissures would not be favored to appear in the vicinity of the fault. Simulations corresponding to sand-like material lead to surface displacements proportionally shorter than the cases of clay-like material. Figure 2.11c indicates that the fault is somewhat constrained to the zone of smallest displacements toward the center of the model on both blocks, but most notably on the hanging wall. In this case, the zone of compression may be located mainly in the zone of smallest displacements. Therefore, fissure formation would not be favored to appear in this entire zone but in the adjacent areas, where the horizontal displacements are relatively higher and where surface tension occurs. Figure 2.11e shows displacements occurring toward the pumping well, while the fault does not appear to significantly influence the simulated displacements. In this case, the hanging wall would likely represent the most likely location for fissuring. Figure 2.11g is similar to Figure 2.11f in that displacements are initially directed toward the fault with a moderate tendency to migrate toward the pumping zone. However, in Figure 2.11g, the terminal vector displacement direction is toward the hanging wall, where the zone of smallest displacements occurs.

In most cases, the fault appears to preferentially influence the patterns of displacement magnitudes rather than directions, as can be observed in the distribution of the simulated magnitudes. In all cases, however, the first segment of vectors (first stage of pumping) is oriented toward the pumping zone or well, but the last segment (when artificial recharge is implemented) is oriented toward the zones of smallest displacements. These changing horizontal motions that may favor the formation of fissures result from the changing pumping history imposed on this heterogeneous system. Figure 2.12 shows the magnitude of horizontal displacements for all cases during pumping and at the end of the simulations; that is, after artificial recharge is added. The cases of clay-like material together with the 0 m-fault width case (cases a to d) are consistent regarding the position of the zone of smallest displacements during pumping because this zone is always positioned adjacent to the zone of pumping during the current pumping step. The cases where clay-like material is used are also consistent in the fact that the zone of smallest displacements is observed on the foot wall adjacent to the pumping zone during pumping. However, at the end of the 95-year simulation time, the zone of smallest displacements is observed on the hanging wall near the fault.

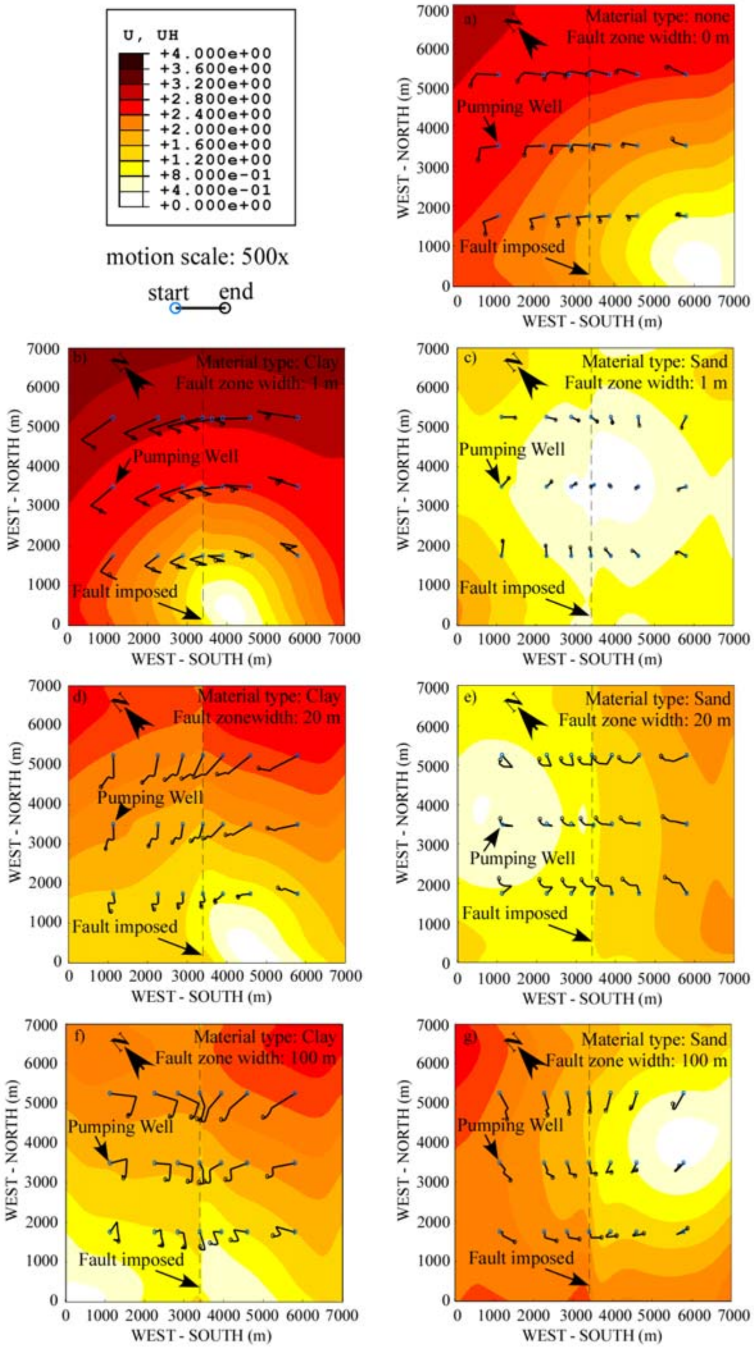

**Figure 2.11. Direction of the horizontal displacement coupled with their magnitudes for all cases (a–g). Units of horizontal displacement (UH) in the scale bar are meters.**

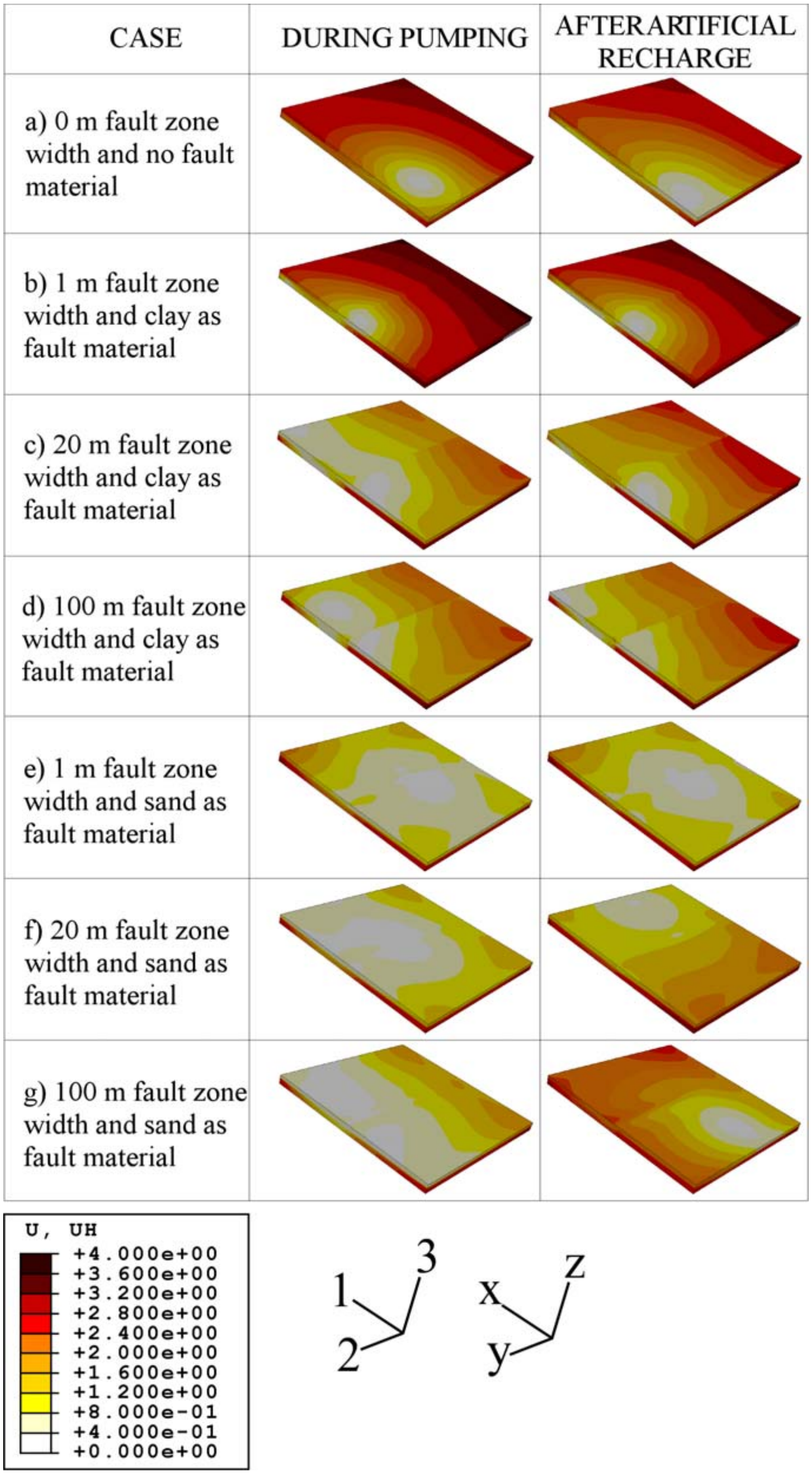

**Figure 2.12. Comparison of horizontal displacement patterns during pumping and after artificial recharge.**

The cases where sand-like material is used also reveal a significant influence by the pumping zone on displacements depending on the pumping step. Case f (Figure 2.12), however, reveals a greater influence by the pumping well than at any time during the entire simulation. This is the only case where the influence of the well exceeds that of the pumping zone. Case e shows an almost imperceptible variation of patterns between the stage of pumping and the end of the simulation. On the other hand, case g reveals the most remarkable difference of patterns between the two steps, indicating that the variables imposed in this case result in the most complex response on the system. Case g can be used to explain why displacement vectors shown in Figure 2.11 are initially oriented toward the pumping zone on the foot wall, and then are suddenly directed toward the hanging wall, where the zone of small displacements is positioned. Figure 2.12 supports the fact that (1) zones of smallest displacement are significantly influenced by pumping, and (2) pumping has an important role in the configuration of the horizontal displacements patterns.

### 2.4.4. Surface zones under compression and tension

Simulated pressures from ABAQUS are included in this analysis because they can be used to better understand localized zones of extensional stress potentially leading to earth fissuring. The evaluation of the maximum extensional stress is important because it may represent the strength of a material up to the point of failure (fissuring). Here the term "tension" will be used to refer to extensional stress and the term "compression" will be used to refer to compressional stress. Fissuring occurs if tension induced by pumping exceeds the tensile strength of the material. For soil masses, this parameter varies depending on conditions such as water content, degree of saturation and grain size of solid particles. In the literature, the value of tensile strength for soil masses is typically estimated to be $1\times10^4$ Pascals (Pa) (Conwell 1965), assuming that the author used the term "soil masses" to refer to soils in a general sense. In the case of caliche, the tensile strength may be as much as one order of magnitude higher than any other geologic unconsolidated material due to its naturally cemented mechanical condition. In a standard geotechnical laboratory test on core samples, Stone and Luke (2001) estimated the tensile strength for caliche to be $3.275\times10^6$ Pa (475 psi). The soils of Las Vegas Valley contain considerable caliche, but its occurrence and distribution is unknown. Therefore, the tensile strength of the unconsolidated materials is considered to range from $1\times10^4$ to $3.275\times10^6$ Pa, but fissuring is likely governed by the weakest materials in any given location.

Figures 2.13 and 2.14 indicate that compression-tension patterns are controlled mainly by the zone of pumping, the pumping well, and the fault zone. A manifestation of a tensional zone in the vicinity of the pumping well is observed in all cases. This manifestation is occurring in both scenarios (sand or clay) but is more prevalent when sand-like material is implemented, and it is also consistent with the theory established by Helm (1994a) indicating that a zone of tension is located in a dynamically outward moving radial distance away from the well. Conversely, the zone immediately adjacent to the pumping well is usually under compression, as observed in the zone of pumping. In terms of the real world, this is a consequence of the radially inward movement of solid particles that are stopped by the well screen, causing a radially increasing zone of compression in the aquifer as a function of time, which is in some way transmitted upward through the vadose zone to the land surface. Figure 2.13 shows that as the width of the fault zone is increased, the zone of tension is reduced on the foot wall block and increased on the hanging wall. However, the zone of pumping tends to cause a region of compression adjacent to its occurrence on the hanging wall block, which becomes slightly larger as the fault zone width is increased. Perhaps the most noticeable characteristic in Figure 2.13 is the occurrence of a zone of tension on the hanging wall which is especially prominent in Figure 2.13c,d. The value of this tension zone is as high as $5.38\times10^5$ Pa and it may be in part the result of the bending caused by the hanging wall as a consequence of the large vertical deformation simulated adjacent to the fault along the foot wall. This result, however, would limit the occurrence of fissures to mostly near the center of the hanging wall block, where the maximum tension is located, at a considerable distance from the fault zone.

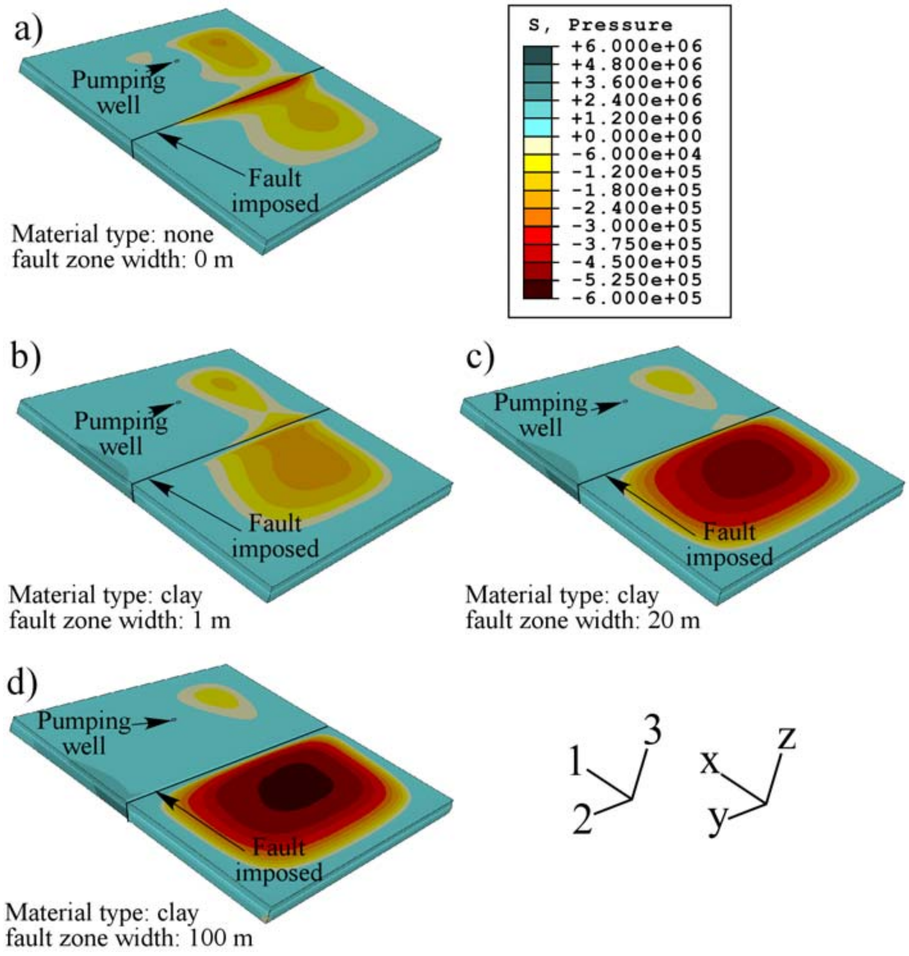

**Figure 2.13. Compression–tension patterns for all clay-type cases (a–d). Negative values (yellow- orange-red-maroon colors) indicate zones of tension. Units of stress (S) in the scale bar are Pascals.**

Figure 2.14 shows an increasing tension zone on the side of the hanging wall as the fault zone width is increased. The highest value of this tension zone ranges on the order of $1.2\times10^5$ –$1.8\times10^5$ Pa and is occurring within and adjacent to the fault, mainly on the hanging wall. A plausible explanation for the creation of this zone is a vertical counterclockwise rotation (surface rotation toward the foot wall) of the fault as a consequence of the subsidence bowl being created on the foot wall block (Helm 1994b). This rotation may also explain why the zone of maximum tension is located on the surface along the fault, as observed primarily in Figure 2.14c. The difference of this suggested vertical rotation with respect to that assumed in Figure 2.13 is that the main tension zone tends to be concentrated close to the fault zone. On the other hand, Figure 2.14 shows that the location of the zones of higher tension tends to occur toward the side of the hanging wall, near the lateral face opposite to the pumping zone. This observation, along with the location of the region of maximum compression adjacent to the pumping zone, may suggest that the fault plane tends to rotate not only vertically, but also horizontally with its pivot located on the lateral point of the fault close to the pumping zone. The tendency of the fault to rotate both vertically and horizontally may create regions of tension on the hanging wall adjacent to the fault. On the foot wall, however, the zones of tension are mainly created by pumping. The maximum simulated tensions are lower than tensile strength for caliche but higher than for soil masses; moreover, the zones of this maximum tension are increasingly varying not only in size but also in magnitude as the fault width is increased. This implies that depending on the actual geologic material within the simulated portion of Las Vegas Valley, fissures can be generated in this zone. The vast differences observed in these results between the two materials used for the fault zone, especially the cases of 20 and 100 m width, clearly indicate that the hydromechanical differences in properties of sand and clay greatly affect the results. The simulation results suggest that the type of field conditions that would lead to large tension in the EFZ and the greatest potential for fissure formation is when sand dominates the fault zone and the fault zone is on the order of 100 m in width.

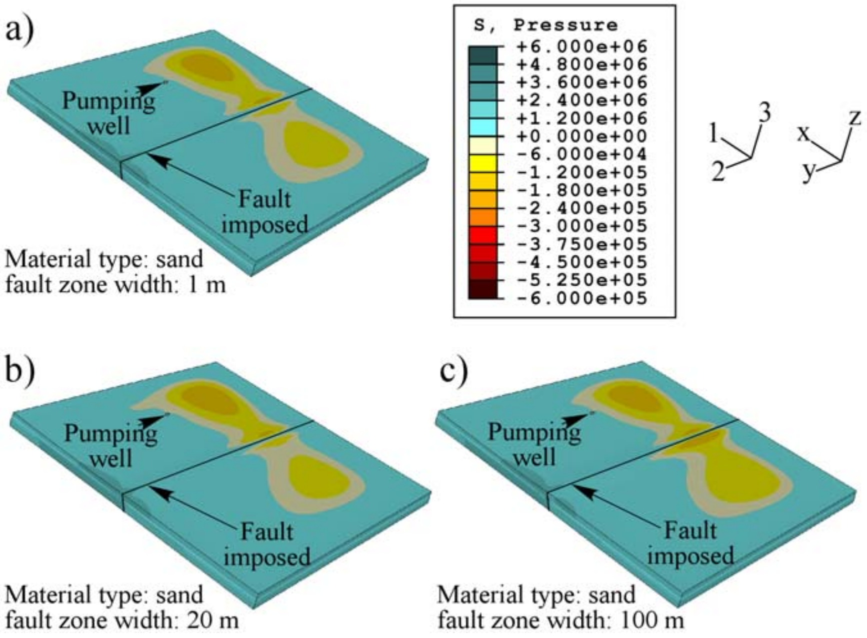

**Figure 2.14. Compression–tension patterns for all sand-type cases (a–c). Negative values (yellow-orange colors) indicate zones of tension. Units in the scale bar are Pascals.**

### 2.4.5. Model limitations and future work

The analysis presented here contributes to the understanding of the hydromechanical processes leading to the observed deformation patterns in Las Vegas Valley, especially those that lead to fissuring. However, calibration of the developed models is based on observed vertical displacement information only. Therefore, in the absence of horizontal surface deformation and precise hydraulic head data in the vicinity of the EFZ, it is difficult to accurately quantify fault zone width. An analysis of the direction of observed horizontal displacements would allow for corroboration of the results discussed herein, particularly those related to the fissuring process. Moreover, the inclusion of cyclical pumping as well as plastic deformation should be considered to more accurately reflect field conditions, particularly since the simulation results herein indicate that the nature of pumping (location and quantity) affects the direction and magnitude of surface horizontal deformations. Future work should also involve the effect of the dip angle on the deformation patterns. Additionally, a stress-strain field analysis should be undertaken to evaluate how the deposits in the vicinity of the fault zone respond to imposed stresses, which can lead to a better understanding of the origin of earth fissures (at depth) in, and adjacent to, the fault zone. Such a study would also provide information on the type of material (saturated or unsaturated) where fissures are most likely to be generated in.

## 2.5. Summary and conclusions

The hypothetical modeling study performed here has been addressed to gain a better understanding of the resulting patterns of surface deformation with special attention to the fissuring process in the vicinity of the Eglington Fault zone in Las Vegas Valley. This study covers the 95-year period from the predevelopment phase in which only natural inflow and outflow are considered, through a prolonged period of heavy pumping and then a final period consisting of modified pumping rates to accommodate the inclusion of artificial recharge. A finite-element code using the commercial software ABAQUS was developed on the basis of perceived characteristics of the Eglington Fault zone, located on the northwest portion of Las Vegas Valley. The hydrostratigraphy of this zone is made up of alternating aquifers and aquitards, including an upper 100-m-thick vadose zone. The entire analyzed sedimentary sequence is cut by a normal sub-vertical NE–SW trending fault system. Along with the analysis of surface deformation in both vertical and horizontal directions, the analysis includes identification of zones of compression and tension on the surface in order to obtain a better understanding of the potential zones where fissures may occur. Fissures are believed to commence when the tensile strength of the geologic surface material yields to the acting extensional stress within the underlying aquifer system. Since the only available observational information is the vertical deformations in the vicinity of the Eglington Fault zone, a trial-and-error method of calibration was performed by comparing the current land subsidence information with simulated vertical displacements.

Simulated vertical displacement patterns indicate that a sand-filled fault constrains pumping induced displacements along the lateral edge of the foot wall (large differential vertical displacements occur across the fault zone). A sand-dominated fault zone will also allow significant groundwater flow across the fault and would not result in a large head change across the Eglington Fault zone as there is no evidence for such a head change based on scant hydraulic head observations. Simulated horizontal displacements indicate that the largest motion occurs in the saturated region, especially in the pumped aquifer. Results show significant contrasting magnitudes between the saturated and unsaturated regions, which may lead to the generation of horizontal fissures at this transition. Furthermore, surface horizontal displacements tend to be on the order of centimeters when sand-like material is implemented and slightly higher than 1 m for clay-like material , indicating an appreciable difference in the response of these two materials to horizontal displacements. In addition, results indicate that the direction of the surface displacements is mainly toward the zones of smallest horizontal displacements (in the direction of the gradient). In most of the simulated cases surface motion is not in the direction of the pumping centers at the end of the simulation. However, during pumping, vectors of displacement are preferentially oriented to the pumping zone and pumping well. Perhaps the complex combination of pumping centers, their magnitude and area of influence, along with the variations in the fault properties result also in complex magnitudes and direction patterns of horizontal motion.

