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scale. The interpreted intrusive boundaries and geometry can be used in regional hydrologic models to evaluate their influence on ground water flow. Deeper seated anomalies are interpreted as magmatic reservoirs that perhaps served as sources for the late-Cretaceous volcanism. A small scale very high resolution magnetic data set was acquired in 2003 as part of a helicopter electromagnetic survey of the North Seco Creek study area, which is outside the main Uvalde volcanic field. In addition to a single small volcanic pipe, this data set reveals the trace of the Woodard Cave fault, a major normal fault juxtaposing the rocks of the Trinity Group, comprising the upper Trinity aquifer to the north, with the Devils River Formation, constituting the Edwards aquifer to the south. This important finding, that a fault between adjoining limestone units is associated with a linear magnetic low, led to a re-examination of the fixed-wing aeromagnetic data. Through careful micro-leveling, filtering and image enhancement techniques, we see that major faults of the Balcones fault zone are associated with vestigial magnetic lineaments on a regional scale.

91-8 **BTH 68** Waugh, John Russell

USE OF MAGNETIC RESONANCE LOGS TO EVALUATE AQUIFER CHARACTERISTICS ALONG THE FRESHWATER/SALINE-WATER INTERFACE OF THE EDWARDS AQUIFER

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The freshwater/saline-water interface of the Edwards aquifer is defined by a mapped contour line representing a total dissolved solids (TDS) concentration of 1,000 mg/l. TDS values increase from 300-500 mg/l in the freshwater zone to values of several thousand on the saline side. Close proximity of the freshwater/saline-water interface to Comal and San Marcos springs, as well as many municipal well fields, has raised a continuing concern that potential future long-term severe droughts might cause serious water quality problems in these and other areas of the aquifer region, due to potential encroachment of saline water into the freshwater portion of the aquifer.

Development of a monitor well network was begun in the 1980's, and has recently been expanded by a program initiated by the San Antonio Water System. Additional wells will be constructed across the Edwards region during the next five to ten years. One of the wells recently activated as part of this network was logged using the Schlumberger Combinable Magnetic Resonance Plus (CMR-Plus) logging tool, as well as conventional logs. Results of analyses from these logs revealed valuable information concerning qualitative productivity data, identification of porosity regardless of matrix composition, and more accurate water quality estimation. An additional benefit from the use of the CMR-Plus tool is the ability to avoid the use of radioactive sources in potable water zones.

Results of the logging comparison show a better porosity evaluation and estimates of moveable pore space. Use of the CMR-Plus log to better evaluate permeability, productivity, and water quality in fractured/karst carbonate aquifers such as the Edwards will be a valuable tool in future water resource studies.

91-9 **BTH 69** Lindgren, Richard J.

CONCEPTUALIZATION AND SIMULATION OF THE EDWARDS AQUIFER, SAN ANTONIO REGION, TEXAS

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Numerical ground-water flow models for the Edwards aquifer in the San Antonio region of Texas generally have been based on a diffuse-flow conceptualization, with the aquifer being considered a porous-media continuum at the regional scale. Whether flow through large fractures and conduits or diffuse flow predominates in the Edwards aquifer at the regional scale is an open question, however. A new numerical ground-water-flow model (Edwards aquifer model) that incorporates important components of the latest information and an alternate conceptualization of the Edwards aquifer was developed. The conceptualization upon which the Edwards aquifer model is based emphasizes conduit development and conduit flow. The model incorporates conduits simulated as generally continuously connected, one-cell-wide (1,320 feet) zones with very large hydraulic-conductivity values (as much as 300,000 feet per day). The locations of the conduits are based on a number of factors, including major potentiometric-surface troughs in the aquifer, the presence of sinking streams, geochemical information, and geologic structures (for example, faults and grabens).