The simulated patterns of compression-tension are controlled largely by the zone of pumping, the pumping rate, and the fault. Two main zones of tension are observed when sand-like material is used as fault zone. One is located on the foot wall, adjacent to the pumping well which remains almost constant as the fault zone width is increased. This tension is attributed to the direct affect of pumping. The second occurs on the hanging wall, with its maximum value located adjacent to the fault. The location of these simulated tension zones suggests that the fault tends to rotate vertically and horizontally. The vertical rotation may be a consequence of vertical deformation on the foot wall block, whereas the horizontal rotation may be a direct result of the stress and subsequent strain derived from the pumping zone. It is concluded that the zones of tension on the side of the hanging wall are directly related to the tendency of the fault to rotate. On the other hand, the zones of tension located on the foot wall are related only to pumping from both the zone of pumping and the pumping well.

Simulated patterns of vertical and horizontal displacement along with tensional zones suggest that the fault zone material is likely to have mechanical properties similar to sand. A strain analysis is used to estimate fault width because of the sensitivity of the patterns of compression and tension to fault width. Results suggest that the Eglington Fault is best represented by a 100-m-wide fault zone.

## References

Amelung, F., Galloway, D.L., Bell, J.W., Zebker, H.A., Laczniak, R.J. 1999. Sensing the ups and downs of Las Vegas: InSAR reveals structural control of land subsidence and aquifer-system deformation. Geology 27(6):483–486.

Bell, J.W. 1981. Subsidence in Las Vegas Valley, Bulletin 95. Nevada Bureau Mines Geol Bull 95:1–84.

Bell, J.W., Amelung, F., Ramelli. A,R,, Blewittet. G. 2002. Land subsidence in Las Vegas, Nevada, 1935–2000: new geodetic data show evolution, revised spatial patterns, and reduced rates. Environ Eng Geosci 7(3):155–174.

Bell, J.W., Amelung, A., Ferreti. A,, Bianchi. M., Novali, F. 2008. Permanent scatterer InSAR reveals seasonal and long-term aquifer-system response to groundwater pumping and artificial recharge. Water Resour Res 44, W02407. Doi:10.1029/2007WR006152

Bredehoeft, D.J., Belitz, K., Sharp-Hansen, S. 1992. The hydro-dynamics of the Big Horn Basin: a study of the role of faults. AAPG Bull 76:530–546.

Burbey, T.J. 1999. Effects of horizontal strain in estimating specific storage and compaction in confined and leaky aquifer systems. Hydrogeol J 7(6):521–532.

Burbey, T.J., .2002. The influence of faults in basins-fill deposits on land subsidence, Las Vegas Valley, Nevada, USA. Hydrogeol J 10(5):525–538.

Burbey, T.J. (2006) Three-dimensional deformation and strain induced by municipal pumping, part 2: numerical analysis. J Hydrol 330:422–434.

Burbey, T.J. 2008. The Influence of geologic structures on deformation due to ground water withdrawal. Ground Water 46(2):202–211.

Burbey, T.J., Warner, S.M., Blewitt, G., Bell, J.W., Hillet, E. 2006. Three-dimensional deformation and strain induced by municipal pumping, part 1: analysis of field data. J Hydrol 319:123–142.

Coache R (2005) Las Vegas Valley water usage report. Clark County, Nevada, State of Nevada, Division of Water Resources, Las Vegas, NV, 23 pp.

Conwell, F.R. 1965. Engineering geology and foundation condition survey of Las Vegas, Nevada. Publ NVO-99-05, US Atomic Energy Commission, Washington, DC, 49 pp de Polo CM, Bell JW (2000) Map of faults and earth fissures in Las Vegas area. Open-File Report 01-4, Nevada Bureau of Mines and Geology, Reno, and Las Vegas Water District, Las Vegas, NV.

Harbaugh, A.W., Banta, E.R., Hill, M.C., McDonald, M.G. 2000. MODFLOW-2000, the US Geological Survey modular ground-water model: user guide to modularization concepts and the ground- water flow process. US Geol Surv Open-File Rep 00-92, 121 pp.

Harrill, J.R. 1976. Pumping and ground-water storage depletion in Las Vegas Valley, Nevada, 1955–1974. Nevada Div Water Resour Bull 44, 70 pp.

Helm, D.C. 1984. Analysis of sedimentary skeletal deformation in a confined aquifer and the resulting drawdown. In: Rosenshein JS, Bennet GD (eds) Groundwater hydraulics. American Geophysical Union, Washington, DC, pp 29–82.

Helm, D.C. 1994a. Horizontal aquifer movement in a Theis-Thiem confined system. Water Resour Res 30(4):953–964.

Helm, D.C. 1994b. Hydraulic forces that play a role in generating fissures at depth. Bull Assoc Eng Geol 31(3):293–302.

Hibbit, 2004. ABAQUS/CAE User's manual. Sorensen, Pawtucket, RI, USA.

Holzer, T.L. 1984. Ground failure induced by groundwater withdrawal from unconsolidated sediments. In: Holzer TL (ed) Reviews in Engineering Geology. Geological Society of America, pp. 67–105.

Lin, M., Chung, C., Jeng, F. 2006. Deformation of overburden soil induced by thrust fault slip. Eng Geol 88:70–89.

Lofgren, B.E. 1978. Hydraulic stresses cause ground movement and fissures, Picacho, Arizona. Geol Soc Am Abstr 10(3):113.

Marler, J., Ge, S. 2003. The permeability of the Elkhorn Fault Zone, South Park, Colorado. Ground Water 41(3):321–332.

Maxey B.G., Jameson C.H. 1948. Geology and water resources of the Las Vegas, Pahrump, and Indian Spring Valley, Clark and Nye Counties, Nevada. Water Resources Bulletin 5, Nevada Department of Conservation and Natural Resources, Reno, 128 pp.

Mayer A., May W., Lukkarila C., Diehl J. 2007. Estimation of fault-zone conductance by calibration of a regional groundwater flow model: Desert Hot Springs, California. Hydrogeol J 15:1093–1106.

Morgan S.D., Dettinger M.D. 1996. Ground-Water conditions in Las Vegas Valley, Clark County. Nevada, part 2: hydrogeology and simulation of ground-water flow. US Geol Surv Water Suppl Pap 2320-B, 124 pp.

Pavelko M.T. 2004. Estimates of hydraulic properties from a one-dimensional numerical model of vertical aquifer-system deformation, Lorenzi Site, Las Vegas, Nevada. US Geol Surv Water Resour Invest Rep 03-4083

Pavelko, M.T., Hoffmann, J., Damar, N.A. 2006. Interferograms showing land subsidence and uplift in Las Vegas Valley, Nevada, 1992–99. US Geol Surv Sci Invest Rep 2006-5218.

Sheng, Z., Helm, D.C., Li, J. 2003. Mechanism of earth fissuring caused by groundwater withdrawal. Environ Eng Geosci 9(4):351–362.

Stone, C.R., Luke, B. 2001. An overview of engineering with cemented soils in Las Vegas. In: Luke B, Werle JL (eds) Proceedings, 36th Annual Western States Symposium on

Engineering Geology and Geotechnical Engineering, Las Vegas, March 2001, pp 135–144.

Werle, J.L., Luke, B. 2007. Engineering with heavily cemented soils in Las Vegas, Nevada. In: Olsen HW (ed) Geo-Denver 2007 New peaks in Geotechniques, Denver, CO, February 2007, pp 1–9.

Wolff, R.G. 1970. Relationship between horizontal strain near a well and reverse water level fluctuation. Water Resour. Res. 6(6):1721–1728.

# CHAPTER 3

# Fault-controlled deformation and stress from pumping-induced ground-water flow in a hydrogeologic setting

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# Fault-controlled deformation and stress from pumping-induced ground-water flow in a hydrogeologic setting

## Abstract

Four two-dimensional numerical model scenarios are developed to gain a better understanding of how earth fissures may form under a pumping induced stress. The simulated aquifer-aquitard system contains a low compressibility sub-vertical 100 m wide fault zone that transects the hydrostratigraphic system that includes a 100 m thick vadose zone. Two scenarios represent constant and cyclical pumping over a five-year period and two scenarios are used to evaluate the difference between using purely elastic aquitards versus elasto-plastic aquitards. The model provides for the analysis of the spatial distribution of deformation, and normal and shear stress that may potentially lead to the formation of earth fissures. Results indicate that this fault-zone largely controls the deformation and stress regime of the system during pumping. Patterns of deformation and stress are similar for all scenarios with only the magnitudes being affected. Simulation results show that pumping induces a counterclockwise rotation of the fault plane on the footwall. The distribution of deformation through the fault is damped and the deformation patterns are more subdued on the hanging wall but all deformation is directed toward the pumping well. These deformations result in two areas of stress accumulation that may lead to fissure formation: (a) near the land surface in the fault zone, and (b) near the saturated-unsaturated interface on the hanging wall adjacent to the fault zone. These results reveal the importance of both the fault and vadose zones in fissure genesis.

## 3.1. Introduction

In many arid-zone basins, the necessity for clean and inexpensive water for industry, agriculture and human consumption, has led to considerable overexploitation of aquifers, resulting in problems such as depleted aquifer storage, land deformation in the form of land subsidence (vertical) and earth fissuring (mostly horizontal). Problems associated with land deformation have resulted in large economic losses from damage to infrastructures and subsequent costly litigation. In terms of deformation, vertical subsidence is typically observed first as a response to pumping-induced stress. Later, horizontal and vertical differential stresses propagate and can accumulate along structural discontinuities (such as faults) and result in earth fissures at the land surface if the unsaturated zone is sufficiently brittle.

Recent interest has focused on the influence of natural discontinuities such as geologic faults on land subsidence and earth fissuring. For instance, Helm (1994a), and Sheng and Helm (1998) idealized conceptual models of surface deformation processes. In both investigations, the analysis of planes of weakness (geologic faults) indicated that these features perform a critical role in the generation of earth fissures. In Arizona, US, the Picacho earth fissure zone has been linked to a high angle normal fault (Holzer 1984). In Xian, China, stresses induced by pumping caused (and probably are still causing) the reactivation of Quaternary buried faults to manifest at the surface as earth fissures (Lee et al. 1996). A similar process is suspected to be occurring in some locations in the Querétaro Valley of Central México (Pacheco et al. 2006; Rojas et al. 2002). A geophysical survey at this locality demonstrated that buried scarps from the basement associated with ancient normal faults can be geometrically linked to recent surface scarps and earth fissuring. Further work involving numerical analyses in selected zones of this valley indicate that faults and fissures observed on the surface are spatially correlated to maximum values of horizontal deformation and tensile stress and to where change in direction of shear stress is occurring (Pacheco et al. 2006). In Las Vegas Valley, Bell (1992) showed statistically that earth fissures are spatially associated with Quaternary faults. Recent mapping of vertical deformation from satellite interferograms has shown that land subsidence is largely controlled by normal faulting within the basin-fill sediments (Amelung et al. 1999; Bell et al. 2008; Bell et al. 2002). The mapped stratigraphy suggests that earth fissures have a complex association to faulting (Bell et al. 1998; dePolo and Bell 2000).

Another factor that may play an important role in the surface deformation patterns is the vadose zone. Little work has been done to address the role of this zone on aquifer displacement and on the propagation of earth fissures at the land surface. In one recent investigation, however, Budhu (2008) develops a conceptual model based on the mechanics of the origin of earth fissures that includes the unsaturated zone. Budhu emphasizes that fissures can be formed mechanically at depth and can migrate to the surface or commence at the surface and migrate downward, although some assumptions included in his analysis consider only an unconfined aquifer. However, little is known about the relation between this static brittle zone and the underlying dynamic aquifer system in basins undergoing pumping-induced surface deformation. For convenience, the hydrogeologic setting will be referred to here as the arrangement of alternating permeable semi-rigid aquifers, low-permeable compressible aquitards, and an upper rigid vadose zone.

Las Vegas Valley represents a good example of how cyclical pumping can substantially affect ground deformation. Heavy pumping commenced here in the late 1950's. Since then, seasonal pumping has occurred with the maximum pumping volume extracted during the summer months and minimum pumping volume extracted during the winter months (Pavelko et al. 1999). This type of seasonal stress has influenced the nature of water-level and subsidence patterns (Bell et al. 2008; Hoffmann et al. 2001). This type of seasonal response has also been observed in the Santa Clara Valley, in California (Schmidt and Bürgmann 2003). Wilson and Gorelick (1996) applied a multi-layered flow model to the Santa Clara aquifer system using a single pumping well with different pumping and recovery periods. They concluded that pulsed pumping causes more subsidence near the well than constant pumping, but constant pumping creates more subsidence far from the well. In another example, applying analytical models in a single hydrogeologic system (two aquifers separated by an aquitard), Li (2003) concluded that for periods larger than 1 year and under sinusoidally-influenced hydraulic loads, non-linear elastic solutions give more realistic results than linear elastic solutions.

Traditionally, numerical models have been implemented to gain insight into the processes responsible for land subsidence due to overdraft of groundwater. Some applications have included the prediction of vertical deformation (i.e. (Gambolati et al. 1974; Kihm et al. 2007; Teatini et al. 2006)), and others have included the inference of hydromechanical conditions, including parameters and natural boundaries on surface deformation (i.e. (Burbey 2008)). Recent investigations have addressed the process of earth fissuring in their investigations using elastic single layered models (Burbey 2002; Rojas et al. 2002), and multi-layered models (Cheng et al. 2003; Hernandez-Marin and Burbey in press). An elasto-plastic material deforms first elastically to imposed stresses, but once its preconsolidation stress is exceeded, it behaves plastically (Figure 1). Chapter 3.2.2. provides a more complete definition of an elasto-plastic material.

In this investigation, a series of numerical simulations have been performed to study the potential processes leading to the occurrence of earth fissures based on the analysis of the distribution of both vertical and lateral displacements as well as both tensile and shear stresses in a faulted hydrogeologic setting. Different conditions or properties have been incorporated into the models for comparative analyses including: a) purely elastic response of the layers, b) elasto-plastic response of the aquitards; c) constant-pumping; and d) cyclical pumping that simulates the response to both heavy and light seasonal groundwater demand. In total, four simulations are performed with a combination of these characteristics. The elasto-plastic response in aquitards (condition b) along with cyclical pumping (condition d) are simulated separately in order to investigate the effect of fluctuating loads and elasto-plastic effects of aquitards on simulated deformation patterns and in the potential concentration of stress that may lead to earth fissuring. Furthermore, cyclical pumping is used to investigate how pumping variations may affect stress accumulation. A single well is used to simulate the load of groundwater pumping from the deepest aquifer.

The main objectives of this investigation are to (1) analyze the effects that elasto-plastic aquitards and cyclical pumping have on deformation and stress patterns; (2) observe and describe the response of the entire system to groundwater flow induced by pumping; and (3) analyze and describe the patterns of deformation, particularly those of horizontal deformation and stress (tensile and shear) in order to identify and evaluate the zones most susceptible to earth fissuring, especially in the topmost layers of a hydrogeologic sequence.

## 3.2. Elasto-Plastic mechanical behavior

### 3.2.1 Poroelasticity theory

The hydromechanical formulation for deformation of aquifer systems during groundwater depletion started with the theory of one-dimensional consolidation developed by Terzaghi (1928). In this theory, Terzaghi incorporated the well-known concept of effective stress, which has been extensively used in hydrogeology and geomechanics. In the same year, Meinzer (1928) was able to analyze the elastic response of aquifers during pumping. This work was later expanded by Biot (1941) to a fully coupled three-dimensional consolidation theory that describes the horizontal and vertical deformation of aquifer media. Coupled with Darcy's law for flow through porous materials, Biot's theory has been able to satisfactorily explain the three-dimensional deformation that occurs in hydrogeologic settings when ground-water flow is induced. Subsequent to Biot's pioneering work, Verruijt (1969) reexamined Biot's consolidation theory and using Hooke's law of elasticity for soils applied exclusively to the mechanical behavior of aquifers, including an analysis of reverse water-level fluctuations referred to as the Nordbergum effect.

For a three-dimensional homogeneous and isotropic porous medium where body forces are ignored and incorporating the mathematical developments of Terzaghi (1928) and Biot (1941) as a mathematical foundation, the conditions of equilibrium can be represented in terms of pore pressure and effective stress as

$$\begin{aligned}
\frac{\partial \sigma'_{xx}}{\partial x}+\frac{\partial \sigma'_{xy}}{\partial y}+\frac{\partial \sigma'_{xz}}{\partial z}&=\frac{\partial p}{\partial x}\\
\frac{\partial \sigma'_{yx}}{\partial x}+\frac{\partial \sigma'_{yy}}{\partial y}+\frac{\partial \sigma'_{yz}}{\partial z}&=\frac{\partial p}{\partial y}\\
\frac{\partial \sigma'_{zx}}{\partial x}+\frac{\partial \sigma'_{zy}}{\partial y}+\frac{\partial \sigma'_{zz}}{\partial z}&=\frac{\partial p}{\partial z}
\end{aligned} \tag{1}$$

where $\sigma'_{ij}$ represents the effective stress in the *ij* direction, and *p* is the pore pressure. Verruijt (1969) used Hookian elastic theory to relate the effective stresses to strain by including the physical constants *G* and $\lambda$ (Lame's constants). These three relations are expressed as:

$$\begin{aligned}
\sigma'_{xx}&=2G\varepsilon_{xx}+\lambda\varepsilon_{v}\\
\sigma'_{yy}&=2G\varepsilon_{yy}+\lambda\varepsilon_{v}\\
\sigma'_{zz}&=2G\varepsilon_{zz}+\lambda\varepsilon_{v}
\end{aligned} \tag{2}$$

In expression (2), $\varepsilon_v$ and $\varepsilon_{ii}$ represent volumetric and *ii*-direction strain, respectively, and the constants *G* and $\lambda$ are defined as follows:

$$G=\frac{E}{2(1+\nu)} \tag{3}$$

$$\lambda = \frac{vE}{(1-2v)(1+v)} \tag{4}$$

where *E* is Young's modulus and *v* is Poisson's ratio. The strain components are related to the displacement field, $u_i$, as follows:

$$\begin{aligned} \varepsilon_{xx} &= \frac{\partial u_x}{\partial x} \\ \varepsilon_{yy} &= \frac{\partial u_y}{\partial y} \\ \varepsilon_{zz} &= \frac{\partial u_z}{\partial z} \end{aligned} \tag{5}$$

The sum of the normal strain components is the volume strain.

$$\varepsilon_v = \varepsilon_{xx} + \varepsilon_{yy} + \varepsilon_{zz} = \nabla \cdot u_s \tag{6}$$

Combining equations (5) and (6) into equation (2) yields:

$$\begin{aligned} \sigma'_{xx} &= 2G\left(\frac{\partial u_x}{\partial x}\right) + \lambda\varepsilon_v \\ \sigma'_{yy} &= 2G\left(\frac{\partial u_y}{\partial y}\right) + \lambda\varepsilon_v \\ \sigma'_{zz} &= 2G\left(\frac{\partial u_z}{\partial z}\right) + \lambda\varepsilon_v \end{aligned} \tag{7}$$

Substitution of equations (7) into the equilibrium equations (1) yields:

$$\begin{aligned} G\nabla^2 u_x + (\lambda + G)\frac{\partial \varepsilon_v}{\partial x} &= \frac{\partial p}{\partial x} \\ G\nabla^2 u_y + (\lambda + G)\frac{\partial \varepsilon_v}{\partial y} &= \frac{\partial p}{\partial y} \\ G\nabla^2 u_z + (\lambda + G)\frac{\partial \varepsilon_v}{\partial z} &= \frac{\partial p}{\partial z} \end{aligned} \tag{8}$$

Pore pressure can be defined as $p = \rho_w\, g\, (h)$ and combined with (8) to yield a new expression in terms of displacement and hydraulic head. In the same way, if these three equations are combined into one single equation in terms of displacement, the result produces:

$$G\nabla^2 u_s + (\lambda + G)\nabla(\nabla \cdot u_s) = \rho_w g \frac{\partial h}{\partial x} \tag{9}$$

The above equation involves four unknown variables. Therefore, another equation that relates the displacement field to hydraulic head is needed. A revised form of the groundwater flow equation, (Burbey and Helm, 1999) provides the fourth equation:

$$\frac{\partial}{\partial t}\left(\nabla \cdot u_s\right) = K\nabla^2 h \qquad (10)$$

### 3.2.2 Elasto-plastic mechanical response

In Las Vegas Valley, an aquifer storage and recovery program has been implemented to curtail or at least mitigate subsidence in areas historically prone to large subsidence rates. This program has been largely successful as subsidence rates have decelerated and even rebounded in some of the most severe areas (Bell et al. 2008). However, in other areas in the valley deformation continues despite the efforts made to mitigate the problem. The decline of land surface levels is probably influenced mostly by the plastic-behavior of aquitards, which undergo irreversible deformation when stressed by declining hydraulic heads. Figure 3.1 shows the elasto-plastic behavior of compressible soils.

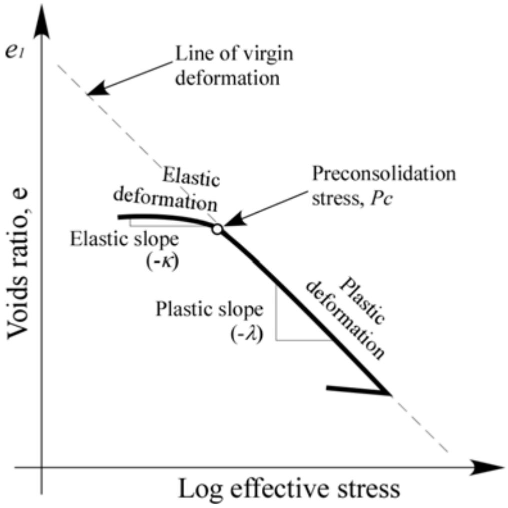

**Figure 3.1. Typical compressibility curve for a material under stress showing all mechanical parameters associated with it.**

An elasto-plastic deformation pattern results in curves represented by the dark, thick line, which is comprised of two branches: the branch over the line of virgin deformation indicates the plastic stage of deformation, while the other branch represents the elastic stage of deformation and recovery. The material responds to stress in the plastic range when the preconsolidation stress (past maximum stress) is exceeded and responds elastically when the stress is less than its past maximum value. Thus, when the stress is reduced from its past maximum level, the recovery does not return to its original state as a result of permanent compaction. This behavior is believed to be critical during the practice of cyclical pumping, resulting in non-linear strain patterns in complex hydrogeologic settings.

In the formulation of elasto-plastic mechanical response, the variables used are mainly derived from compressibility curves as the one shown in Figure 3.1. For instance, the elastic and plastic slopes (denoted as $\kappa$ and $\lambda$ in the figure) are based on the fact that a material under linear or nonlinear load will sustain initially elastic and then further plastic strain. In other words, once the load is removed, the material will undergo permanent plastic, or irreversible, strain. For the case of geomaterials, the variables $\kappa$, $\lambda$, $e_1$ and *Pc* as shown in the Figure 3.1 depend on the type of sediment, and their characteristic properties. In this figure $e_1$ is the void ratio at the initial consolidation state, and is graphically denoted by the intercept of the plastic line when effective pressure stress is equal to zero. *Pc* is the preconsolidation stress or yield stress in hydrostatic compression. Typically, the elasto-plastic response of geomaterials is associated with fine-grained sediments, particularly clays.