The model was calibrated for steady-state (1939–46) and transient (1947–2000) conditions. Transient simulations were conducted using monthly recharge and pumpage (withdrawals) data. The predominantly conduit-flow conceptualization incorporated in the Edwards aquifer model yielded a reasonably good match between measured and simulated hydraulic heads in the confined part of the aquifer and between measured and simulated springflows.

The simulated directions of flow in the Edwards aquifer model are most strongly influenced by the presence of simulated conduits and barrier faults. The simulated flow in the Edwards aquifer is appreciably influenced by the locations of the simulated conduits, which tend to facilitate flow. The simulated subregional flow directions generally are toward the nearest conduit and subsequently along the conduits from the recharge zone into the confined zone and toward the major springs. Structures simulated in the Edwards aquifer model influencing ground-water flow that tend to restrict flow are barrier faults. The influence of simulated barrier faults on flow directions is most evident in northern Medina County.

91-10 **BTH 70** Schindel, Geary

TRACER TESTS IN THE EDWARDS AQUIFER RECHARGE ZONE

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The Edwards Aquifer Authority conducted a series of tracer tests in the Edwards Aquifer Recharge Zone in northern Bexar County in the vicinity of San Antonio, Texas. The purpose of the tests was to measure the groundwater velocity, investigate groundwater flowpaths, and evaluate the hydraulic connectivity between the Edwards and the Trinity aquifers in the Recharge Zone beneath the Panther Springs Creek basin. The tests consisted of injecting invisible, harmless fluorescent dyes through caves into the aquifer and then collecting groundwater samples from wells in the area to determine dye arrival. The monitoring system consisted of more than 20 public and private wells completed in either the Edwards or the Trinity aquifers.

The recharge zone is defined by the outcrop of the Edwards Limestone, which is underlain by the Trinity Aquifer; both are karstified Cretaceous marine limestone formations. The area is located in the Balcones Fault Zone, which has faulted the Panther Springs Creek basin into several northeast-trending fault blocks. In addition, units of the Edwards Limestone are juxtaposed against the uppermost units of the Trinity Aquifer (Upper and Lower Glen Rose limestones) due to displacements up to 350 ft on the faults.

The results of the tracer tests revealed discrete groundwater flowpaths beneath Panther Springs Creek. Dyes were detected primarily in a single monitoring well (68-28-608), which is completed in the Edwards Aquifer. Dye was also detected in two of the Edwards Aquifer wells at the Club at Sonterra. Apparent groundwater velocities ranged from 3,000 to 12,000 feet per day. The results demonstrate the high groundwater velocities that are characteristic of karst aquifers.

The results also indicate that groundwater flows freely between the upper member of the Glen Rose Formation, which is the uppermost layer in the Trinity Aquifer, and the Edwards Aquifer. Dyes traveling along the flowpaths between the caves and Well 68-28-608 crossed several northeast-southwest trending faults in which members of the Edwards and Glen Rose formations are juxtaposed.

91-11 **BTH 71** Mitchell, Evelynn

STORAGE CONSTANT VALUES FOR THE EDWARDS AQUIFER BALCONES FAULT ZONE AS DETERMINED FROM SEISMIC EFFICIENCY

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Determining storativity values for a confined aquifer typically requires data such as (1) observation-well water levels during a drawdown test or (2) calculated values for barometric or tidal efficiency. Data from paired wells suitable for classic storativity calculations are, however, generally sparse in any aquifer. Barometric and tidal efficiency provide estimates of aquifer compressibility, which is used to calculate storativity using the equation developed by Jacob in 1939. Calculating barometric or tidal efficiency require long-term, detailed records on water levels and either atmospheric pressure or Earth-tide fluctuations. Efficiency ratio estimates need data processing to remove trends including but not limited to pumping-related drawdown and weather patterns. Tidal efficiency requires access to geodetic Earth-tide models.

Seismic efficiency calculations provide another approach to estimating aquifer compressibility. Pressure waves generated by seismic events can cause a water-level response in confined aquifers through which the waves pass. The duration of the water-level response is very brief, so detrending is not needed. A method of estimating the magnitude of the Rayleigh waves in the aquifer and a water-level monitoring network are needed. Continuous recording paper charts can capture more seismic-efficiency data than digital recorders with sampling intervals greater than 15 minutes.

A review to date of fifteen years of historical hydrographs for twelve wells in the Edwards Aquifer, Balcones Fault Zone, shows that seismic events of 7.0 magnitude or greater in North America display a characteristic signal in many of the recorded hydrographs. Events have also been recorded on the hydrographs from the December 26, 2004 and March 28, 2005 Indonesian earthquakes. Differences in amplitude on the same well for separate events correlate with the change in the strength of the pressure wave due to event magnitude or source distance. The variation in amplitude seen between wells during the same event may indicate the difference in storage between the regions. Finding storage constants for a variety of wells through out the Edwards Aquifer Balcones Fault Zone can provide hard data of the storage trends through out the region, and assist in the establishment of a more representative model for the region.

91-12 **BTH 72** Clark, Allan K.

HYDROGEOLOGIC AND GEOCHEMICAL IDENTIFICATION OF GROUND-WATER FLOW PATHS IN THE EDWARDS AQUIFER, NORTHEASTERN UVALDE AND NORTHERN MEDINA COUNTY, TEXAS

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The Edwards aquifer is the major source of water for more than 1.5 million people in the San Antonio area and provides nearly all of the water used for industrial, military, irrigation, and public supplies. The Edwards aquifer is composed of several geologic formations consisting primarily of limestone and dolostone, depending on location and depositional province. Most of the recharge to the San Antonio segment of the Edwards aquifer occurs in Medina and Uvalde Counties from direct infiltration of precipitation and streamflow loss in the recharge zone. The Balcones fault zone is characterized by an en echelon network of mostly down-to-the-southeast normal faults where the Cretaceous strata is displaced vertically, fractured intensively, and rotated differentially within a series of southwest-to-northeast trending fault blocks. These faults are responsible for the complexity of study area's ground-water-flow system. Ground-water flow paths within the Edwards aquifer recharge zone are complicated by geology, structure and influences of surface water recharge. Ground-water flow paths in the Edwards aquifer recharge zone of Medina County are, generally to the southwest parallel to Balcones faults. Ground-water flow paths in northeastern Uvalde County are to the southeast. These oppositely moving flow path coalesce in an area locally known as the Knippa Gap, where they generally turn to the south and then east.

Extension within the Balcones fault zone is a major controlling factor in ground-water flow paths within the study area. Primary extension is down to the coast; however secondary extension parallel to the Balconies fault zone has resulted in recharge along fractures which are perpendicular to the major faults. Results from this study indicates five major flow paths within the study area; four of these flow paths move from the northeast to the southwest parallel to the Balcones fault zone. The flow paths are from north to south; the Northwestern Medina flow path, the Northcentral Medina flow path (northern portion), the Northcentral Medina flow path (southern portion), the Southcentral Medina flow path and to the west the Northeastern Uvalde flow path.

91-13 **BTH 73** Blome, Charles D.

AN IMPROVED METHOD FOR MODELING THE INFILTRATION POTENTIAL OF THE EDWARDS AQUIFER RECHARGE AREA, COMAL COUNTY, SOUTH-CENTRAL TEXAS

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One of the areas for recharge to the Edwards aquifer occurs in Comal County, south-central Texas. Comal Springs sustains federally-listed endangered species and provides a major water supply to downstream users in Comal and adjacent counties. Residential and commercial development atop the recharge area have increased the risk for ground-water contamination from point and non-point pollution sources. Previous ARC GIS analyses of readily-available spatial datasets of Bexar County have produced vulnerability maps of the Edwards contributing and recharge zones. The five digital datasets used in these models included: (1) hydraulic properties of Edwards Group hydrostratigraphic units, (2) faults/fractures, (3) caves/sinkholes, (4) slope analyses from 30-meter DEM surfaces, and (5) soil characteristics.