Several analytical models have been proposed to explain elasto-plastic behavior of geomaterials (i.e. Mohr-Coulomb, Drucker-Prager, Cam-clay and Modified Cam Clay models). The model used here is the Modified Cam Clay, which corresponds to the group of models based on the critical state concept (Roscoe and Shofield 1963; Roscoe and Burland 1968; Schofield and Wroth 1968). A clayey geomaterial is said to be in the critical state condition if, when under triaxial stress, undergoes shearing without variations in its volume (Helwany 2007). In the Modified Cam Clay model both the elastic and plastic parts are included in the analysis; however, at stresses smaller than the preconsolidation stress the mechanical behavior of the material is solved using either the linear-elastic or the porous-elastic theories. If the preconsolidation stress is exceeded by the current stress then the plastic behavior is invoked.

Formulations of the plastic part of this analytical model are based on (a) the triaxial stress condition ($\sigma_{yy} = \sigma_{zz}$ and $\sigma_{xx} \neq \sigma_{yy}$); (b) the yield surface concept, which is equivalent to the yield stress in a uniaxial stress-strain relationship. The shape of the yield surface is critical for the values of some constants included in the formulations; and (c) the hardening/softening rule that defines the size of the yield surface and depends on the volumetric plastic strain. Thus, when the strain is extensive (causing an increase in the volume of the soil skeleton) the size of the yield surface is reduced. In contrast, if the strain is compressive, the soil skeleton is compacted and the yield surface size is increased.

The numerical formulation of this model of plasticity departs from the definition of three variables: the mean effective stress, the misses equivalent or deviatoric stress and the third invariant of stress, namely $\overline{p}$ , *q* and *r*, respectively (Helwany, 2007; Hibbit, 2004; Perić and Ayarib, 2003). Equations (11a), (11b) and (11c) define these three variables as functions of effective stresses.

$$\overline{p} = -\frac{1}{3} trace\sigma'_{kk} = \frac{\sigma'_{xx}+\sigma'_{yy}+\sigma'_{zz}}{3} = \frac{\sigma'_{xx}+2\sigma'_{zz}}{3} \qquad (11a)$$

$$q = \left(\frac{3}{2}s_{ij}s_{ij}\right)^{1/2} \qquad (11b)$$

$$r = \left(\frac{9}{2}s_{ij}s_{jk}s_{ki}\right)^{1/3}, \text{ where } s_{ij} = \sigma'_{ij}+p\delta_{ij} \quad . \qquad (11c)$$

The yield surface as defined in the critical state condition consists graphically of an ellipsoid with one vertex at the origin, but the critical state surface is a cone with the vertex also at the origin, as indicated in Figure 3.2. The equation that defines the three-dimensional yield surface is as follows:

$$F(\overline{p},q,r) = \frac{1}{\beta^2}\left(\frac{P}{a}-1\right)^2 + \left(\frac{t}{Ma}\right)^2 - 1 = 0 \qquad (12)$$

in which $\beta$ is a variable that depends on the shape of the yield surface and whose maximum value is 1. This variable also depends on natural constants such as temperature. *P* is the current stress acting on the material, *M* represents the ratio of *t* to $\overline{p}$ when critical state condition is reached, *t* is a deviatoric stress and depends on the yield surface in a Π-plane as the shown in Figure 3.3; *t* is defined as:

$$t = \frac{1}{2}q\left[1+\frac{1}{K}-\left(1-\frac{1}{K}\right)\left(\frac{r}{q}\right)^3\right] \qquad (13)$$

where *K* describes the shape of the yield surface as depicted in the example of Figure 3.3 and its value must occur between 0.778 to 1.0 to geometrically ensure the convexity of the yield surface, as in Figure 3.2. The parameter *a* in equation (14) defines the hardening/softening rule and is one of the most important parameters in the definition of the size of the yield surface. This parameter is denoted as:

$$a = a_0 \exp\left[(1+e_0)\frac{1-J^{pl}}{\lambda - \kappa J^{pl}}\right] \tag{14}$$

where $e_0$ indicates the initial void ratio, and $J^{pl}$ is the ratio of current volume change to original volume in the plastic phase and represents the change in volume of the material under plastic deformation and is related to the volume strain $(\varepsilon_{vol}^{pl})$ through the expression $\varepsilon_{vol}^{pl} = \ln J^{pl}$.

Parameters $\lambda$ and $\kappa$ are defined as previously described in this section and represent the elastic and plastic slopes of the compressibility curve. In addition, the parameter $a_0$ represents a hardening parameter that physically represents the quantity of plastic volume change as a result of an imposed stress. It can also represent the size of the yield surface and its evolution characterizes the hardening or softening of the material under an imposed stress. The equation that defines this parameter is given as follows:

$$a_0 = \frac{1}{2}\exp\left[\frac{e_1 - e_0 - \kappa \ln p_0}{\lambda - \kappa}\right] \tag{15}$$

where $p_0$ conceptually represents the initial value of the mean pressure stress defined in equation (11a), $e_1$ as indicated previously, is the initial (natural) void ratio and is graphically portrayed in Figure 3.1.

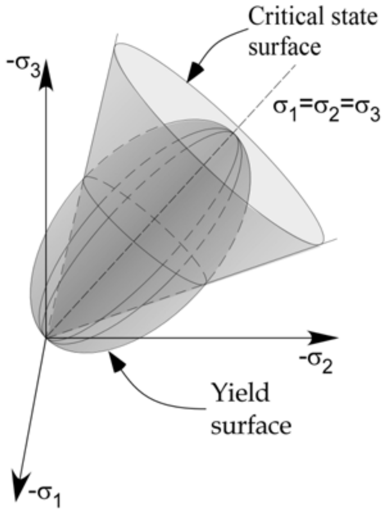

**Figure 3.2. Graphical representation of the principal stress space in the critical state showing the yield surface for the Cam Clay Model (from Helwany 2007).**

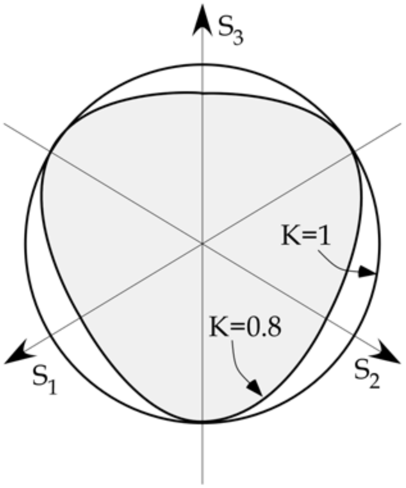

**Figure 3.3. Projection of the Cam Clay Model yield surface in a deviatoric stress plane (Π-plane) (from Helwany 2007).**

In a practical sense, the Cam Clay Plasticity model is based on two main conditions in accordance with the stress field acting on the material. The first is that the acting effective stress must be sufficiently large to exceed the preconsolidation stress of the material. Otherwise only the elastic (linear elastic or porous elastic) response of the material is expected. The second condition is that the initial effective stress must lie inside or on the initial yield surface so the equation (12) is satisfied exactly; otherwise the parameter $a_0$ is suitably readjusted until this second condition is achieved.

### 3.3. Model Development

The software package ABAQUS (Hibbit 2004) is used in this investigation to analyze the behavior of sedimentary deposits undergoing elasto-plastic strain under constant and cyclical pumping-induced stresses. ABAQUS is a sophisticated finite-element modeling package that allows for the analyses of pore pressures, displacements, stresses, and strains in geometrically-complex, heterogeneous, hydrogeologic settings. In this investigation, a two-dimensional multi-layered model is developed to simulate a stratigraphically complex sedimentary basin. Shown in Figure 3.4 is the conceptual model used in this investigation, which consists of a saturated/unsaturated multi-layered system with two aquitards, two aquifers and a thick vadose zone. This stratigraphy is based on the description of Pavelko (2004) for the Lorenzi site, which is located in the west-central part of Las Vegas Valley near where the greatest subsidence has occurred. However, unlike Pavelko's stratigraphy, an approximately 100 meter-thick vadose zone is included into the simulated stratigraphy for the purpose of evaluating the stress and strain regime through this zone where earth fissures are observed. The chosen thickness of the vadose zone is based on observed maps of groundwater level declines for this part of Las Vegas Valley (Bell et al. 2008) that have occurred as a result of long-term heavy pumping in the basin. The conceptual model and numerical simulations in this investigation are intended to represent the hydrogeologic conditions in the vicinity of the Eglington fault and northwest subsidence bowl area (see Hernandez-Marin and Burbey in press) where large differential subsidence and earth fissures have occurred. Many of the fissure zones in Las Vegas Valley are believed to be associated with inactive Quaternary faults in the basin (Bell et al. 1992; Bell et al. 2002; dePolo and Bell 2000). Therefore, in addition to the described stratigraphy, a normal fault dipping at a 60° angle and extending through the entire stratigraphic sequence is included in the simulations in order to evaluate the potential role such features may have on the development of earth fissures in such basins. The fault zone is simulated to be 100 m wide and composed of a sand-like material. The hydromechanical characteristics of the fault zone are based on the results of Hernandez-Marin and Burbey (in press) and listed in Table 3.1.

**Table 3.1. Hydromechanical elastic properties of all stratigraphic layers.**

| | **Material type** | **Young's Modulus ($N/m^2$)** | **Poisson Ratio (ν)** | **Hydraulic Conductivity (m/s)** | **Void Ratio (e)** | **Density ($kg/m^3$)** |
|---|---|---|---|---|---|---|
| Vadose zone | Caliche | 1.0E+10 | 0.30 | 1.0E-07 | 0.3 | 1500 |
| Middle aquitard | Clay-silt | 2.5E+07 | 0.30 | 1.0E-08 | 1.8 | 1700 |
| Middle aquifer | Sand | 1.0E+09 | 0.25 | 1.0E-05 | 0.28 | 1600 |
| Deep aquitard | Clay-silt | 5.0E+07 | 0.30 | 1.0E-09 | 1.5 | 1700 |
| Deep aquifer | Sand | 1.0E+09 | 0.25 | 1.0E-05 | 0.25 | 1600 |
| Shallow aquifer | Sand | 1.0E+09 | 0.25 | 6.0E-05 | 0.28 | 1600 |
| Fault zone | Sand | 1.0E+09 | 0.30 | 1.0E-05 | 0.3 | 1500 |

Groundwater flow is simulated to occur as a consequence of pumping and natural flow (lateral recharge), as indicated by the conceptual model shown in Figure 3.4. Natural inflow is simulated by including an elevation-dependent pore pressure distribution on the left edge of the model (footwall block). This pore pressure varies linearly with depth from zero at the interface of vadose zone and middle aquitard to 2,452.5 kPa at the base of the system. In other words, initial values depend on the hydrostatic pressure as a function of depth. A zero pore pressure on the opposite edge (hanging wall) is prescribed in order to induce a flow from the footwall to the hanging wall. In this way, natural flow is simulated to occur from left to right in the model domain. One pumping well is simulated along the left edge of the footwall to represent anthropogenic groundwater pumping. The inclusion of a single well to represent the entire pumping load in an aquifer system has been successfully implemented in hydromechanical numerical analyses (i.e. (Burbey 2002; Gambolati and Freeze 1973)). In addition, the model was mechanically prescribed to have free displacements, except on the base, where zero vertical displacement is imposed.

A five-year simulation period that incorporates pumping is used for model scenarios. This time frame provides the system to achieve a dynamic equilibrium for lateral inflows and outflows from pumping and related deformations. Preliminary simulations excluding the pumping load are also performed to establish a steady-state pore pressure distribution for the transient model scenarios. Thus, a water table localized at a depth of 100 m is represented by a zero pore pressure and represents the unsaturated-saturated zone boundary. Similarly above the water table, a simulated negative pore pressure occurs with the most negative pressure occurring at the land surface 100 meters above the water table.

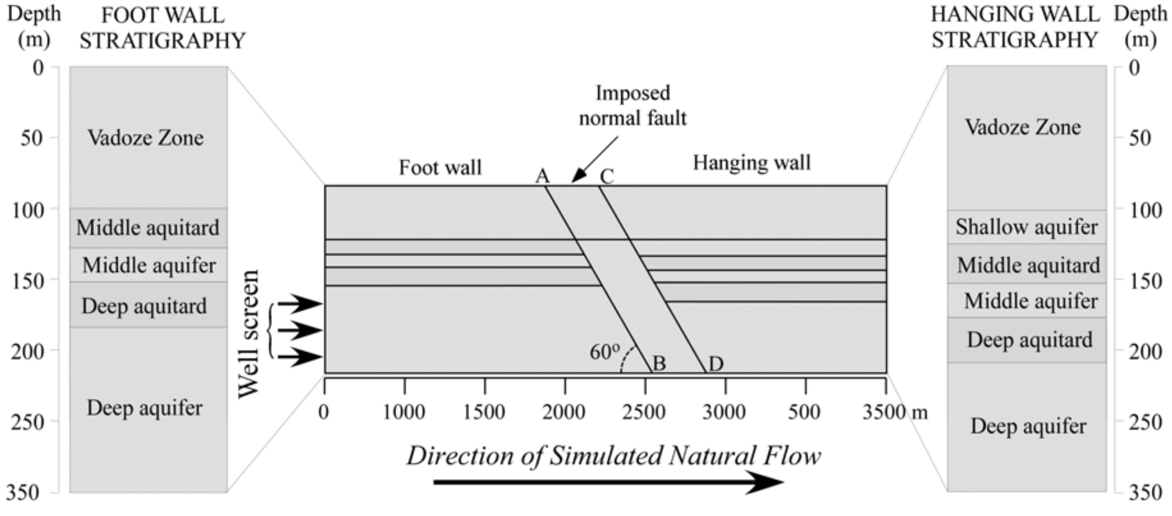

**Figure 3.4. Stratigraphy, flow and pumping conditions used in the model simulations.**

### 3.4. Model scenarios

Four numerical scenarios have been developed to observe firstly the hydromechanical response of the faulted system during seasonal and steady pumping, including aquitards that display purely-elastic and elasto-plastic mechanical behavior; and secondly the detailed spatial variation of displacements and stress fields, particularly in the vicinity of the imposed normal fault. The first two scenarios assume steady or constant pumping but include varying mechanical aquitard properties in which purely-elastic and elasto-plastic conditions are evaluated. The third and fourth scenarios involve imposing cyclical (seasonal) pumping conditions and as well as the two different mechanical aquitard properties as mentioned for scenarios I and II.

#### 3.4.1. Scenarios I and II: Purely-elastic hydrostratigraphic layers

Elastic behavior has been observed in the coarse-grained deposits in Las Vegas Valley as evidenced by the land-surface rebound at some localities as a result of the aquifer storage and recovery program implemented since 1987 (Bell et al. 2008). These particular observations result from a preferentially-elastic response of the main aquifer when pore pressures have been allowed to increase. Scenarios I and II are simulated with purely-elastic layers and the pumping pattern in scenario I is simulated to be held at a constant rate. Scenario II imposes the same hydromechanical aquifer conditions as scenario I but includes cyclical pumping. Table 3.1 lists the hydromechanical properties of each layer implemented, which includes aquifers, aquitards, a fault zone and a vadose zone. These properties are based on average values found in the literature for arid to semiarid basins undergoing land subsidence and earth fissuring (e.g. Las Vegas Valley).

#### 3.4.2. Scenarios III and VI: Elasto-plastic aquitards

The inclusion of elasto-plastic aquitards is particularly important to correctly analyze the behavior of the clay aquitards in response to cyclical pumping because of the dynamic stress conditions that are inherent in this type of analysis. Table 3.2 summarizes all elasto-plastic properties of aquitards, which also represent average values for typical compressible poorly-permeable hydrostratigraphic layers. It should be noted that the aquitards in these analyses represent only 17 % of the total stratigraphic thickness. Also, the two aquitards included in the models (middle and deep aquitards) are simulated to have different elasto-plastic properties

(Table 3.2). This difference is based on the fact that normally consolidated aquitards are assumed. That is, their initial compressibility is the result of pressures caused exclusively by the weight of the overlaying sediments. Therefore, the upper aquitard would be more compressible because it has undergone less historical vertical stress.

Constant pumping is incorporated to the model for scenario III while cyclical pumping is used for scenario IV. As indicated previously, the Modified Cam Clay model is selected to simulate elasto-plastic aquitard behavior.

### 3.5. Relevance of a cyclical groundwater pumping rate

Figure 3.5 illustrates the example of the notable correlation between cyclical pumping in west central Las Vegas Valley to the resulting vertical compaction. This illustration shows that the maximum land subsidence lags behind the minimum hydraulic head by several months and a continual compression occurs even during episodes of water-level recovery. This indicates that the variation of land subsidence is strongly influenced by the temporal changes in pore pressure through the low permeable clay units, but it also suggests that elasto-plastic consolidation is likely occurring within those low-permeable units.

**Table 3.2. Elasto-plastic mechanical properties of the aquitards.**

| **Physical property** | **Middle aquitard** | **Deep aquitard** |
|---:|:---:|:---:|
| PLASTICITY | | |
| Intercept, $e_1$ | 2.5 | 2.5 |
| Log plastic bulk modulus, $\lambda$ | 7.32 | 7.62 |
| Stress Ratio, M | 1 | 1 |
| Initial yield surface size, $a_o$ | 0 | 0 |
| Wet yield surface size, $\beta$ | 1 | 1 |
| Flow stress ratio, K | 1 | 1 |
| POROUS ELASTICITY | | |
| Log bulk modulus, $\kappa$ | 0.01957 | 0.01957 |
| Poisson Ratio, $\nu$ | 0.3 | 0.3 |
| Tensile stress | 0 | 0 |

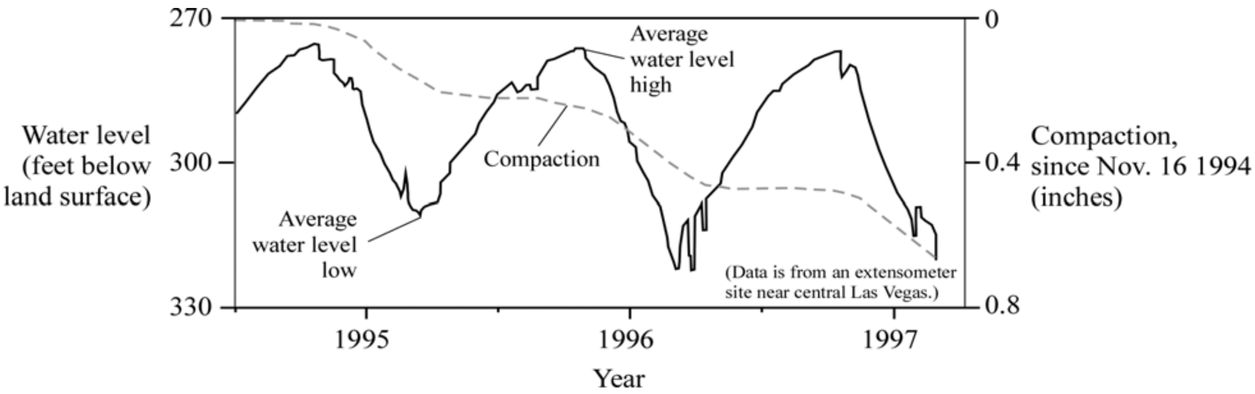

**Figure 3.5. Variation of hydraulic head and surface vertical deformation recorded from the fall of 1994 to the spring of 1997 in Central Las Vegas. From (Pavelko et al. 1999).**

Little is known about the repercussions of the depletion-recovery process on horizontal deformation and stress accumulation, particularly in the vicinity of a fault. In this investigation, seasonal pumping variations are simulated by implementing a sinusoidal pumping pattern to simulate the gradual reduction and increase in pumping during the summer and winter, respectively (Figure 3.6). The same total pumping volume was used in each scenario regardless the mechanical response of the aquitards. However, the sine function was chosen over a step function whereby the maximum pumping rate is instantaneously implemented and then turned off all at once. However, this effect produces a similar result as indicated in Figure 3.5.

Simulated vertical surface deformation for all four scenarios is shown in each graph of Figure 3.6. The plotted points from the simulations correspond to the top (land surface) point of each grid block where the largest vertical deformation occurs. Important observations made regarding these simulations are: (1) in all scenarios, the time in which the aquifer system reaches a dynamic equilibrium between deformation and pumping rate occurs between 2 to 2.5 years after the start of pumping; (2) a larger vertical deformation occurs when steady pumping is used over cyclical pumping, with the range of maximum deformation between 1.50 and 1.90 m for steady pumping and between 1.10 and 1.49 m for cyclical pumping; and (3) the difference in maximum deformation between the footwall and hanging wall after five years of pumping is slightly larger when elasto-plastic aquitards are simulated (Figure 3.6b); (4) the lag time between maximum pumping and maximum vertical deformation is slightly larger when elasto-plastic aquitards are incorporated (Figure 3.6b). This is likely caused by the plastic mechanical response of the aquitards, which results in permanent deformation over time.

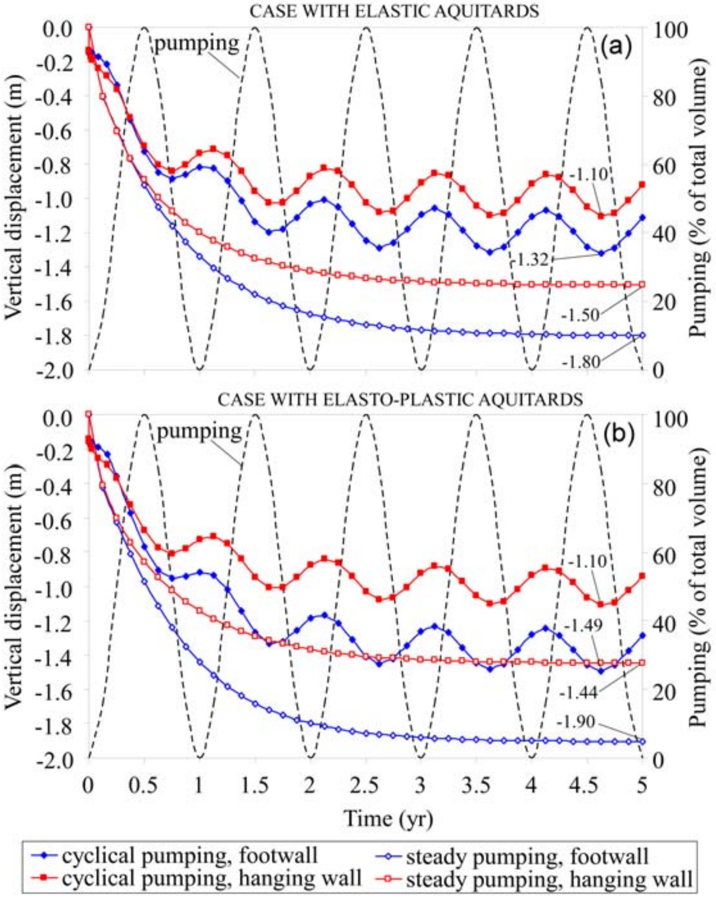

**Figure 3.6. Corresponding vertical deformation derived from pumping where (a) represents the case for purely elastic layers (b) represents the case for elasto-plastic aquitards. Maximum vertical deformation is included in all scenarios.**

This latter result indicates that less pumping-derived strain is transferred from the footwall to the hanging wall when elasto-plastic aquitards are used. Recall that all loads derived from pumping are located on the footwall block. Therefore, it appears that the fault acts to slightly reduce the transference of strain from the footwall to the hanging wall, resulting in less vertical deformation on the hanging wall. This particular deformation pattern has been observed in the Eglington Fault located in Las Vegas Valley (Amelung et al. 1999; Bell et al. 2002). These interpretations suggest that the differential vertical deformation on each side of the fault depends not only on the mechanical properties of the material in the fault zone, but also on the elasto-plastic mechanical response of the adjacent layers.

### 3.6. Simulated Vertical Displacement at the Land Surface

In sedimentary basins under regular pumping, vertical deformation tends to occur as a consequence of the loss of fluid pressure. This deformation varies in magnitude and rate depending on the hydromechanical characteristics of the sedimentary sequence undergoing stress. Figure 3.7 shows the simulated variation of vertical deformation on the surface using elasto-plastic and elastic mechanical responses of the aquitards. In this figure, the curves presented correspond to the maximum vertical deformation for all scenarios after a period of 5 years. For convenience, however, curves from scenarios III and IV show deformation at 4.5-years in accordance to the maximum vertical deformation depicted in Figure 3.6, which corresponds in turn to the last maximum load from cyclical pumping. For comparative analysis, this period of 4.5 years in scenarios III and IV will be used also in the further analyses of horizontal deformation, tensile/compressive stress and shear stress (subsequent sections in this paper).

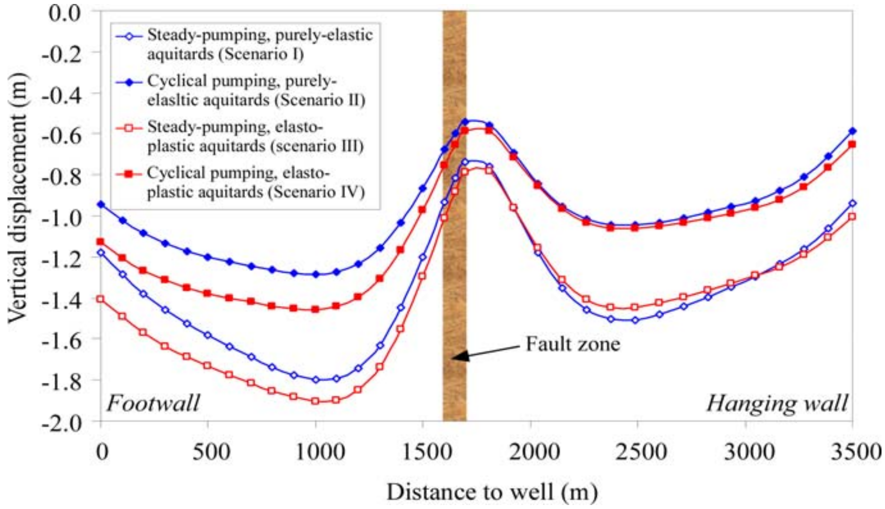

**Figure 3.7. Surface vertical deformation for all scenarios. Negative values in y-axis indicate downward displacement. The fault zone is graphically indicated with the grey strip.**

Vertical displacements simulated along the lateral boundaries (0 m and 3,500 m in the x-axis) reflect the pore pressure distribution implemented as boundary conditions (Figure 3.7). However, a significant change in the curvature of surface deformation can be observed in the vicinity of the fault zone. The maximum vertical deformation always occurs on the side of the fault zone containing pumping (footwall). The rigid behavior of the sand-like fault zone may explain the location of these maximum values. The shape of the vertical deformation curves indicates a high concentration of strain in the vicinity of the fault, particularly on the hanging wall side of the fault. This may suggest that differential subsidence is contributing significantly to this concentration of strain in the proximity of the fault where the slope is steepest. This strain distribution may also greatly favor the initiation of earth fissures, particularly where the strain is greatest (steepest slope).

The fact that the zone adjacent to the fault in the footwall side undergoes the maximum simulated vertical deformation is a consequence of two main factors; one is the position of the pumping well on the footwall and the other is the rigid nature of the fault zone. In general, steady pumping causes more vertical deformation than cyclical pumping. It should be noted too that scenarios with elasto-plastic aquitards (II and IV) produce larger surface deformations (about 20 cm) than those simulated in scenarios with purely-elastic aquitards (I and III).

The difference in magnitudes of displacements between the two scenarios under cyclical pumping and those two under steady pumping is more remarkable than the difference resulting from different mechanical properties in the aquitards (purely-elastic or elasto-plastic), which indicates that the nature of pumping (cyclical or steady) has more influence on the patterns of vertical deformation than whether the aquitards exhibit elasto-plastic behavior.

### 3.7. Simulated horizontal displacements

Simulated horizontal deformation is hereafter presented for analysis and discussion in three key zones within the model domain: (1) on the surface, because initial reports on the analysis of earth fissures, indicate that these discontinuities initiate at the surface as a direct consequence of concentrated tensile stress (Jachens and Holzer 1979; Holzer and Pampeyan 1981); (2) at the unsaturated/saturated zone interface, because this zone constitutes an abrupt change in hydromechanical properties in the hydrostratigraphic sequence; and (3) along a sub-vertical line on each block along the edge of the fault zone in accordance with the geometry of the fault imposed in the model (60$^{o}$ from the vertical), and thus represents a zone of contrasting hydromechanical properties between the fault zone and the adjacent layers. This third zone is important for investigating the influence of the hydrostratigraphy on patterns of horizontal displacement adjacent to the fault on both the footwall and hanging wall.

### 3.7.1 Horizontal displacements on the surface and at the saturated/unsaturated interface

The fault zone has a significant impact on both the magnitude and direction of simulated horizontal displacement at the land surface (Figure 3.8). Maximum simulated horizontal displacements are on the order of 52 cm and 29 cm for the cyclical pumping and steady pumping simulations, respectively. Simulated horizontal displacement vectors at the surface boundary are directed toward the pumping well with the maximum magnitudes in the footwall block. Maximum simulated values in this block correspond to the cyclical pumping and elasto-plastic aquitards (scenario IV), while minimum values correspond to the elasto-plastic aquitards with steady pumping (scenario III). However, contrary to results in the section above on surface vertical deformation, the greatest horizontal displacements correspond to the scenarios with cyclical pumping. This difference is more remarkable when elasto-plastic aquitards are incorporated, suggesting that the nature of pumping has more influence on horizontal displacement patterns than the mechanical properties of the aquitards. This observation is contrary to results of vertical deformation on the surface, as discussed in section 6, where the nature of pumping seems to have more influence than the mechanical properties of the system.

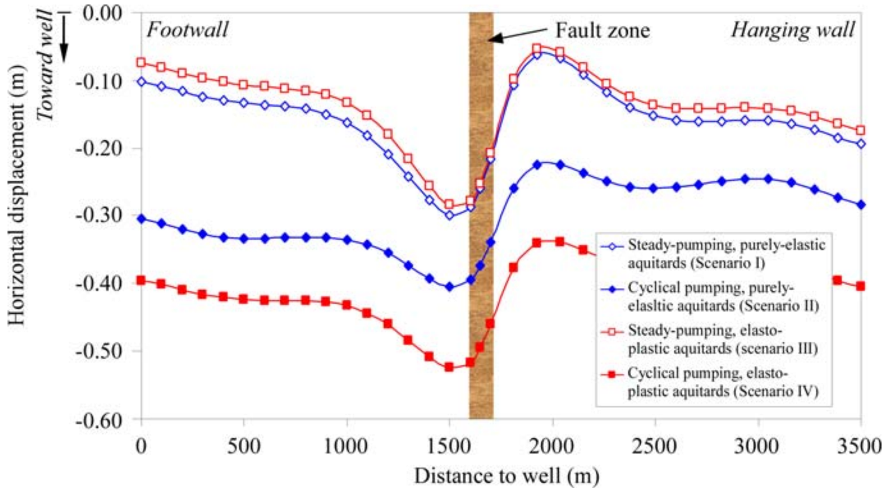

**Figure 3.8. Horizontal displacement at the land surface. Positive values denote displacements moving away from the pumping well, and negative values indicate motion of particles toward the pumping well.**

Even though all horizontal displacements are directed toward the well, maximum values are located on the footwall adjacent to the fault, and minimum values are located adjacent to the fault zone on the hanging wall. Thus, a sudden change in the magnitude of surface horizontal displacement is occurring in the vicinity of the fault zone, imposing a large horizontal strain within the fault zone. This pattern of maximum and minimum magnitudes on both sides of a fault is consistent with observations made in faulted oil fields after prolonged periods of pumping (Segall 1989). In that work however, the difference in magnitudes is such that the vectors are displaced in opposite direction on both blocks of the fault. It is speculated here that the pumping conditions and hydrostratigraphy implemented in this work are not conducive for the fault zone to cause displacement vector orientations away from the pumping well on the hanging wall near the fault zone.

The fault zone also has a profound impact on horizontal deformation patterns at the base of the vadose zone (down to a depth of 100m). Similar to the simulated surface motion, the direction of simulated motion at the base of the vadose zone is toward the pumping well (Figure 3.9). However, contrary to the surface patterns, maximum values (22 to 45 cm) are simulated on the hanging wall in the vicinity of the fault, and minimum values (0.1 to 32 cm) on the footwall near the fault zone (Figure 3.9). The smaller magnitudes correspond to the scenario III (steady pumping and elasto-plastic aquitards) and the larger magnitudes to scenario IV (cyclical pumping and elasto plastic aquitards). These contrary patterns indicate that the fault is rotating counterclockwise with the greatest deformations occurring at the land surface (see discussion in section 3.7.2 below). This result may be attributed to the fact that the fault dip angle is such that the top of the fault is closer to the pumping well. The enhanced motion in the vadose zone could be due to a critical change in the degree of saturation as indicated by the relationship between the deformation pattern and the simulated pore pressures across this unit. In addition, the greater motion at the surface may also be attributed to the traction-free boundary surface (no resistance to horizontal motion).

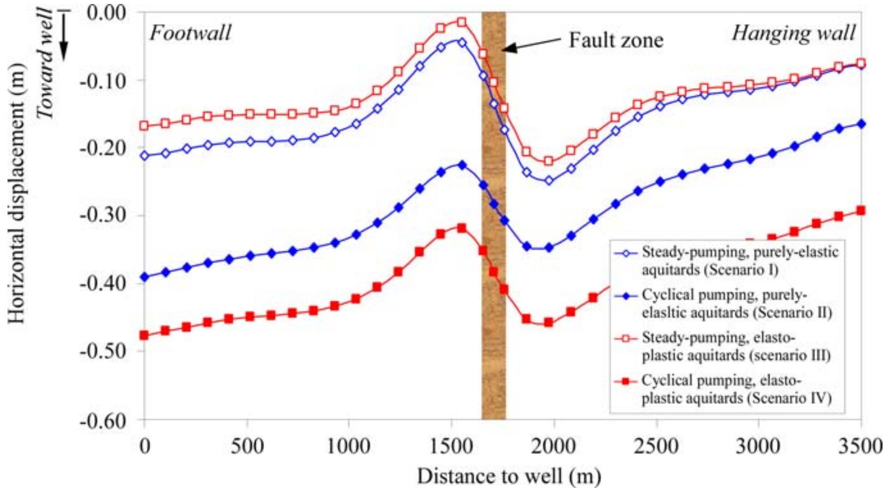

**Figure 3.9. Horizontal displacement at the saturated/unsaturated interface. Positive values denote displacements moving away from the pumping well, and negative values indicate motion of particles toward the pumping well.**

### 3.7.2 Vertical distribution of horizontal displacements in the vicinity of the fault

The complex layered stratigraphy and the presence of the fault greatly affect the vertical distribution of horizontal motion as shown in Figure 3.10. Figure 3.10a represents the fault boundary on the footwall (pumping side) and Figure 3.10b represents the fault boundary on the hanging wall (side opposite of pumping). It should be noted that the total depth of 404.14 m in Figure 3.10 is slightly higher than the real 350 m used in the simulations because the y-axis (equivalent depth) is measured along a line at $60^{o}$ from the vertical as shown at the in the lower-left corner of that figure. Negative values in the x-axis indicate vectors of displacement directed toward the pumping well.

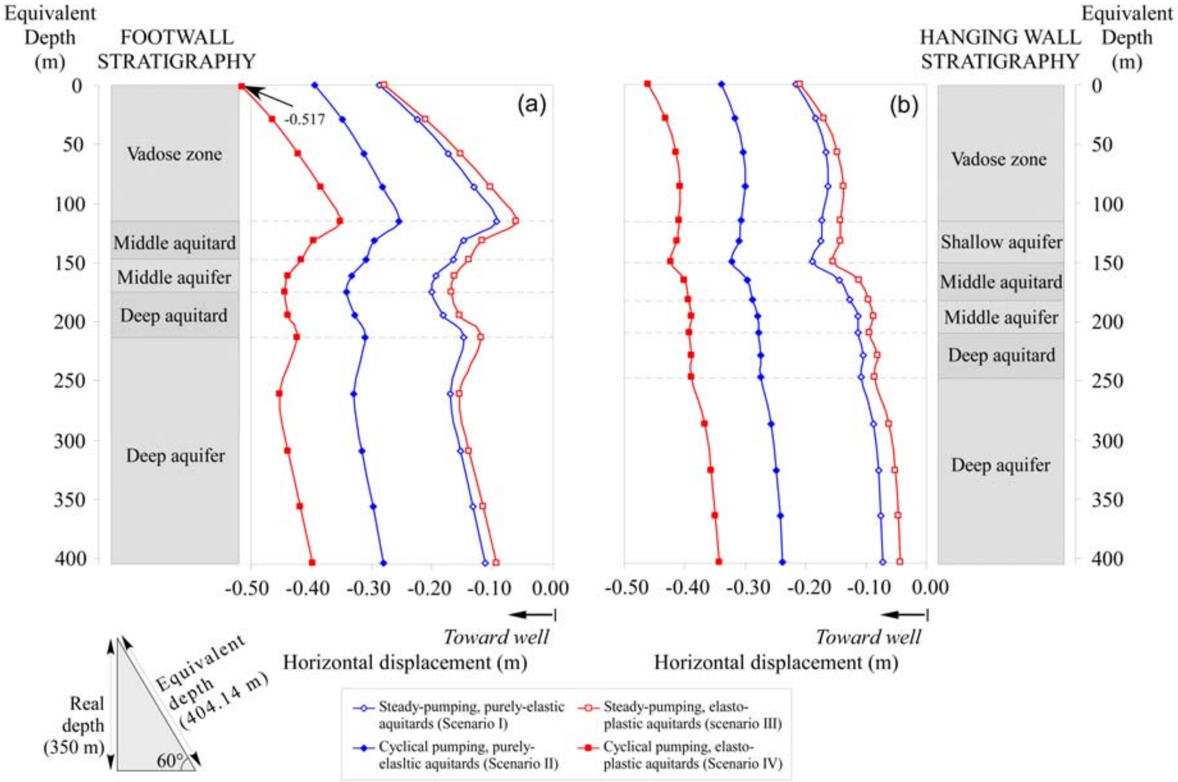

**Figure 3.10. Horizontal deformation along the vertical edge of the fault zone in both blocks. Variations of horizontal displacements in case (a) correspond to the line AB of Figure 3.2, and variations in case (b) correspond to line CD.**

Curves in Figure 3.10 reveal differing magnitudes of horizontal displacements with depth as discussed in regard to Figures 3.8 and 3.9. This, in part, suggests that the mechanical response of the system is similar to that proposed by Sheng et al. (2003) for an aquifer-aquitard system under hydraulic stress. In that investigation, the interfaces between layers were suggested to represent potential planes of weakness resulting from vertical dynamic hydraulic forces induced by pumping. In this investigation, simulation results at the footwall-fault boundary reveal a sudden change in the magnitude of horizontal deformation in two particular zones; one at the unsaturated/saturated interface (vadose zone/middle aquitard boundary), and the second in the deep aquitard/deep aquifer boundary. In both zones, the change in magnitude is a consequence of the contrasting hydromechanical properties of the layers. In the hanging wall, however, the most significant change in the magnitudes is observed in the shallow aquifer/middle aquitard boundary, but this magnitude change is greatly subdued (damped) compared to those on the footwall. On both sides of the fault the common feature is that the maximum negative displacements are located at the land surface. This simulated response is due to a counterclockwise rotation of the entire fault plane but with enhanced motion toward the well through the vadose zone and the middle aquifer. Helm (Helm 1994a) was the first to suggest that fault rotation was plausible for initiation of fissures when an uneven vertical distribution of horizontal deformation occurs within the aquifer system. The results here seem to confirm Helm's supposition. This significant rotation on the footwall, however, does not appear to be transferred completely through the fault to the hanging wall (Figure 3.10b), despite the fact that the entire system is being displaced toward the pumping well. That is, the hanging wall side of the fault is rotating less than the footwall, creating significant extension near the land surface. In addition to the large amount of fault rotation in the vadose zone, the difference in horizontal displacement between figures 3.10a and 3.10b suggests that the fault zone is being horizontally widened during pumping (e.g. the fault width change for scenario I is almost 5 cm at the base of the model domain).

The location of the larger magnitude values in Figure 3.10 suggests that horizontal displacements are mainly controlled by the hydromechanical response of individual layers in the system. On the other hand, it should be noted that generally some horizontal displacement should be expected in the deep aquifer because the well pumps groundwater from this hydrostratigraphic layer, which causes horizontal dynamic stresses to induce flow of solid particles and fluid according Darcy-Gersevanov law (Helm 1994b). Therefore, simulated displacements in the lower layers must be attributed to this law of particle and fluid displacement through the aquifer system.

Pumping stresses propagate through coarse-grained deposits and result in larger compressional strain in aquifers; while aquitards, because of their vastly different hydromechanical characteristics, typically represent zones of transition in horizontal motion (Burbey, 2001).

In the hanging wall (Figure 3.10b), the patterns of horizontal displacement are significantly different to those simulated for the footwall because stress is unequally propagated through the fault and the fault zone also appears to absorb some of the pumping stress. The unequal propagation of stress is in part due to the different stratigraphy on the hanging wall. In this side of the fault deformations are also toward the pumping well with maximum values above the middle aquitard in all pumping scenarios. Once again, the aquitard represents the zone of transition in horizontal deformation and as a result represents a region of high tensional strain. Clays tend to resist failure under tensile strain more readily than sand type materials. Nonetheless, the large amount of tensile strain exhibited across this aquitard may make it susceptible to failure and lead to the upward propagation of an earth fissure. The location of the concentration of strain is precisely where earth fissures are observed to occur in proximity to basin-fill faults in Las Vegas Valley (Bell and Helm 1998).

In summary, the most favorable locations for the formation of earth fissures are (a) within the fault zone near or at the land surface due to large differences in horizontal motion between the footwall and the hanging wall in this region (particularly under steady pumping conditions as shown in Figure 3.10); and (b) within the middle aquitard on the hanging wall where a large transition in horizontal displacement occurs causing a large enough strain to allow the clay or overlying aquifer to fail. (Figure 3.10b). Here, the contrasting difference in hydromechanical properties between these units is sufficient to explain the large change in horizontal displacement.

## 3.8. Simulated stress

### 3.8.1 Distribution of tensile and compressive stress

The evaluation of simulated tensional and compressive zones may be important in the analysis of potential zones of fissuring. Fissures may form where the pumping-induced tensional stress surpasses the tensile strength of the material in question. Simulated tension is shown in Figure 3.11 to be at a maximum of $2.5 \times 10^6$ Pa at the land surface in and adjacent to the fault on the hanging wall. The magnitude of tension then decreases with depth through the vadose zone. Conversely, a zone of maximum compression occurs at the base of the vadose zone within and adjacent to the fault. Along with these zones of tension and compression, another horizontally elongated zone of tension with values of $5 \times 10^5$ Pa is observed on the footwall side of the fault at the base of the vadose zone. The idea of the layer interfaces representing potential zones of failure was proposed by Sheng and Helm (1998) and by Sheng et al. (2003), and is corroborated by the simulated zone of tension located on the base of the vadose zone in this investigation. The resulting patterns of tension/compression simulated in the vicinity of the fault corroborates the concept of a rotating fault zone with tensional accumulation occurring in the locations shown in

Figure 3.11. The simulated stress pattern suggests that fissures are more prone to be initiated in the upper half of the vadose zone in the fault zone or the adjacent hanging wall.

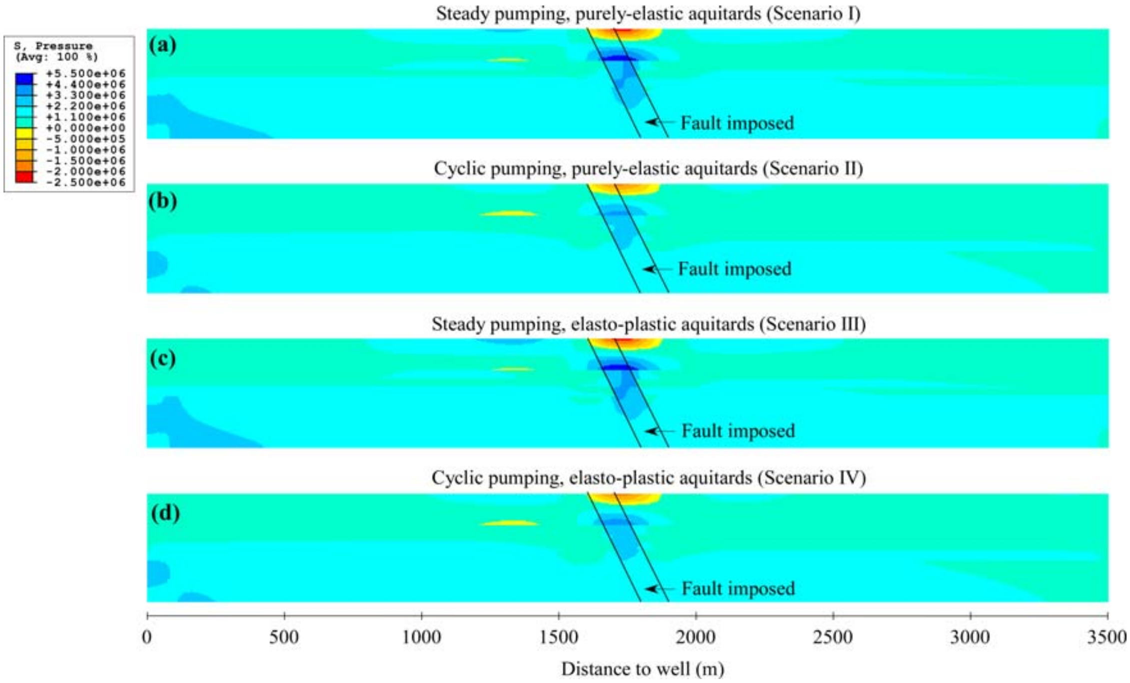

**Figure 3.11. Distribution of tension and compression for all four model scenarios. Negative values in bar scale indicate tension (range of colors from yellow to red), and positive values indicate compression (range of colors from green to blue). The gray area in case (c) indicates a positive tension (compression) with a range from $5.5 \times 10^6$ to $7.269 \times 10^6$ Pa.**

The magnitude of the zones of tension and compression in the upper part of the fault zone are slightly larger when steady pumping is implemented (scenarios I and III), which may be due to the fact that constant pumping does not allow the layers to release stress, resulting in the accumulation of strain in these specific locations. On the other hand, the prominent zone of compression simulated on the left edge of the deep aquifer, and more evident in scenarios I and II, is a direct response to pumping. The compressive strain at this locality increases radially as a function of time and the hydraulic properties of the aquifer as suggested by Helm (1994b).

Even though the stress patterns for all the scenarios are very similar, with the main distinction being the relative magnitudes, some small differences in the tensile/compressive stress configurations can be observed between scenarios I and III (Figures 3.11a and 3.11c) as well as between II and IV (Figures 3.11b and 3.11d), and indicates that the differences in the stress configurations are a function of the pumping patterns rather than due to discrepancies in the mechanical properties of the aquitards (purely-elastic versus elasto-plastic). It is possible that the total accumulated thickness of the two aquitards is not sufficiently large to cause abrupt changes in the patterns of tensile/compressive stress. In addition, the fact that the tension zones are of less magnitude in Figures 3.11b and 3.11d is likely the result of the capacity of the elasto-plastic aquitards to mechanically release stress when the load is removed or mitigated.

### 3.8.2 Distribution of shear stress

Few investigations have made the association between the occurrence of zones of high shear stress to earth fissuring. Pacheco et al. (2006), for example, correlated the change of directional horizontal shear with observed and potential zones of either fissuring or faulting caused by differential subsidence. More recently, Budhu (2008), indicated that shear stress is one of the potential causes of cracking (the initiation of a fissure) at depth.

Figure 3.12 shows the simulated shear stresses for each scenario. As in previous simulations, the vadose zone in the vicinity of the fault shows the greatest change during the pumping stress with the maximum shear gradient (of about $2.5 \times 10^6$ Pa) situated at the base of the vadose zone on the hanging wall and in the middle of the vadose zone in the footwall, but in the opposite direction. As in the case of the tensile stress patterns, the rotation of the fault zone in a counterclockwise direction seems to be the responsible of the occurrence of these two high-gradient shear zones. The combination of a rigid fault zone and the tendency of the vadose zone to bend (or rotate) more substantially compared to the upper aquitard causes both differential vertical compaction in the vicinity of the fault and differential horizontal motion that is exacerbated in the vadose zone. Therefore, the location of maximum simulated shear stress is not symmetric on both sides of the fault because both maximums are not located at the same position with respect the position of the fault. This probably results from (a) the effect of the dip angle of the fault (a vertical fault zone would likely result in maximum gradients at the base of the vadose zone on both sides of the fault); (b) the variations in the stratigraphy in each of the blocks, since an additional thin sandy layer (shallow aquifer) is simulated in the hanging wall resulting in additional rigidity of the block.

As for the compressive and tensile stresses, the patterns of shear stress are similar with only some differences in their magnitudes. For all scenarios, but in particular scenarios I and III corresponding to steady pumping (Figures 3.12a and 3.12c), the conditions most conducive for fissure formation are in the middle of the vadose zone of the footwall and at the base of the vadose zone on the hanging wall where maximum shear stresses are simulated. Constant pumping results in a greater magnitude of shear stress (Figures 3.12a and 3.12c) and therefore a greater likelihood for fissure formation relative to cyclical pumping.

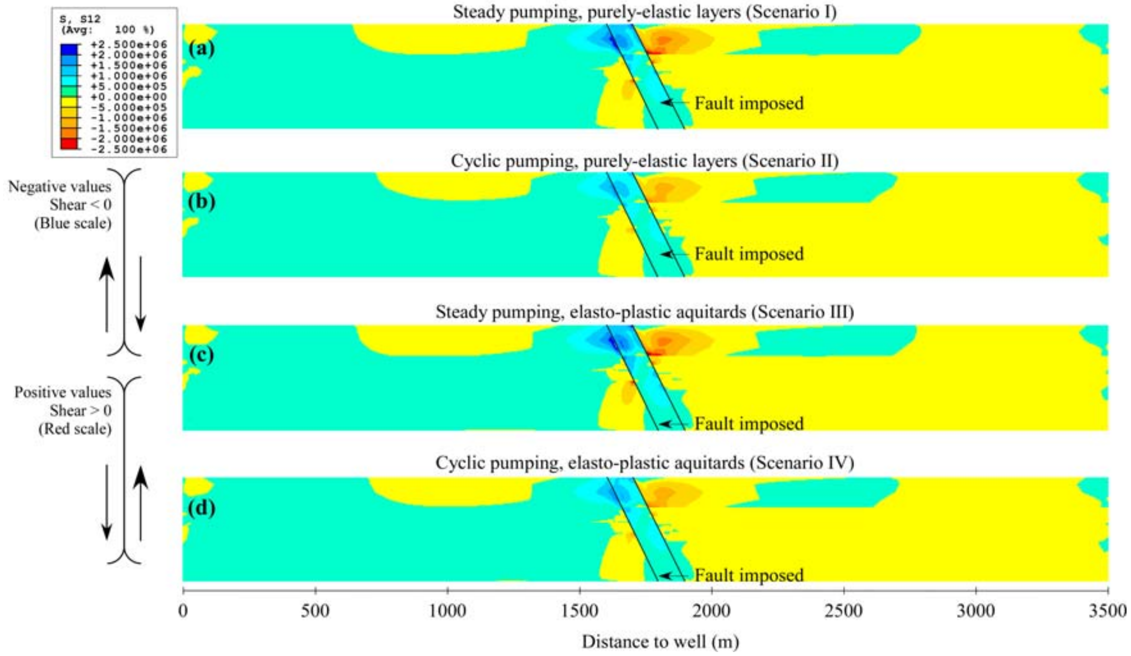

**Figure 3.12. Distribution of shear stress for all scenarios. Bar scale magnitudes are in Pa.**

### 3.9. Discussion

Based on the results of the hypothetical numerical simulations, the patterns of vertical and horizontal displacement suggest that strain is concentrated in the unsaturated portion of the fault zone and its vicinity. Patterns of tensile/compressive and shear stress may be better indicators for identifying the location of potential zones of fissuring. Based on these results, the three most likely locations for fissure commencement are (1) on the footwall near the middle of the vadose zone, (2) on the hanging wall at the base of the vadose zone, and (3) in the upper portion of the vadose zone within the fault and hanging wall. Zones (1) and (2) are the result of shear stresses and zone (3) is a result of tensile stresses.

The aim of the numerical simulations developed here is to reflect the conditions occurring in the vicinity of the Eglington Fault in the northwest part of the Las Vegas Valley (Bell et al. 2002; Hernandez-Marin and Burbey in press). The Eglington Fault area exhibits large differential subsidence truncated by the fault with large vertical deformation occurring on the footwall side where pumping is believed to be greatest. Earth fissures form adjacent to the fault on the hanging wall. Hydraulic head changes across the fault are largely unknown but evidence of regional groundwater levels suggest that the head changes across the fault are small. The results presented in this investigation using a fault zone with greater rigidity (sand infill) than the surrounding deposits results in (a) less vertical deformation within the fault zone, (b) a high concentration of strain in the vadose zone of the fault and adjacent hanging wall (as a consequence of the counterclockwise rotation of the vadose zone occurring as a result of pumping-induced stress patterns); and (c) a negligible change in groundwater levels from one side of the fault to the other, (as a direct consequence of the high-permeability infill material being simulated). These simulated characteristics are either observed or inferred along the Eglington Fault in Las Vegas Valley as a result of cyclical pumping of groundwater caused by variations in seasonal water use and the implementation of artificial recharge. The large change in vertical deformation observed and simulated across the fault implies that the fault zone is capable of absorbing and concentrating pumping induced stress so that the fault behaves as a conduit to groundwater flow and a mechanical barrier for stress. It is important to emphasize that the two-dimensional nature of the models used in this investigation, limits of the manner in which pumping wells can be simulated in the model domain because of the radial nature of induced pumping stress. A more complete analysis of the response of the system to pumping would include a fully three-dimensional analysis that allows for more than one well at different key position to be simulated and observing how the fault may affect stress distributions in a three dimensional system.

The combination of deformation patterns, along with the location of maximum stress, suggests that the entire fault zone is rotating counterclockwise. This rotation is most notable in the unsaturated zone. Figure 3.13 shows the conceptual model of deformation based on the combination of stresses and displacements simulated in the four scenarios described herein. In this figure, the locations of high tensile and shear stress zones suggest that fissures may be initiated simultaneously in the fault zone near the land surface or at the base of the vadose zone on the hanging wall as a result of tensile stress, shear stress or a combination of the two. This is perhaps the most important finding in this work and may contribute to the understanding of fissuring initiation in the presence of a fault zone. Previously, only conceptual work was addressed regarding fissure formation in the vicinity of a fault (Helm 1994a). Additionally as shown in this investigation, fissures may occur as a consequence of shear stress concentrations as the vadose zone bends or rotates differentially on either side of the fault during differential compaction. In a recent investigation by Budhu (2008), shear stresses were shown to be an important factor in the development of buried cracks potentially leading to fissures at the surface. Budhu's work implies that shear-induced earth fissuring would be a secondary effect of bending (in our case this deformation process is caused by the rotating fault zone). These fissures would originate preferentially at depth and migrate upward toward the land surface.

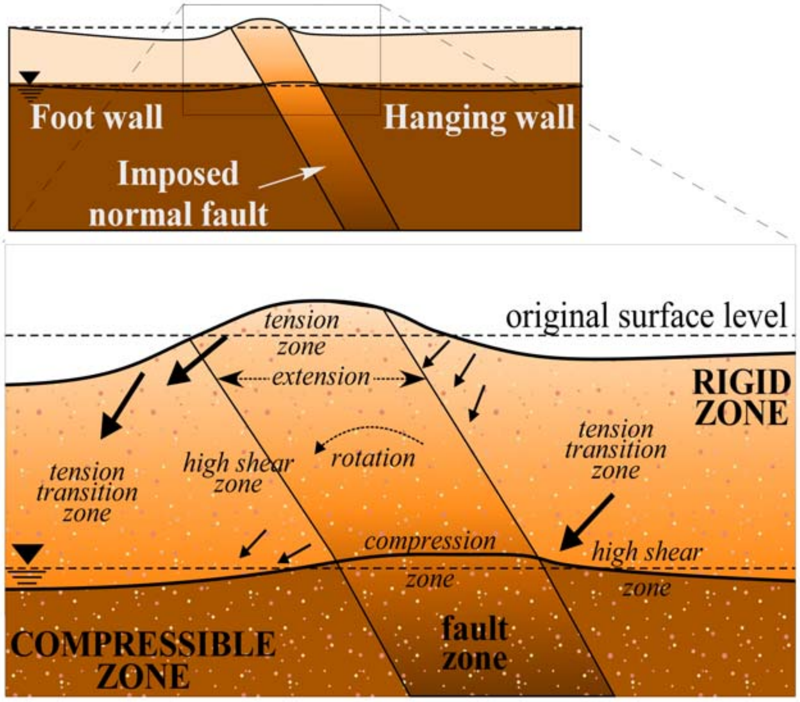

**Figure 3.13. Conceptual model of deformation and location of simulated tensile and shear stress. The fault plane tends to rotate in a counterclockwise manner. Displacement vectors are shown with arrows in different sizes, depicting the magnitude of the displacement.**

The fact that the scenarios using elasto-plastic aquitards yields more horizontal deformation than the cases with purely-elastic layers may provide important clues as to the behavior of natural faulted hydrogeologic systems. This result implies that the accumulated thickness of aquitards is highly relevant because a system with a large cumulative thickness of aquitards would respond more significantly (in the vertical direction) to stresses caused by groundwater flow. In contrast, a system composed mainly of sandy material, would respond elastically to stresses, and would require more induced stress to cause significant horizontal and vertical deformation. In all cases however, a surface fault zone controlling the stress and deformation patterns during pumping represents a zone of high concentrated strain, regardless of the hydromechanical properties of the hydrostratigraphic layers.

### 3.10. Conclusions

A series of simulations using the finite-element software package ABAQUS, have been developed here in order to gain a better understanding of the mechanisms that lead to fissuring in hydrogeological settings under a pumping-induced stress in the vicinity of a fault. This investigation is based on the analysis of the relationship of a fairly rigid fault in a varying hydrostratigraphic system undergoing vertical and horizontal deformation due to both constant and cyclical pumping stress. The analysis includes the investigation of fault stresses, and tensile/compressive stresses in the adjacent footwall and hanging wall blocks and shear stresses in all parts of the system, which includes both saturated and unsaturated sediments. The conceptual mode presented herein consists of a hydrogeologic system undergoing stress imposed by variable pumping and consisting of alternating aquifers and aquitards, with a thick vadose zone and a 100 m wide fault zone dipping at an angle of 60º and penetrating the entire hydrogeologic system. Varying conditions were imposed such that four different simulation scenarios were developed that include constant and cyclical pumping and both purely-elastic and elasto-plastic type aquitards that represent 17 % of the total simulated thickness. The simulations were all run for a period of five years.

Simulation results indicate that more vertical displacement occurs on the footwall than on the hanging wall. This is expected because pumping is simulated to occur on the far edge of the footwall. However, the difference in vertical deformation between the blocks is increased when elasto-plastic aquitards are implemented. This suggests that the fault behaves as a mechanical barrier, absorbing stress and inhibiting its transfer to the hanging wall. This results in higher stresses within the fault zone and areas concomitant to the fault zone.

The vertical distribution of simulated horizontal deformation reveals that the entire fault plane is rotating counterclockwise The amount of rotation and the irregularities in horizontal deformation are likely a function of both the hydromechanical properties of the stratigraphic layers and the moisture content of the vadose zone. Although there is some counterclockwise rotation of the fault zone on the hanging wall, it appears that the fault dampens the transfer of strain to the hanging wall and it also distributes the strain to all the units above the middle aquitard as there is a nearly uniform vertical distribution of horizontal motion toward the pumping well in these upper units (except near the land surface where there is greater motion directed toward the pumping well). These simulated deformation patterns result in normal and shear stresses that accumulate in the vadose zone of the fault and its vicinity. These stresses suggest that the most likely place for fissures to form is (a) near the land surface in the fault zone where tensional strain is large due to fault rotation, and (b) near the base of the vadose zone on the hanging wall where there are large normal and shear stresses associated with hydromechanical differences in the stratigraphy and fault rotation.

With respect to variations in tensile and shear stress, simulations indicate a smaller magnitude of tensile and shear stresses when cyclical pumping is used. Cyclical pumping appears to allow for the unloading of stress in the system.

These findings reveal the importance of the vadose zone for the formation of earth fissures and this unit may be an important reason why these structural features are usually linked to arid-zone basins that exhibit a thick low-moisture vadose zone. Cyclical pumping appears to be more significant in affecting the magnitudes of vertical and horizontal deformation than the hydromechanical behavior of the aquitards. However, a complex combination of three dimensional deformation, and tensile and shear stress seems to be responsible for the location of potential fissures. The presence of a mechanical barrier on the other hand, such as a high-rigidity fault (infill with a low compressibility material such as sand) is vitally important for the accumulation of stress and strain, which can lead to the formation of earth fissures similar to those observed in Las Vegas Valley in the vicinity of the Eglington Fault.

## References

Amelung, F., Galloway, D.L., Bell, J. W., Zebker, H.A., and Laczniak, R.J. 1999. Sensing the ups and downs of Las Vegas: InSAR reveals structural control of land subsidence and aquifer-system deformation. Geology, 27(6):483-486.

Bell, J.W., Price, J.G., and Mifflin, M.D. 1992. Subsidence induced fissuring along preexisting faults in Las Vegas Valley, Nevada, 35th annual meeting of the Association of Engineering Geologists. Association of Engineering Geologists, Long Beach, CA, United States (October 02, 1992), pp. 66-75.

Bell J.W., Helm D.C. 1998. Ground cracks on Quaternary faults in Nevada– hydraulic and tectonic. In: Borchers J. W. (ed) Land subsidence case studies and current research. Proc Dr J. Poland Symp. on Land Subsidence, Assoc. Eng. Geol. Spec. Pub 8:165–173

Bell, J.W., Amelung, A., Ferreti, A., Bianchi, M., and Novali, F. 2008. Permanent scatterer InSAR reveals seasonal and long-term aquifer-system response to groundwater pumping and artificial recharge. Water Resources Research, 44.

Bell, J.W., Amelung, F., Ramellt, A.R., and Blewitt, G. 2002. Land subsidence in Las Vegas, Nevada, 1935 - 2000: New geodetic data show evolution, revised spatial patterns, and reduced rates. Environmental & Engineering Geoscience, 7(3):155–174.

Biot, M.A. 1941. General theory of three-dimensional consolidation. Journal of Applied Physics, 12(2):155-164.

Budhu, M. 2008. Mechanics of Earth Fissures Using the Mohr-Coulomb Failure Criterion. Environmental & Engineering Geoscience, 14(4):281–295

Burbey, T.J., and Helm, D.C. 1999. Modeling three-dimensional deformation in response to pumping of unconsolidated aquifers. Environmental & Engineering Geoscience, 5(2):199-212.

Burbey, T.J. 2001. Storage coefficient revisited: Is purely vertical strain a good assumption? Ground Water, 30(3): 458-464.

Burbey, T.J. 2002. The Influence of faults in basins-fill deposits on land subsidence, Las Vegas Valley, Nevada, USA. Hydrogeology Journal, 10(5):525–538.

Burbey, T.J. 2008. The Influence of geologic structures on deformation due to ground water withdrawal. Ground Water, 46(2):202–211.

Cheng, C., Pei, S., and Jui, J.J. 2003. Land subsidence caused by groundwater exploitation in Suzhou City, China. Hydrogeology Journal 11:275–287.

dePolo, C.M., and Bell, J.W. 2000. Map of faults and earth fissures in Las Vegas area. Nevada Bureau of Mines and Geology and Las Vegas Water District.

Gambolati, G., and Freeze, R.A. 1973. Mathematical simulation of the subsidence of venice 1. Theory. Water Resources Research, 9(3):721–733.

Gambolati, G., Gatto, P., and Freeze, R.A. 1974. Mathematical simulation of the subsidence of Venice 2. Results. Water Resources research, 10(3):563–577.

Helm, D.C. 1994a. Horizontal aquifer movement in a Theis-Thiem confined system. Water Resources Research, 30(4):953-964.

Helm, D.C. 1994b. Hydraulic forces that play a role in generating fissures at depth. Bulletin of the Association of Engineering Geologists, 31(3): 293-303.

Helwany, S. 2007. Applied soil Mechanics with ABAQUS applications. John Wiley & Sons. New Jersey. p. 235

Hernandez-Marin, M., and Burbey, T. J. in press. The role of faulting on surface deformation patterns from pumping induced ground-water flow. DOI 10.1007/s10040-009-0501-8

Hibbit, 2004. ABAQUS/CAE User's manual. Karlsson Sorensen Inc.

Hoffmann, J., Zebker, H.A., Galloway, D.L., and Amelung, F. 2001. Seasonal subsidence and rebound in Las Vegas Valley, Nevada, observed by synthetic aperture radar interferometry. Water Resources Research, 37(6):1551–1566.

Holzer, T.L. 1984. Ground failure by ground-water withdrawal from unconsolidated sediment. Geological Society of America Reviews in Engineering Geology VI, 67–105.

Holzer, T.L., and Pampeyan, E. H. 1981. Earth fissures and localized differential subsidence. Water Resources Research, 17: 223-227.

Jachens, R.C., and Holzer T. L. 1979. Geophysical investigations of ground failure related to ground-water withdrawal – Picacho Basin. Groundwater 17(6):574–585

Kihm, J.H., Kim, J.M., Song, S.H., and Lee, G.S. 2007. Three-dimensional numerical simulation of fully coupled groundwater flow and land deformation due to groundwater pumping in an unsaturated fluvial aquifer system. Journal of Hydrology, 335:1–14.

Lee, C.F., Zhang, J.M., and Zhang, Y.X. 1996. Evolution and origin of the ground fissures in Xian, China. Engineering Geology, 43:45-55.

Li, J. 2003. A nonlinear elastic solution for 1-D subsidence due to aquifer storage and recovery applications. Hydrogeology Journal, 11:646–658.

Meinzer, O.E. 1928. Compressibility and elasticity of artesian aquifers. Economic Geology, 23(3):263–291.

Pacheco, J., Arzate, J., Rojas, E., Arroyo, M., Yutsis, V., and Ochoa G. 2006. Delimitation of ground failure zones due to land subsidence using gravity data finite element modeling in the Querétaro valley, México. Engineering Geology, 84(3-4):143–160.

Pavelko, M.T., Wood, D.B., and Laczniak, R.J. 1999. Las Vegas, Nevada: gambling with water in the desert., USGS, Las Vegas, Nevada.

Pavelko, M.T. 2004 Estimates of hydraulic properties from a one-dimensional numerical model of vertical aquifer-system deformation, Lorenzi Site, Las Vegas, Nevada. US Geol Surv Water Resour Invest Rep 03-4083

Perić, D., and Ayari, M.A. 2002. On the analytical solutions for the three invariant Cam clay model. International Journal of Plasticity. 18:1061–1082.

Rojas, E., Arzate, J., and Arroyo, M. 2002. A method to predict the group fissuring and faulting caused by regional groundwater decline. Engineering Geology, 65:245–260.

Roscoe, K.H., and Schofield, A. N. 1963, Mechanical behavior of an idealized ‘wet’ clay, 2nd ECSMFE, Wiesbaden, vol. 1, pp 47-54

Roscoe, K.H., and Burland, J.B. 1968. On the generalized stress-strain behavior of ‘wet’ clay, Engineering Plasticity, Cambridge, pp. 535–609.

Schmidt, D., and Bürgmann, R. 2003. Time-dependent land uplift and subsidence in the Santa Clara valley, California, from a large interferometric synthetic aperture radar data set. Journal of Geophysical Research, 108(B9):2416, doi:10.1029/2002JB002267, 2003.

Schofield, A.N., and Wroth, C. P. 1968. Critical state of soils mechanics. McGraw Hill, London.

Segall, P. 1989. Earthquakes triggered by fluid extraction. Geology, 17:942–946.

Sheng, Z., and Helm, D.C. 1998. Multiple steps of earth fissuring caused by ground-water withdrawal. In: J.W. Borchers (Editor), Proceedings of the Dr. Joseph Poland Symposium on Land Subsidence. Bulletin of the Association of Engineering Geologists, pp. 149-154.

Sheng, Z., Helm, D.C., and Li, J. 2003. Mechanism of earth fissuring caused by groundwater withdrawal. Environmental & Engineering Geoscience, 9(4):351–362.

Teatini, P., Ferronato, M., and Gambolati, G. 2006. Groundwater pumping and land subsidence in the Emilia-Romagna coastland, Italy: Modeling the past occurrence and the future trend. Water Resourser research, 42:1–19.

Terzaghi, K. 1928. Die Berechnung der Durchlässigkeitziffer des Tones aus dem Verlauf der hydrodynamischen Spannungserscheinungen. [The computation of permeability of clays from the progress of hydrodynamic strain]. Akad Wissensch Wien Sitzungsber Mathnaturwissensch, pp.125–138.

Verruijt, A. 1969. Elastic storage of aquifers. In: D. RJM (Editor), Flow through porous media. Academic Press, , New York, pp. 331–376.

Wilson, A.M., and Gorelick, S. 1996. The effects of pulsed pumping on land subsidence in the Santa Clara Valley, California. Journal of Hydrology, 174:375–396.

# CHAPTER 4

## Controls on Initiation and Propagation of pumping-induced Earth Fissures: Insights from Numerical Simulations

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# Controls on Initiation and Propagation of pumping-induced Earth Fissures: Insights from Numerical Simulations

## Abstract

Pumping-induced earth fissuring occurs in many localities around the world and represents an important economic problem due to the financial loss associated with damage to infrastructures and subsequent litigation. In this work, an initial descriptive conceptual analysis of the natural conditions of selected localities undergoing fissuring is first performed. Then, numerical simulations are developed using the finite-element code ABAQUS to analyze the evolution of stress that can favor the occurrence of fissures, as well as their initiation and propagation. The scenario used in the numerical simulations is based on the observed natural conditions from the descriptive analysis. These natural conditions can be described as having: a complex stratigraphy, a buried fault scarp and a fault zone cutting the entire sedimentary sequence. In general, both fault zones and buried fault scarps influence the accumulation of tensile and shear at different times. The fault zone has more influence on the patterns of tension/compression, while the buried fault scarp has more influence on the patterns of shear stress. In addition, simulation results show that a tensile-induced fissure is initiated in the vicinity of the fault zone in the hanging wall side. This fissure originates near the surface and migrates downward through the vadose zone. This fissure terminates near the saturated-unsaturated interface. Factors involved in the path propagation of the fissure seem to be the occurrence of a fault zone, the location of pumping, and the hydromechanical properties of the vadose zone.

## 4.1. Introduction

Earth fissuring caused by groundwater pumping occurs in many localities around the world and represents an important economic problem due to the financial loss caused by damage to infrastructures and subsequent litigation. Pumping-induced earth fissures can be defined as cracks occurring in the soil surface with or without vertical offset. The dimensions of these structural features can be highly variable, depending mainly on the magnitude of the stress and the strength of the geologic material in which the crack forms. Typically, fissure dimensions vary from centimeters to more than a kilometer in length, from millimeters to several meters in width, and their depths can extend to the water table. Even though several investigations have been specifically addressed to better understand the genesis of these structural features, their relation to anthropogenic pumping and natural structural features is not well known. For example, what is the role of pumping and faults-zones in the initiation and propagation of earth fissures in sedimentary basins? Why are some fissures observed on both sides of quaternary faults, even when some of these faults clearly act as mechanical barriers to vertical deformation, such as the case of Las Vegas Valley? What is the role of planes of weakness on the origin of earth fissures if these planes are considered to include both semi-vertical fault zones and semi-horizontal inter-stratigraphic layer planes? How do pumping-induced stresses evolve to create earth fissures? In this investigation, we attempt to answer these questions.

Several hypotheses aimed at explaining pumping-induced earth fissuring occur in the literature. These include:

1) *Differential subsidence*: Feth (1951) was one of the first authors to suggest that differential subsidence was the main mechanism producing earth fissures. His argument was that lateral variations in aquifer thickness contribute to this type of subsidence. In the late 1960's, Schumann and Poland (1970) refined Feth's idea about the origin of earth fissuring, by suggesting that buried scarps produce variations in aquifer thickness that

favor the occurrence of fissures on the surface. During the last decade the idea of irregularities in the bedrock, from either a fault scarp or a buried ridge, have been used to explain the concentration of stresses leading to fissuring, such as at Queretaro, Mexico (Rojas et al. 2002; Pacheco et al. 2006). In fact, it has been suggested that the fault scarps in Xian China (Lee et al. 1996) have been reactivated by pumping-induced stresses.

2) *Hydraulic forces*: Lofgren (1971) proposed that horizontal seepage stresses have a significant role in the origin of earth fissures. He also formulated the analytical basis for how these hydraulic forces impact the skeletal frame during pumping. Lofgren concluded that a matrix deformation process is caused by fluid motion. Another important contribution to the hydraulic forces concept was proposed by Wolf (1970) who used strain measurements in the vicinity of a well under constant pumping to conclude that pumping-induced hydraulic forces can indeed cause significant concentrations of strain, particularly at a short distance from the well.

3) *Darcy-Gersevanov Theory*: This theory indicates that the matrix and fluid are combined as a bulk flux that is dependent on the porosity of the material (Helm 1994b). This theory is different than the seepage force concept proposed by Lofgren because it implies that an induced stress immediately initiates motion of the aquifer matrix regardless of the nature of fluid flow.

Studies aimed at providing conditions necessary for fissuring can be found in literature. Helm (1994a) and Sheng and Helm (1998) for instance, developed conceptual models to examine various aquifer conditions in order to identify controlling factors in the genesis of earth fissures. Hernandez-Marin and Burbey (in press) used numerical techniques to understand the key factors influencing fissure formation in the vicinity of basin-fill faults having heterogeneous stratigraphy.

This investigation explores first conceptually, and then numerically, the conditions that favor the occurrence of earth fissures in faulted basins under continuous pumping. An inventory of localities undergoing earth fissuring is provided to highlight the most common conditions favoring the initiation and development of earth fissures. Furthermore, based on the most common conditions found in the literature, numerical models are developed to examine the processes leading to the initiation and development of earth fissures. This work includes the analysis of the evolution of tensile and shear stress and their role in fissure formation. Numerical simulations are based on a two-dimensional conceptual model that includes a simple three-layered system (aquifer, aquitard and vadose zone) bounded at the base by faulted bedrock leading to an abrupt change in aquifer thickness and a related fault zone that subvertically cuts all three sedimentary units. The fault zone is considered to have different hydraulic and mechanical characteristics than the adjacent sedimentary aquifer system. A subsequent numerical model is developed to simulate the initiation and propagation of pumping-induced earth fissures.

The key objectives in this investigation are to: (a) simulate the stress distribution in settings where fissures are known to occur; (b) identify the locations in the model domain that are most susceptible for the initiation of earth fissures based on the analysis of the evolution of tensile and shear stress patterns; and (c) simulate the initiation and propagation of earth fissures based on the maximum principal stress criteria.

## 4.2. Typical Observations in Basins with Pumping-induced Fissures

Determining the characteristic features responsible for the formation and propagation of earth fissures is difficult because of the potentially large number of complex factors involved in the process. The hydrostratigraphic setting (including heterogeneities), the nature of pumping, the mechanical properties of the compressible materials (including moisture content) and their thickness, and the time the system has been under stress, all potentially contribute to the formation of earth fissures. Burbey (2002) generalized the conditions that would favor the formation of earth fissures, which include: a) an arid to semi-arid climate; b) long-term overexploitation of groundwater; c) a considerable thickness of accumulated aquitards with high coefficients of compressibility; d) the occurrence of natural discontinuities that can lead to strain accumulation in their vicinity; and e) differential vertical deformation as a consequence of differences in compressibility due to stratigraphic heterogeneities. Any or all of these conditions are typically present in basins in which anthropogenically induced earth fissures occur (ex. Las Vegas Valley, NV; Picacho Basin, AZ)

Table 4.1 presents the characteristics of selected zones where fissuring has been observed in recent decades. The pertinent points from the table are:

1. In areas where water-level reductions have been small, the cause of fissure genesis is difficult to determine. For example, in the Tesistan valley of Mexico and the Ethiopian valley of eastern Africa, the principal stress source may be tectonic in origin and not pumping because the water levels remain near land surface, indicating that the natural recharge exceeds anthropogenic discharge. Both regions are located in highly active tectonic areas, with the Tesistan Valley at the margin of the Tepic-Zacoalco Rift in Mexico (Rosas-Elguera et al. 1996), and the Ethiopian Valley in the Ethiopian Rift zone, in eastern Africa (Ayalew et al. 2004). Thus, it is feasible that tectonics is producing a stress field that is leading to the development of earth fissures at these two localities. Additionally, both locations are prone to heavy rains, which tend to greatly enhance fissure formation at the land surface through piping (Suarez-Plascencia et al. 2005). The radial stress induced in the vicinity of pumping wells may also be contributing locally to the formation of earth fissures.
2. Fissures occurring near surface scarps have been geometrically associated to buried faults scarps located in the underlying bedrock. Fissures observed in the Picacho basin, Queretaro valley and Xian region, in China, coincide with some

## Table 4.1. Principal characteristics of pumping-induced fissuring for selected locations.

| Location | first-fissure / major-fissuring (Recording Year) | Simplified pumping history | Water table depth | Aquifer system: major characteristics | Vadose zone: major mechanical features | Observed influence of faults on fissures | References |
|---|---|---|---|---|---|---|---|
| Las Vegas, valley, USA | 1925 / Not clearly indicated | Pumping began in 1905 but became intensive in 1946 | ~100 m | Complex aquifer-aquitard system of hundred of meters of lacustrine origin | High concentration of caliche resulting in rigid higher-strength material | High spatial control of fault on earth fissures | Bell et al. 1992;<br>Bell and Helm 1998;<br>Burbey 1995 |
| Ethiopian Valley, ETHIOPIA | 1996 / between 1996 - 1998 | No intensive depletion yet | < 25 m | No information available, but lacustrine sediments are inferred to dominate | Low strength due to the presence of illitic and kaolinitic clays | Faults are present but the evidence of fault influence on fissuring is not clear | Ayalew et al. 2004 |
| Queretaro valley, MEXICO | early 1970's / early 1980's | Pumping began prior to 1970, but maximum pumping rates started in 1990 | >100 m | Main aquifer located in fractured volcanic rocks and sands. Aquifers are free to semi-confined | Highly plastic soils in the top layers. Shallow sands and intebedded clay and deep rigid fractured volcanic rocks and sands | Some early fissures evolved into fault scarps. Fissures are geometrically linked to buried ancient faults | Carreon-Freyre et al. 2005;<br>Rojas et al. 2002;<br>Pacheco et al. 2006 |
| Picacho basin, USA | 1927 / 1949 | Pumping began in 1900. Intensive pumping occurred in the early 1940's | ~ 140 m | Unconsolidated alluvial sediments as unconfined aquifers | Unconsolidated young alluvium. Probably consisting in rigid material with high strength* | Some fissures appear on surface scarps, which in turn are linked to buried faults | Jachens and Holzer 1979<br>Holzer 1984<br>Schumann and Cripe 1986 |
| Tesistan valley, MEXICO | Since 1912 / late 1970's | No intensive depletion yet | < 25 m | Poorly consolidated pyroclastic sands and gravels | Loose sands and gravels with low to medium strength capacity | Influence of faults on fissures is not clear | Suarez-Plascencia et al. 2005 |
| Xi'an region, CHINA | 1959 / 1972 | Pumping initiated in 1951 | Between 50 and 100 m | Fine to coarse alluvial sands | Alluvial sloes probably resulting in low to medium strength capacity | Fissures typically coincide with buried normal fault zones | Lee et al. 1996<br>Li et al. 2000 |

* Inferred based on the geological characteristics described as well as the dry weather.

surface scarps that are related to ancient buried bedrock faults typically located in the basement. In some cases, as in the Queretaro valley, the manifestation of buried faults scarps initiate as earth fissures without considerable vertical offset. Typically, they evolve into fault scarps in a period of a few years as stress associated with pumping increases (Rojas et al. 2002).

3. Fissures are rare in the vicinity of large water-level declines (near the center of cones of depression of more than 100 m). This occurs because during pumping, particles and fluid are dragged toward the pumping zone, producing a zone of radial compression in the vicinity of the pumping well (Helm 1994a). Therefore, zones of large water-level declines are generally not associated to tension but rather compression.

4. Fissure enlargement at the surface is common in most settings. The low tensile strength of the uppermost deposits, as described, for example, in the Tesistan and Ethiopian valleys, contributes to erosion of particles and underground piping after heavy rain events. However, the final destination of these sediments is unknown. It has been speculated that some of these mobile sediments make their way pumping wells, which has been observed in some wells in the Tesistan valley (Ochoa, personal communication). Surface erosion from piping can be observed in the fissures of this valley in figure 4.1. The volume of sediments removed from the soil zone during the fissuring process (piping) has been estimated to be nearly 13,000 $m^3$ (Suarez-Plascencia et al. 2000). This amount suggests that the volume of recovered sediments through pumping wells is relatively small compared to the total removed from fissure openings. Therefore, the question of the destination of these sediments remains unanswered and constitutes one of the unsolved mysteries in the study of earth fissuring and subsidence research.

**Figure 4.1. Aerial view of the most spectacular fissure of the Tesistan valley, Mexico. The dashed white line in the aerial photograph indicates the inferred location of the fissure on the land surface. The photograph in the lower left shows the affect of piping that increased the size of this fissure after a heavy rain.**

## 4.3. On the Mechanisms of Fissuring in the Presence of a Fault

According to the direction of the pumping-induced stresses under the surface, two main types of earth fissures manifested on the surface have been distinguished: tensile and shear fissures (Holzer 1984). The main difference between these two fissure types is the vertical offset observed in the field. Typically, tensile-induced earth fissures create small or null offsets, while shear-induced earth fissures are recognized in the field as having measurable scarps. However, some of these shear-induced fissures are manifested initially without vertical offset, as mentioned previously for the Queretaro valley where almost ten years were needed for the initial earth fissures to evolve to produce surface scarps (Rojas 2002).

The formation of pumping-induced earth fissures in the proximity of a fault boundary can be grouped into three conceptual models:

1) *Bending Beam Model*: This is the first and most widely accepted used to explain the creation of earth fissures. According to this model, fissures are produced exclusively by differential subsidence around the periphery of a subsidence bowl (Bouwer 1977; Holzer and Pampeyan 1981; Jachens and Holzer 1982). As observed in Figure 4.2a, all fissures are caused by tension and are initiated on the surface and propagate downwards. The fault tends to rotate as a consequence of hydraulic stresses induced by pumping. This rotation then contributes enormously to the concentration of strain and stress at the surface. The bending beam model only explains the occurrence of fissures on the side of the fault opposite to the rotation of the fault. It is believed that some fissures in the Picacho basin are formed in this manner (Holzer 1984; Jachens and Holzer 1979 ).

2) *Helm Model*: According to this model, fissures can be formed by vertical and horizontal displacements (Helm 1994b). Pumping-induced forces act on both the fluid and the skeletal soil frame causing the fault plane to rotate as indicated in figure 4.2b. Note that this fault rotation is opposite of the rotation described in the bending beam model. Therefore, this model explains only the formation of fissures on the block where groundwater is being pumped. One of the weaknesses of this model is that it does not explain why fissures occur on both sides of the fault, such as in Las Vegas Valley. Like in the bending beam model, the Helm model assumes that fissures are initiated at the land surface.

3) *Horizontal Displacement Discontinuity Model*: This model states that fissures form as a consequence of a significant stress accumulation along a plane of discontinuity such as a fault (Figure 4.2c) (Burbey 2002; Sheng et al. 2003). According to this model, fissures can originate at any point within the vadose zone close to the water table where they then tend to migrate upward to the surface, even though some evidence indicates that fissures may initiate deeper in the exploited aquifer.

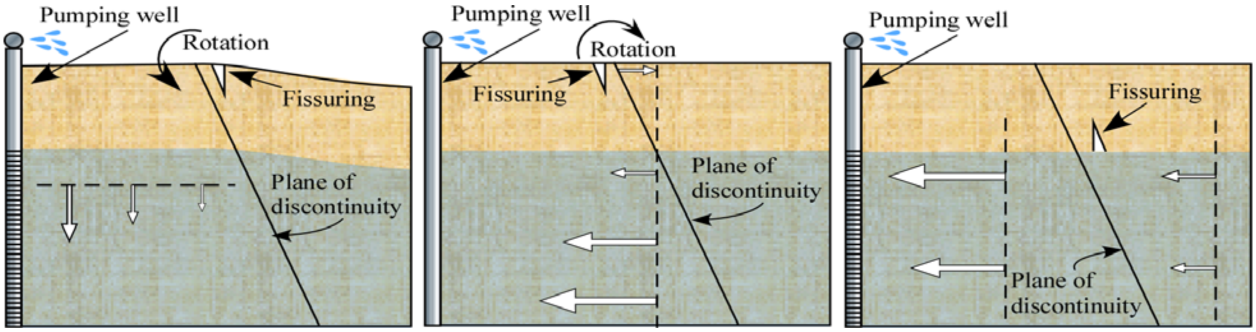

**Figure 4.2. Schematic representation of the hypothetical models that explain the mechanism of fissuring: a) Bending Beam Model, b) Helm model, and c) Horizontal Displacement Discontinuity model. White arrows indicate the direction and relative magnitude of displacements.**

## 4.4. Numerical Approaches

The finite element package ABAQUS was selected for the two-dimensional numerical experiments. Some of the capabilities of this software package include the simulation of: (a) the displacement of solids and flow of water caused by external stresses such as pumping; (b) non-linear or cyclical pumping, which is common in many areas experiencing fissures; and (c) the onset and propagations of cracks in elastic and plastic materials (typically occurring in the vadose zone).

The conceptual model for the simulations in this investigation contains three layers (figure 4.3): a fragile vadose zone, an aquifer and a highly compressible aquitard. The selected hydromechanical parameters of each layer are based on average values found in the literature (Table 4.2). A second model feature is that the three horizontally oriented stratigraphic layers are cut by a 100-meter wide fault zone dipping at 60º and composed of a sand-like material. The third model feature corresponds a 25-meter high buried fault scarp located at the base of the model and results in an abrupt change in aquifer thickness.

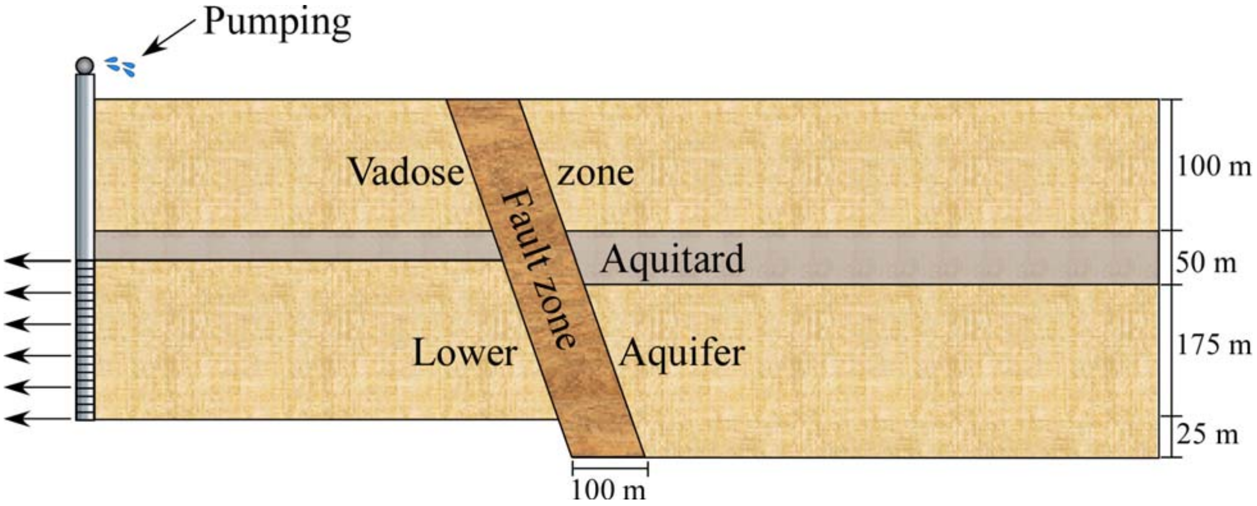

**Figure 4.3. Conceptual model used for the numerical simulations.**

**Table 4.2. Hydrostratigraphic properties for all aquifer-system units used in the model simulations.**

| | **Material type** | **Young's Modulus (N/m$^2$)** | **Poisson Ratio ($\nu$)** | **Hydraulic Conductivity (m/s)** | **Void Ratio (*e*)** | **Density (kg/m$^3$)** |
|---|---|---|---|---|---|---|
| aquitard | Clay-silt | 1.00E+007 | 0.30 | 1.0E-09 | 0.8 | 1700 |
| Deep aquifer | Sand | 1.0E+09 | 0.25 | 1.0E-05 | 0.2 | 1600 |
| Shallow aquifer | Sand | 1.0E+09 | 0.25 | 5.00E-005 | 0.2 | 1600 |
| Fault zone | Sand | 1.0E+09 | 0.30 | 1.0E-05 | 0.2 | 1500 |

An initial dynamic consolidation analysis was performed in order to simulate the impact of pumping that results in the time-dependent accumulation of tensile and shear stress. The initial and boundary conditions for this consolidation test are defined as follows: (1) a constant rate of ground water depletion occurs from the deep aquifer on the left lateral edge of the model. This pumping-derived load prescription can include one or more pumping wells acting simultaneously and causing horizontal flow through the aquifer system. The magnitude of pumping is based on the simulated vertical component of displacement. In other words, a final selected value of pumping was obtained when the simulated vertical deformation reached 1.5 to 2.0 meters over a 50-year simulation period. This range of magnitude was selected because this quantity of subsidence is common in many pumping-induced subsiding basins; (2) a positive elevation-dependent pore pressure was assigned to the left edge of the model to simulate natural recharge.

Similarly a zero pore pressure was assigned to the right edge of the model to simulate natural discharge. Both positive and zero pore pressures acting simultaneously satisfactorily reproduce natural flow in the system from left to right in the model domain. Another characteristic of the simulation is that each layer behaves elastically. The main mechanical difference in the layer properties resides in the Young's moduli selected according to the type of material and its expected mechanical response. A total of 6 time periods were used to simulate the 50-year total time. Periods were geometrically increased from an initial time of 12 hours to secure convergence of the model and to show the progression of stress through the aquifer system as a function of time. Ending stress periods correspond to 12 hours, 1 day, 1 month; and 1, 10 and 50 years of simulation time.

A second independent static analysis was conducted, which is based on the location of maximum tensile and shear stress simulated in the initial consolidation model. Stresses were applied by trial and error until the patterns of tensile and shear stress were approximately equal to the results of the consolidation analysis. Since the pumping load is not allowed in static general simulations, an equivalent distributed pressure stress was implemented simulating the pumping load. The model domain used in this static analysis includes the geometric distribution of the layers used in the consolidation analysis as well as their mechanical characteristics.

A third and final analysis involves the initiation and propagation of fissures, which was performed using the Extended Finite Element Method, or XFEM (Belytschko and Black (1999), which is an extended capability of ABAQUS. The XFEM technique allows for the incorporation of enrichment functions, which are usually asymptotic functions that capture singularities around the fissure tip. These singularities are needed for the analysis of a dynamic growing fissure. Therefore, an enriched element in the model domain is one in which a fissure can initiate and propagate.

A fissure initiates when a defined enriched element is degraded. This element degradation occurs when the simulated stress or strain satisfy a given fissure (failure) criteria. If the maxim principal stress is selected as the fissure criteria, then the following ratio is evaluated: $f = \sigma_{\max} /$

$\sigma^{o}_{\max}$, where $\sigma_{\max}$ is the maximum principal stress criteria and $\sigma^{o}_{\max}$ is the simulated maximum principal stress. A fissure onset occurs if $f > 1 + f_{tol}$. In this equation, $f_{\mathrm{tol}}$ is a user-specified tolerance parameter and is usually less than 0.1.

Once the fissure is initiated, three damage evolution parameters need to be incorporated in the XFEM analysis during the fissure propagation. These parameters represent the normal and shear (tangential) components of the traction stress vector, and define the rate at which two nodes of the same element are separated during the fissuring process. Thus, the fissure propagation analysis is ruled by a traction separation law.

An important advantage of the XFEM technique is that minimal remeshing is required during the fissure propagation analysis (Hibbit 2004). The analysis on the propagations of fissures in conventional finite element techniques is typically mesh-dependent, and the mesh is required to continuously fit the geometric discontinuities. Therefore, the mesh in the vicinity of the growing fissure is constantly updated to a more finely spaced grid network. Another advantage that the XFEM technique has over the conventional finite element techniques is that an existing fissure tip is not needed *a priori*. If no fissure tip is incorporated for the propagation of the fissure, ABAQUS recognizes the zones in which the specified stress criterion is exceeded by the simulated stress and automatically inserts a fissure tip. This capability is very convenient if the modeler is not sure of the exact location of the fissure onset. One disadvantage of this technique however, is that the criteria is based exclusively on the maximum principal stress or strain. Therefore, fissures are simulated only by tension but not by shear stress.

## 4.5. Modeling Scenario: Fault-Zone Cutting the Sedimentary Sequence

The main objective of this model scenario is to analyze the temporal evolution of stresses occurring simultaneously along a dipping fault zone and in the vicinity of a buried fault scarp that may lead to earth fissuring. The fault zone and buried scarp are expected to influence the distribution of stress. In Las Vegas Valley, for example, stresses tend to concentrate near fault zones and therefore favor the occurrence of earth fissures on both sides of the fault, as observed in recent fissure maps of the basin (dePolo and Bell 2000). Therefore, this type of setting is broadly representative of localities such as Las Vegas Valley, even though the existence of a buried fault scarp in the basement rock is unknown due to the thick sequence of sedimentary deposits totaling more than 1500 m. Conversely in the Queretaro Valley, the existence of buried fault scarps has been corroborated (Pacheco et al. 2003) but the width of the zone of influence of the fault (fault zone) is unknown.

### 4.5.1 Evolution of Tensile and Compressive Stress Patterns

The evolution of the temporal changes in tensile/compressive allows us to understand how and when the aquifer system achieves mechanical equilibrium. Figure 4.4 depicts the sequential evolution of the tensile and compressive stress distribution in the fault zone, on the buried fault scarp and in the zone of pumping. Simulated high-magnitude tensile/compressive stresses occur after the first 12 hours of simulation (figure 4.4a), which indicates a relatively rapid aquifer system response to pumping. The tensile stress is concentrated mostly in the vadose zone and in the vicinity of the pumping well. Two incipient zones of tensile stress develop on the land surface directly above the fault zone, and at the saturated-unsaturated interface on the hanging wall adjacent to the fault. The stress of these tension zones are on the order of $5 \times 10^5$ Pa and are the direct consequence of differential vertical deformation on both sides of the fault. The differential vertical deformation and the semi-rigid fault zone acting as a pivot to horizontal deformation are important factors in producing the simulated distribution of tensile and compressive stress shown in Figure 4.4. The combination of these two factors result in the simulated concentration of extensional strain and stress in the unsaturated portion of the fault zone.

The tensile/compressive stress patterns shown after the first day of simulated pumping (Figure 4.4b) are very similar to those shown in Figure 4.4a. Only small differences in the compressive zone adjacent to the buried fault scarp can be distinguished. The zone of high tension of the vadose zone in the footwall is increased. This a result of the counterclockwise rotation of the fault on the vadose zone. The size of the area of compression adjacent to the zone of pumping is reduced at this time, and seems to gradually be reduced over time. After one month of constant pumping (Figure 4.4c) the zone of tension in the hanging wall is reduced with respect the stress distribution after 1 day (Figure 4.4b). This indicates that the system is beginning to reach some dynamic equilibrium at least in this portion of the model domain. The zone of maximum compressive stress that extends from the base of the footwall to the saturated portion of the fault zone indicates that the fault is rotating counterclockwise (top of fault toward pumping zone), causing a pattern of compressional stress in this area.

After one year of simulation, the pattern of tensile/compressive stress is mostly concentrated in the vicinity of the fault zone (figure 4.4d). This indicates that most of the model domain has undergone a measure of low-magnitude compression. However, two zones of tension persist. The first zone occurs on the land surface within the fault zone and the second zone occurs on the hanging wall in the vadose zone. The size of the first zone of tension remains constant over time but the second zone is gradually reduced, as seen in Figures 4.4a through 4.4d. After ten years, most of the zone of compression is concentrated in the saturated portion of the fault zone.

The distributions of simulated tensile/compressive stress after 20 and 50 years (Figures 4.6e and 4.6f) are similar indicating that the system has reached a new equilibrium after 20 years of pumping. The magnitude of maximum tensile stress also remains unchanged between both simulation times, and magnitudes are on the order of $3 \times 10^6$ Pa. This magnitude is sufficiently large to initiate fissures in most soil types, according to the tensile strength estimated for soil masses by Conwell (1965). Results suggest that stress accumulates within a short distance of the fault zone, and only low-magnitude compressional stress remains in the remainder of the model domain. This result can be expected because pumping-induced stress is typically concentrated in or close to sub-vertical planes of weakness such as faults, resulting in fissuring, as reported for sedimentary basins like Las Vegas valley (Bell and Helm 1998; Bell et al. 1992).

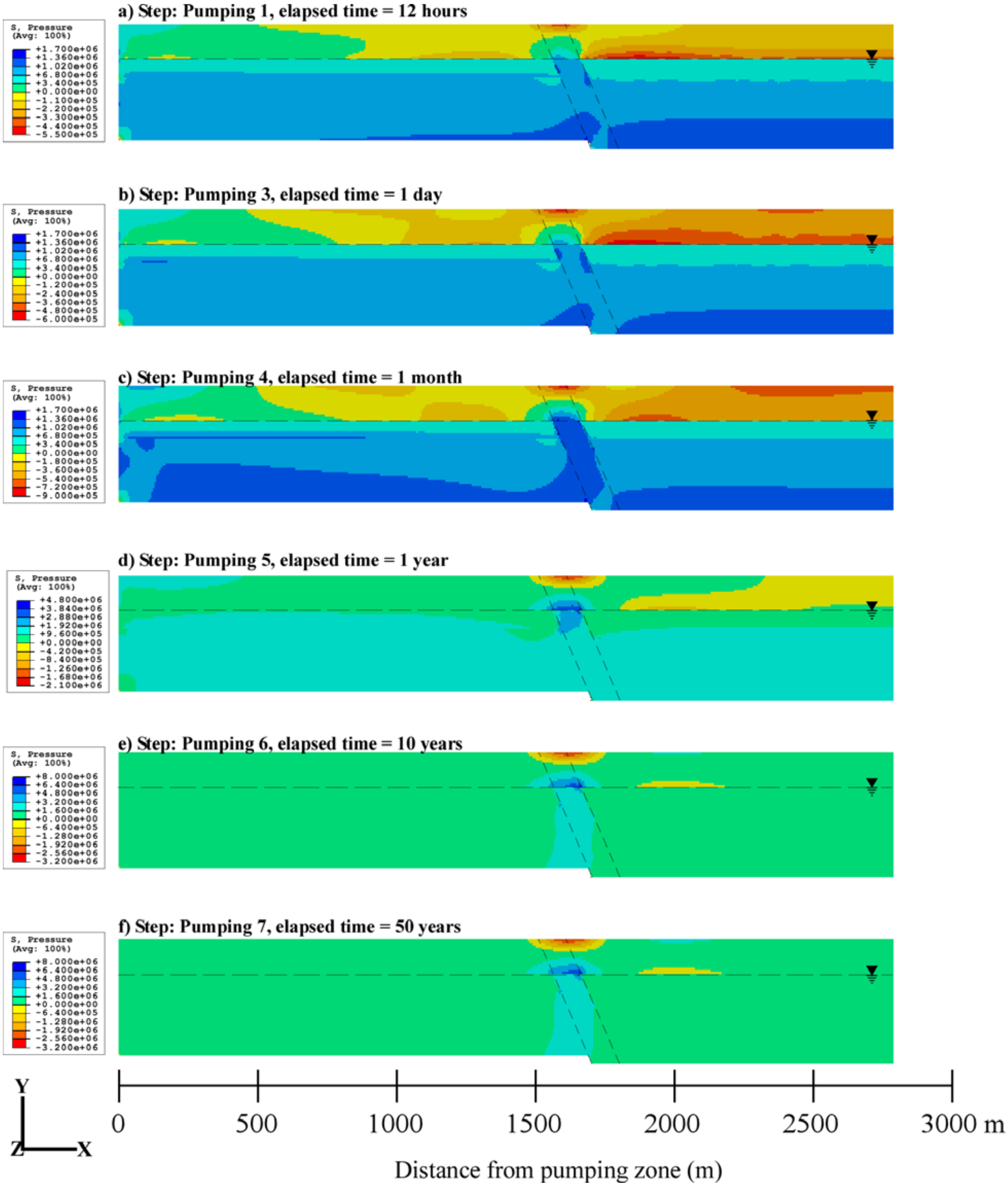

**Figure 4.4. Patterns of tension and compression from the consolidation analysis. Units of pressure stress (S) in the scale bar are Pascals. Yellow to red colors indicate tensile stress condition.**

### 4.5.2 Evolution of Shear Stress Patterns

Evolution of shear stress patterns is most notable in the unsaturated portion of the fault zone (Figure 4.5). Negative and positive zones of accumulated shear stress are present on both sides of the fault during most of the 50-year simulation time.

After 12 hours of constant pumping, a zone of negative shear stress located in the vadose zone and of magnitude 2 x $10^5$ Pa appears adjacent to the fault zone on the hanging wall (Figure 4.5a). This zone of negative shear stress is notable because no stress caused by pumping is directly induced on the vadose zone, only on the aquifer. Another zone of negative shear stress is occurs in the vadose zone and adjacent to the pumping well. Three main zones of positive shear stress are simulated after 12 hours: one is located near the pumping well and the other two are located in the fault zone, the first in the vadose zone and the second at the edge of the buried fault scarp. This latter zone reveals that the fault scarp impacts the fault zone even at early pumping times.

After one month of simulation (Figure 4.5c), both negative and positive shear stresses have increased in magnitude (to -5 x $10^6$ Pa and 1 x $10^6$ Pa, respectively) in the vadose zone portion of the fault zone.

As pumping time increases to one year, the simulated negative shear stress on the hanging wall decreases, while the positive shear stress in the footwall increases (Figure 4.5d). In fact, the region of negative shear stress in the vicinity of the fault zone has been enlarged and extends from the vadose zone to the base of the model domain and encompasses both sides of the fault The magnitude of negative shear stress has increased to a maximum of – 4 x $10^5$ Pa. Conversely, the positive shear stress positioned on the buried fault scarp has been drastically reduced in magnitude (4 x $10^5$ Pa) and size. These reductions in positive shear stress are likely directly related to the buried scarp.

Similar patterns of shear stress are simulated after 20 and 50 years (Figures 4.5e and 4.5f). The influence of the buried fault scarp is no longer observed in the simulated shear stresses. However, the negative shear stress zone now extends from the vadose zone to the base of the model. The magnitude of the negative shear stress is slightly higher in the zones of maximum shear stress accumulation.

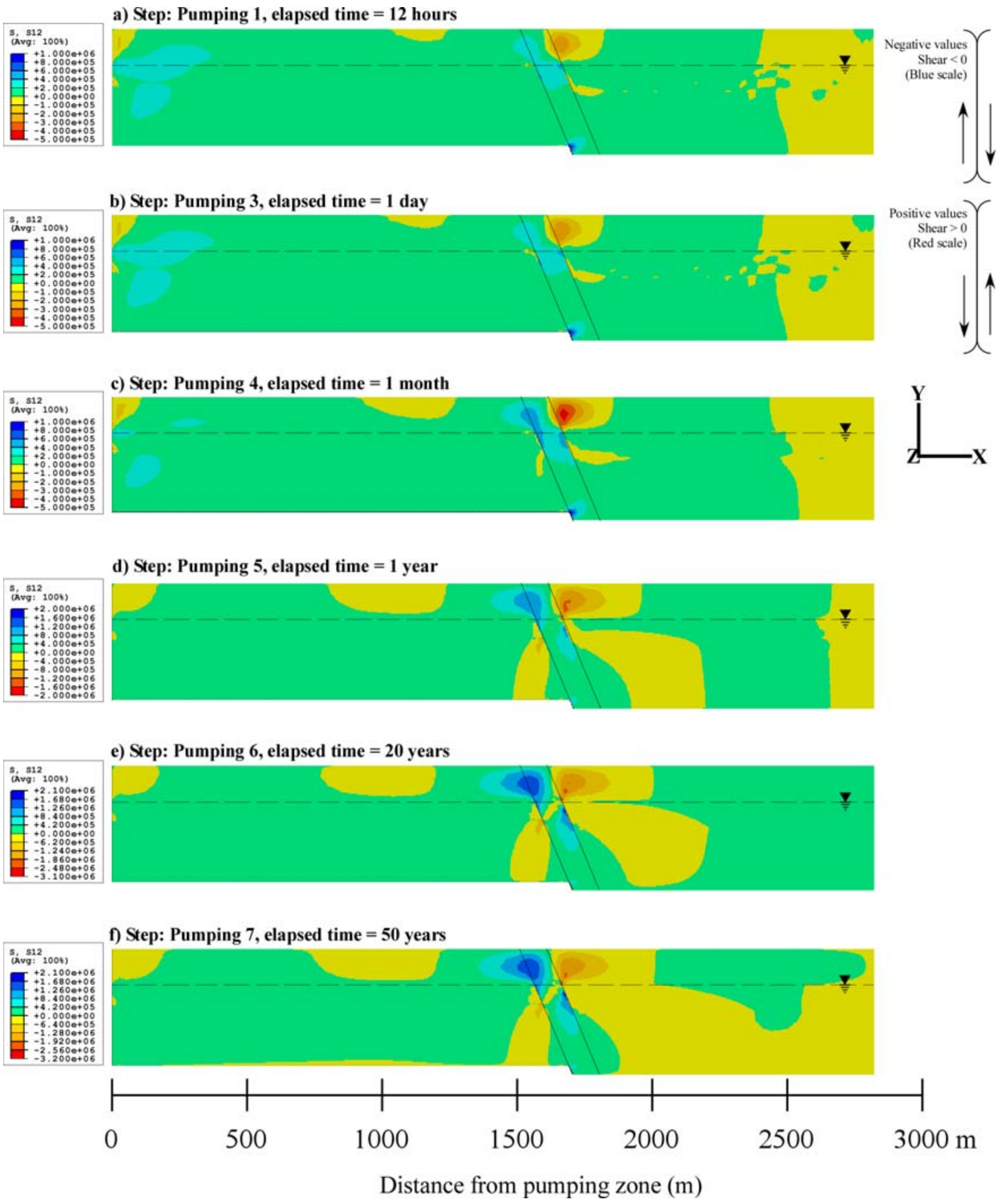

**Figure 4.5. Simulated patterns shear stress from the consolidation analysis. Units of pressure stress (S12) in the scale bar are Pascals.**

### 4.5.3 Initiation and propagation of a tensile fissure

The location of the initiation and propagation of earth fissures due to pumping have been largely speculative up to this time. Incorporating the capabilities of XFEM for simulating the onset and propagation of a tensile-induced fissure has provided valuable insight about fissure formation. An initial comparison of tensile, shear and maximum principal stresses shows that the potential onset of the fissure depends only on the tensile stress distribution. The fault zone and the location of the pumping zone seem to influence the preferential fissure propagation path.

As indicated previously, a simulated fissure using the XFEM technique can occur when the critical stress value exceeds the simulated maximum principal stress. In this numerical analysis, a stress of $1 \times 10^5$ Pa is used as the critical stress value. This stress magnitude is based on the tensile strength estimated for soil masses by Conwell (1965) and the tensile strength estimated for caliche. Conwell's general estimation of critical stress yields a value on the order of $1 \times 10^4$ Pa, which can be applied to a vast range of soil types. However, if we consider that vadose zones typically have been subjected to one of several cementation processes favored in part by their low moisture content, then it is likely that the vadose zone has undergone an increase in tensile strength. Thus, a higher value of critical stress may be required. In localities such as Las Vegas Valley, the low moisture content and high concentration of carbonate in the upper 100 m of sedimentary deposits has resulted in the occurrence of caliche in many of the Valley's upper soils. Caliche has been defined as a rock-like carbonated-cemented soil (Werle and Luke 2007). The incorporation of caliche in the upper quaternary sediments in Las Vegas Valley increases the strength capacity of the upper vadose zone. Stone and Luke (2001), estimated the tensile strength of pure caliche by means of standard techniques in soil mechanics and found that the strength is on the order of $3.27 \times 10^6$ Pa. Therefore, we have chosen to use an intermediate value of $1 \times 10^5$ Pa in the simulations for fracture initiation and propagation.

The point of the fissure onset corresponds to both the zone of maximum principal stress and the zone where the tension is highest. This is because the zones of accumulated tensile stress overlap zones of maximum principal stress, as shown in Figure 4.6. However, the zones of maximum shear stress (Figure 4.6b) are independent of the locations of accumulated maximum principal stress (Figure 4.6c). This implies that only fissures caused by tensile stress can be modeled using the XFEM technique, which is one disadvantage of the analysis. Nevertheless, for the purposes of this investigation, the initiation and propagation of fissures caused by tensional stress represents a significant advancement in our understanding of fissure genesis.

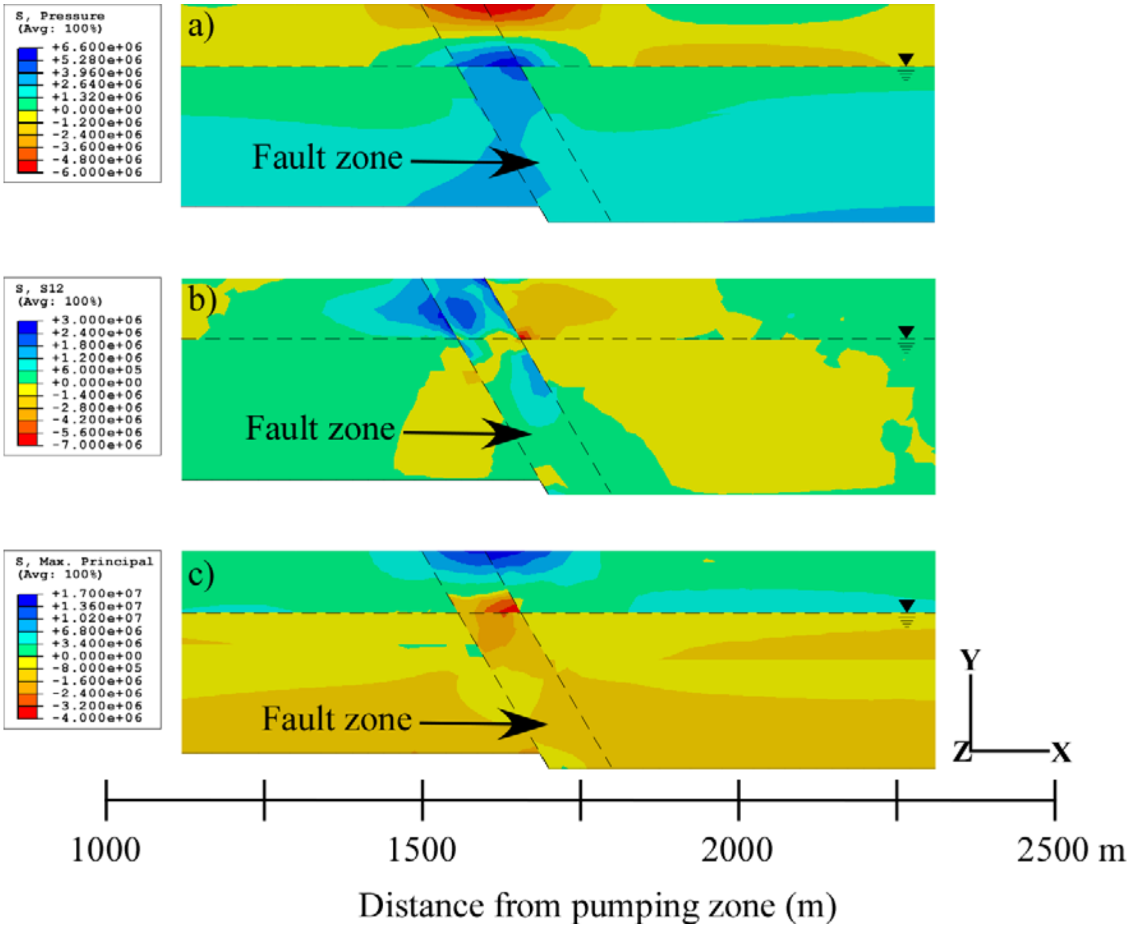

**Figure 4.6. Comparisons of simulated tensile, shear and maximum principal stresses from the static analysis. Units of stress (S) in the scale bar are Pascals.**

The selected frames from the XFEM analysis (Figure 4.7) provide the fissure initiation and propagation path of a tensile-induced fissure. Figure 4.7a shows the fissure onset occurring near the land surface on hanging wall. It is not readily clear whether the fissure is initiated at the surface or at a relatively shallow depth in the vadose zone. The initial frame in which the fissure initiates shows a fissure length of nearly 20 m, which may suggest that fissures do indeed form initially as a linear feature. Thus, the first tensile-induced crack appears at a depth ranging from 0 and 20 meters. In the second frame (Figure 4.7b), of the fissure tends to migrate downward sub-vertically to the contact with the hanging wall of the fault. This is a probable consequence of the homogeneous mechanical properties of the vadose zone. In Figure 4.7c, the fissure propagates toward the center of the fault zone. This horizontal deflection may be influenced by the different hydromechanical properties of the fault zone or by the position of pumping. Figure 4.7d shows the fissure propagating downward and horizontally toward the footwall of the fault. In this frame, the fissure tip is located within the fault zone. A notable horizontal deflection of the fissure occurs when the fissure enters the fault zone. This deflection is most likely caused by the change in the mechanical properties of the medium. In Figure 4.7e the fissure is terminates with a total elongation of nearly 100 meters. In each frame of Figure 4.7 the highest concentration of maximum principal stress is located at the head of the migrating fissure. This indicates that this mechanical variable is being constantly updated in ABAQUS in order to estimate the path of the fissure propagation in the subsequent frames. The fact that the fissure does not propagate below the saturated zone implies that fissures are limited to primarily the unsaturated sediments with low moisture content and low tensional strength.

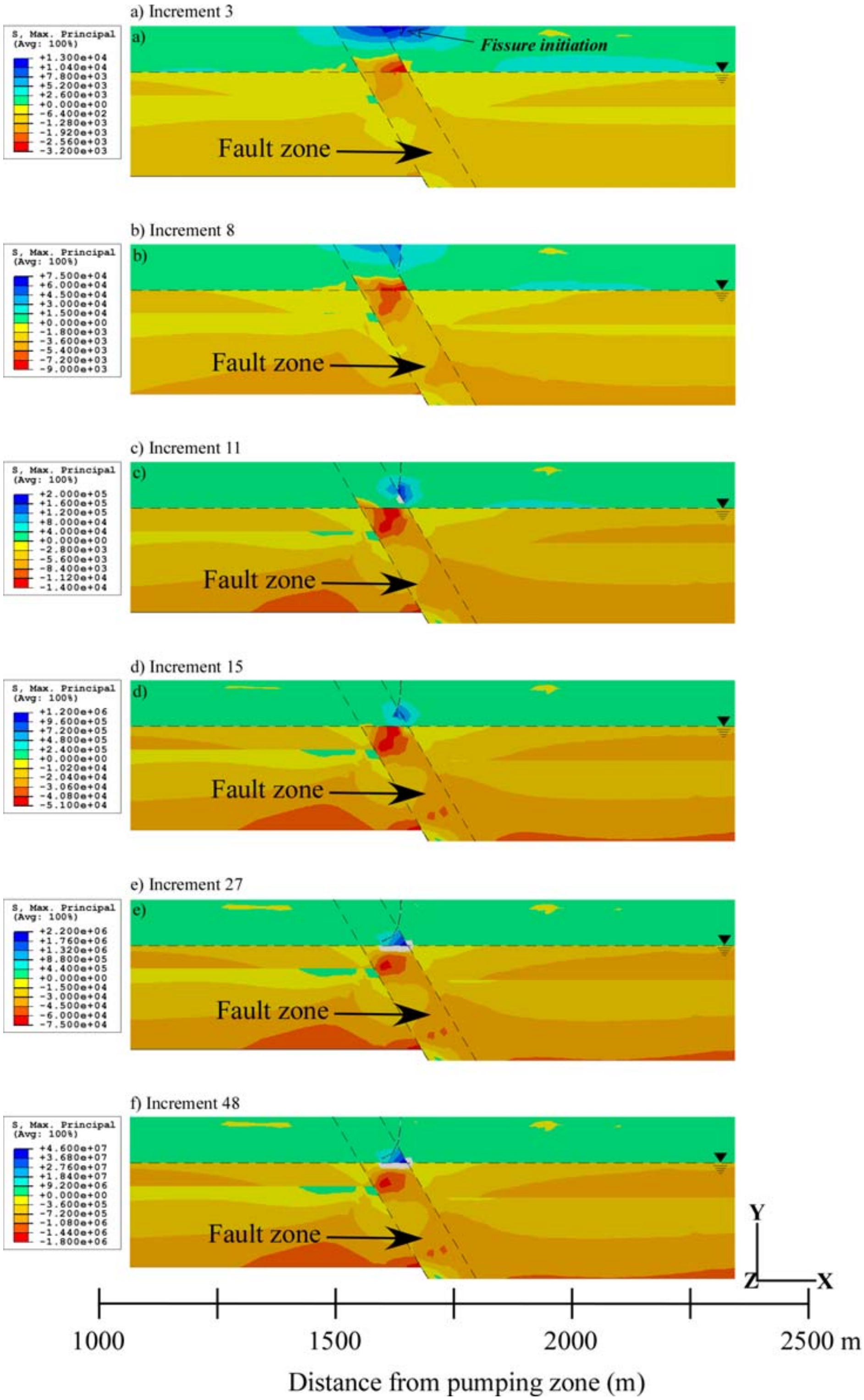

**Figure 4.7. Selected frames (increments) from the sequential evolution of a tensile-induced fissure. Units of Maximum principal stress (S, Max. Principal) in the scale bar are Pascals.**

## 4.6. Summary and Conclusions

The study performed here consists of two parts: the first part represents a descriptive conceptual analysis of the natural conditions that lead to fissuring in current selected localities. The second part consists of a numerical hypothetical study aimed at investigating the initiation and propagation of pumping-induced earth fissures in normally faulted basins.

The conditions described from the selected fissure localities are grouped into three main types. The first type corresponds to a complex simple natural horizontal stratigraphy and is common in localities such as the Ethiopian Valley in Africa and the Tesistan Valley in Mexico, where heavy rain events trigger the appearance of earth fissures. However, these are tectonically active areas with a shallow water table. The tectonically derived is likely to represent the driving force leading to fissuring rather than pumping-induced stress. The second observed type from the descriptive analysis is where the existence of buried fault scarps influence not only the origin of earth fissures but also their location at the land surface. Examples of localities where this condition has been observed include the Queretaro Valley in Mexico and the Xi'an region in China. In the Queretaro valley, buried fault scarps are reactivated by pumping and are manifested on the surface first as fissures and then as surface scarps. In the Picacho basin in Arizona, USA, fissures are additionally related to an abrupt reduction in aquifer thickness, which results in differential subsidence. This reduction in thickness of compressible deposits is mostly due to convex-upward irregularities in the basement rather than the presence of fault scarps. The third and final type is the fault zone that extends vertically through the sedimentary deposits. This type typically results in the accumulation of stress near the fault plane; thus creating favorable conditions for the occurrence of earth fissures. An example of this type is Las Vegas Valley where Quaternary faults control both the occurrence of earth fissures and the distribution of the subsidence patterns. In this locality the earth fissures are observed to occur in both sides of the faults.

The conceptual model used for the numerical investigation of earth fissure formation is the third type described above. The features used in the model include: (a) a complex aquitard-aquifer system that incorporates a rigid 100-meter thick vadose zone; (b) a 25-meter high fault scarp at the base of the model that represents a normal fault in the basement rocks beneath the sedimentary cover; and (c) a 100-meter wide sub-vertical fault zone that extends through the sedimentary units and has different hydromechanical properties than the adjacent aquifer system. This conceptual framework is similar to what occurs in Las Vegas Valley. The finite-element software program ABAQUS is used for conducting the numerical simulations, which consist of an analysis of the evolution of tensile and shear stress patterns followed by a static numerical analysis to investigate the onset and propagation of tensile-induced fissures using the XFEM package for ABAQUS.

The results of the numerical analysis for investigating the evolution of tensile and shear stress indicates that the zones most prone to fissuring are at the land surface in the fault zone for tension and in the base of the vadose zone inside the fault zone for shear. The fault-scarp/fault-zone condition typically leads to the accumulation of stress in the vicinity of the fault and consequently creates conditions favorable for the occurrence of earth fissures. Simulated stress conditions suggest a strong influence of the fault scarp and fault zone in the distribution of tensile/compressive stress beginning shortly after (12 hours) the start of pumping. After one month most of the tensile stress is concentrated in the vadose zone within the fault zone. A well-defined zone of tensile stress occurs on the land surface in the fault zone after one year and prevails over the entire 50-year simulation. Similarly, a well-defined zone of compressive stress exists for the entire simulation time in the saturated portion of the fault zone within the fault. Two notable zones of shear occur throughout the simulation and increase in magnitude as a function of time: one positive zone on the footwall and one negative zone on the hanging wall. Both zones are simulated to occur within the vadose zone.

The XFEM numerical analysis designed to simulate the initiation and propagation of fissures reveals that an incipient tensile-induced fissure develops adjacent to the fault zone in the hanging wall within the uppermost 20 m of vadose zone. The fissure is then simulated to migrate downward to the fault contact. From here the fissure propagates more horizontally into the fault zone. This horizontal deflection is probably influenced by the pumping well in combination with the hydromechanical properties of the fault zone. The fissure stops propagating at the base of the vadose zone within the fault zone. The total elongation of this tensile-induced fissure is nearly 100 meters, which represents nearly the entire thickness of the vadose zone. These results suggest that under the conditions presented here, tensile-induced fissures only propagate through in the vadose zone, which is likely due to its low tensile strength.

The simulated fissure occurs on the hanging wall adjacent to the fault. Certainly, this is one of the chief locations where fissures are observed in Las Vegas Valley. However, due to the conditions used in the model, the XFEM is limited to fissure formation in zones of tensile failure only. Thus it precludes the determination of fissures in areas of high shear stress. This unfortunate limitation represents an area for future work because the propagation of shear-induced fissures is believed to be an important mechanism for upward propagating fissures. Figure 4.7 reveals that a zone of high positive shear stress occurs on the footwall. It is possible, and even likely, that fissures initiate in this region within the vadose zone. If so, they would migrate upwards to land surface. Thus, tensional fissures occur on the hanging wall near land surface and migrate downward, while shear fissures are likely occur on the footwall deeper within the vadose zone and migrate upward to the land surface.

## References

Ayalew, L., Yamagishi, H. and Reik, G., 2004. Ground cracks in Ethiopian Rift Valley: facts and uncertainties. Engineering Geology, 75: 309-324.

Bell, J.W. and Helm, D.C., 1998. Ground crack on quaternary faults in Nevada: hydraulic and tectonic. In: J.W. Broucher (Editor), Proceedings of the Dr. Joseph F. Poland Symposium on Land Subsidence. Bulletin of the Association of Engineering Geologists, pp. 165-173.

Bell, J.W., Price, G. J., and Mifflin, M.D. 1992. Subsidence induced fissuring along preexisting faults in Las Vegas Valley, Nevada, 35th annual meeting of the Association of Engineering Geologists. Association of Engineering Geologists, Long Beach, CA, United States (October 02, 1992), pp. 66-75.

Burbey, T.J., 1995. Pumpage and water-level change in the principal aquifer of Las Vegas Valley, 1980-1990.

Burbey, T.J. 2002. The Influence of faults in basins-fill deposits on land subsidence, Las Vegas

Valley, Nevada, USA. Hydrogeology Journal, 10(5):525–538.

Belytschko, T. and Black, T., 1999. Elastic crack growth in finite elements with minimal remeshing. International Journal for Numerical Methods in Engineering, 45(5): 601-620.

Bouwer, H. 1977. Land subsidence and cracking due to ground-water depletion. Ground Water, 15:358-364.

Carreón-Freyre, D.C., Cerca, M., Luna-Gonzalez, L., Gamez-Gonzalez, F.C. 2005. Influencia de la estratigrafía y estructura geológica en el flujo de agua subterránea del Valle de Querétaro. Revista Mexicana de Ciencias Geológicas, 22(1): 1-18.

Conwell, F.R., (1965) Engineering geology and foundation condition survey of Las Vegas, Nevada. Publ. NVO-99-05, US Atomic Energy Commission, Washington, DC, 49 pp.

dePolo, M.C., and Bell, J.W. 2000. Map of faults and earth fissures in Las Vegas area. Nevada Bureau of Mines and Geology and Las Vegas Water District.

Lofgren, B.E. 1971. Significant role of seepage stresses in compressible aquifer systems (abstract). Transactions – American Geophysical Union 52, 832.

Feth, J.H. 1951. structural reconnaissance of the Rod Rock quadrangle, Arizona, open file report. 32 pp. U.S. Geol. Surv., Tucson, Ariz.

Helm, D. C. 1994a. Horizontal aquifer movement in a Theis-Thiem confined system. Water Resources Research, 30(4):953-964.

Helm, D.C. 1994b. Hydraulic forces that play a role in generating fissures at depth. Bulletin of the Association of Engineering Geologists, 31(3): 293-303.

Hernandez-Marin, M., and Burbey, T. J. in press. The role of faulting on surface deformation patterns from pumping induced ground-water flow. DOI 10.1007/s10040-009-0501-8

Hibbit. 2004. ABAQUS/CAE User's manual. Karlsson Sorensen Inc.

Holzer, T.L., 1984. Ground failure induced by groundwater withdrawal from unconsolidated sediments. In: Holzer and T. L. (Editors), Reviews in Engineering Geology. Geological Society of America, pp. 67-105.

Holzer, T. L., and Pampeyan, E. H. 1981. Earth fissures and localized differential subsidence. Water Resources Research, 17:223-227.

Jachens, R.C., and Holzer, T. L. 1979. Geophysical investigations of ground failure related to ground-water withdrawal – Picacho Basin. Groundwater 17(6):574–585

Jachens, R.C., and Holzer, T. L. 1982. Differential compaction mechanism for earth fissures near Casa Grande, Arizona, Geological Society of America Bulletin. 93:1012

Lee, C.F., Zhang, J. M., and Zhang, Y. X. 1996. Evolution and origin of the ground fissures in Xian, China. Engineering Geology, 43:45-55.

Li, Y., Yang, J. and Hu, S., 2000. Origin of ground fissures in the Shanxi Graben System, Northern China. Engineering Geology, 55: 267–275.

Pacheco, J., Arzate, J., Rojas, E., Arroyo, M., Yutsis, V., and Ochoa, G. 2006. Delimitation of ground failure zones due to land subsidence using gravity data finite element modeling in the Querétaro valley, Mexico. Engineering Geology, 84(3-4):143–160.

Rojas, E., Arzate, J., and Arroyo, M. 2002. A method to predict the group fissuring and faulting caused by regional groundwater decline. Engineering Geology, 65:245–260.

Rosas-Elguera, J., Ferrari, L., Garduño-Monroy, V. H., Urrutia-Fucugauchi, J., 1996. Continental boundaries of the Jalisco block and their influence in the Pliocene-Quaternary kinematics of western Mexico. Geology, 24(10): 921-924.

Schumann, H.H., Poland, J.F., 1970. Land subsidence, earth fissures and groundwater withdrawal in south-central Arizona, USA. In: Tison, L.J. (Ed.), Land Subsidence. International Association of Hydrological Sciences, Tokyo, Japan, pp. 295– 302.

Schumann, H.H., Cripe, L.S., Laney, R.L., 1986. Land subsidence and earth fissures caused by groundwater depletion in southern AZ,USA. In: Proceedings of the 3rd International Symposium on Land Subsidence, IAHS Press, Venice, Wallingford, 19–25 March 1986.

Sheng, Z., and Helm, D.C. 1998. Multiple steps of earth fissuring caused by ground-water withdrawal. In: J.W. Borchers (Editor), Proceedings of the Dr. Joseph Poland Symposium on Land Subsidence. Bulletin of the Association of Engineering Geologists, pp. 149-154.

Sheng, Z., Helm, D.C., Li, J. 2003. Mechanism of earth fissuring caused by groundwater withdrawal. Environmental & Engineering Geoscience. 9(4):351-362.

Stone C.R., Luke B. (2001) An overview of engineering with cemented soils in Las Vegas. In: Luke B, Werle JL (eds) Proceedings, 36th Annual Western States Symposium on Engineering Geology and Geotechnical Engineering, Las Vegas, March 2001, pp 135–144.

Suarez-Plascencia, C., Escalona-Alcazar, J.F. and Diaz-Torres, J.J., 2005. Desarrollo de grietas en el fraccionamiento Prados de Nextipac, Municipio de Zapopan, Jalisco. GEOS, 25(2).

Werle J.L., and Luke B. (2007) Engineering with heavily cemented soils in Las Vegas, Nevada. In: Olsen HW (ed) Geo-Denver 2007 New peaks in Geotechniques, Denver, CO, February 2007, pp 1–9

Wolff, R.G., 1970. Relationship between horizontal strain near a well and reverse water level fluctuation. Water Resources Research, 6(6): 1721-1728.

# CHAPTER 5. FUTURE RESEARCH

The preceding results have greatly expanded our understanding of the mechanisms and conditions leading to pumping-induced earth fissures. However, the research conducted for this dissertation has led to a number of additional questions and issues that need to be further developed in the future. Future work should involve a field component where horizontal strain and tilt meters are installed in a setting similar to that described herein. The acquisition of horizontal strain data and tilt-meter data would be extremely beneficial for verifying the strain distributions in the vicinity of the fault and to assess whether the fault is rotating as suggested in the analyses described herein. Additionally, the discussion of this chapter identifies some additional ABAQUS simulations that should be conducted to expand the work conducted herein. This future work is related to understanding fissure genesis and propagation in environments other than conceptualized in this dissertation. The input file presented at the end of this chapter corresponds to the model simulation for the onset and propagation of a fissure. The nodes numbers are excluded in order to significantly reduce the number of pages. This is provided to serve as a starting point for future ABAQUS simulations related to several future research topics provided below.

## 5.1. Subroutines for non-linear analyses

User defined subroutines can be readily implemented into ABAQUS that provide for the application of nonlinear parameter behavior or nonlinear boundary behavior. A potential use for the use of subroutines in future investigations of earth fissures would be one which would describes the evolution of the mechanical degradation of the vadose zone material. This mechanical degradation represents a reduction in the strength of the material as a result of the incremental changes in tensile and shear stress. For example, a nonlinear change in the Young's modulus typically occurs as a consequence of the mechanical degradation. The stress-dependent Young’s modulus is something that could be readily included using a subroutine and would allow for a more realistic numerical formulation leading to earth fissuring.

## 5.2 Simulation of simultaneous fissuring and fault sliding

Fault slides can occur by tectonic forces, anthropogenic-induced stresses or a combination of each. Some earth fissures represent the reactivation of buried faults that originate in the basement rock (Lee et al. 1996) indicating that these fissures are potentially associated with sliding faults. Therefore, a model simulation in which fault planes are free to slide would better represent this type of condition and provide for more accurate analysis of fissure genesis where fault motion is known to occur.

### 5.3. Simulation of tectonic and pumping-induced forces acting simultaneously

Earth fissures represented by conditions other than those observed at the Eglington Fault in Las Vegas Valley can be simulated in ABAQUS. As suggested in this work, the stress causing earth fissuring in localities such as the Tesistan Valley in Mexico and the Ethiopian Valley in Africa represent a combination of pumping-induced stresses and tectonic forces. In ABAQUS this hypothesis can be tested by developing a model in which loads representing both pumping-induced stresses and tectonic forces are incorporated. The results from this model would allow us to better understand the occurrence of fissures in tectonically active basins under typical pumping conditions.

### References

Lee, C.F., Zhang, J.M., and Zhang, Y.X. 1996. Evolution and origin of the ground fissures in Xian, China. Engineering Geology, 43:45-55.

# INPUT FILE USED IN THE FOURTH CHAPTER

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2547, 2548, 2549, 2550
*Nset, nset=unsat_fault, instance=Part-1-1
    5,    8,   11,   13,  562,  563,  564,  565,  696,  697,  698,  699,
842,  843,  844,  845
  846,  847, 3311, 3312, 3313, 3314, 3315, 3316, 3317, 3318, 3319, 3320,
3321, 3322
*Elset, elset=unsat_fault, instance=Part-1-1, generate
 3074,  3093,     1
*Nset, nset=_PickedSet23, internal, instance=Part-1-1, generate
    1,  3354,     1
*Elset, elset=_PickedSet23, internal, instance=Part-1-1, generate
    1,  3139,     1
*Elset, elset=__PickedSurf21_S2, internal, instance=Part-1-1
 2637, 2638, 2794, 2861
*Elset, elset=__PickedSurf21_S4, internal, instance=Part-1-1, generate
 2795,  2797,     1
*Surface, type=ELEMENT, name=_PickedSurf21, internal
__PickedSurf21_S2, S2
__PickedSurf21_S4, S4
*Nset, nset=_PickedSet14_PP_, internal, instance=Part-1-1
   1,   6, 566, 567
*Nset, nset=_PickedSet11_PP_, internal, instance=Part-1-1
 12,
*Nset, nset=_PickedSet12_PP_, internal, instance=Part-1-1
 9,
*Nset, nset=_PickedSet13_PP_, internal, instance=Part-1-1
 15,
*Enrichment, name=Crack-1, type=PROPAGATION CRACK, elset=_PickedSet23
*End Assembly
**
** MATERIALS
**
*Material, name=aquifer
*Damage Initiation, criterion=MAXPS, tolerance=0.1
10000.,
*Damage Evolution, type=ENERGY, mixed mode behavior=POWER LAW, power=1.
```

```
2880.,2880.,2880.
*DAMAGE STABILIZATION
 0.0002
*Density
1600.,
*Elastic
 1e+09, 0.25
*Material, name=aquitard
*Damage Initiation, criterion=MAXPS, tolerance=0.1
10000.,
*Damage Evolution, type=ENERGY, mixed mode behavior=POWER LAW, power=1.
2880.,2880.,2880.
*DAMAGE STABILIZATION
 0.0002
*Density
1700.,
*Elastic
 5e+07, 0.3
*Material, name=sat_fault
*Damage Initiation, criterion=MAXPS, tolerance=0.1
10000.,
*Damage Evolution, type=ENERGY, mixed mode behavior=POWER LAW, power=1.
2880.,2880.,2880.
*DAMAGE STABILIZATION
 0.0002
*Density
1500.,
*Elastic
 1e+09, 0.25
*Material, name=unsat_fault
*Damage Initiation, criterion=MAXPS, tolerance=0.1
10000.,
*Damage Evolution, type=ENERGY, mixed mode behavior=POWER LAW, power=1.
2880.,2880.,2880.
*DAMAGE STABILIZATION
 0.0002
*Density
1500.,
*Elastic
 1e+10, 0.25
*Material, name=vadose
*Damage Initiation, criterion=MAXPS, tolerance=0.1
10000.,
*Damage Evolution, type=ENERGY, mixed mode behavior=POWER LAW, power=1.
2880.,2880.,2880.
*DAMAGE STABILIZATION
 0.0002
*Density
1500.,
*Elastic
 1e+10, 0.25
**
** BOUNDARY CONDITIONS
**
** Name: base Type: Displacement/Rotation
*Boundary
_PickedSet10, 2, 2
```

```
_PickedSet10, 6, 6
** ----------------------------------------------------------------
**
** STEP: pumping
**
*Step, name=pumping, nlgeom=YES, inc=100000
*Static, stabilize=0.0002, allsdtol=0.05, continue=NO
0.01, 1., 1e-09, 0.01
**
** BOUNDARY CONDITIONS
**
** Name: DISCH Type: Pore pressure
*Boundary
_PickedSet14_PP_, 8, 8
** Name: NR1 Type: Pore pressure
*Boundary
_PickedSet11_PP_, 8, 8
** Name: NR2 Type: Pore pressure
*Boundary
_PickedSet12_PP_, 8, 8, 981000.
** Name: NR3 Type: Pore pressure
*Boundary
_PickedSet13_PP_, 8, 8, 2.4525e+06
**
** LOADS
**
** Name: grav   Type: Gravity
*Dload
, GRAV, 9.81, 0., -1.
** Name: pump   Type: Pressure
*Dsload
_PickedSurf21, P, -0.5
**
** CONTROLS
**
*Controls, reset
*Controls, analysis=discontinuous
*Controls, parameters=time incrementation
, , , , , , , 25, , ,
**
** OUTPUT REQUESTS
**
*Restart, write, frequency=0
**
** FIELD OUTPUT: F-Output-1
**
*Output, field
*Node Output
CF, PHILSM, RF, U
*Element Output, directions=YES
LE, P, S, STATUSXFEM
**
** HISTORY OUTPUT: H-Output-1
**
*Output, history, variable=PRESELECT
*End Step
```