U.S. DEPARTMENT OF ENERGY
MORGANTOWN ENERGY TECHNOLOGY CENTER
MONTHLY STATUS REPORT
FOR PERIOD
August 1 - August 31, 1994



# *NATURALLY FRACTURED TIGHT GAS RESERVOIR DETECTION OPTIMIZATION*

*Submitted by*

*ADVANCED RESOURCES INTERNATIONAL, INC.*

U.S. DEPARTMENT OF ENERGY
MORGANTOWN ENERGY TECHNOLOGY CENTER
MONTHLY STATUS REPORT
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August 1 - August 31, 1994
DATE OF SUBMISSION: 9/15/94

**CONTRACT NO.:**
DE-AC21-93MC30086

**CONTRACTOR:**
Advanced Resources International, Inc.

**CONTRACT NAME:**
Naturally fractured tight gas reservoir detection optimization

**CONTRACT PERIOD:**
September 30, 1993-March 31, 1997

**CONTRACT OBJECTIVE:** No Change

**TECHNICAL APPROACH CHANGES:** No Change

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## A. Subcontractor Progress, Indiana University & World Geoscience

### Indiana University:

**Task 1: Calibrate Basin Fracturing Mapping Model**

**1. Two-dimensional basin simulator:** Priority has temporarily shifted from solute transport (which remains partially complete) in the CIRF.B2 code, to implementation of a fracture model. The fracture model will allow release of fluid pressure via hydraulic fracturing, by simulating the corresponding changes in matrix permeability and fluid velocity. Phenomenology for authigenic mineral nucleation has been implemented in the code and is currently being tested. A subroutine has been added that accounts for mechanical grain rotation as the grain aspect ratio changes; this allows enhanced grain dissolution at the grain free-face compared to the vertical grain surfaces. This subroutine is nearly completed and is currently being fine-tuned. Work has also commenced on the next generation of the textural model that

allows interaction between minerals of difference species; the current model assumes that all grain interaction occurs between grains of the same mineralogy.

**2. Three dimensional basin simulator:** Work continues on increasing the numerical precision and integrity of the pressure solver. A method for direct calculation of pressure, instead of overpressure, was attempted and abandoned because of numerical difficulties. Coding and testing of the energy balance equation for calculating temperature and the boundary conditions (notably imposed heat flux from below) have been completed. Problems remain in the implementation of the finite difference stress solver. For contacts between units in which the textural differences are gradational, it is fully operational. For sharp contacts, the local error in calculated stress can be greater than the vertical change in stress between adjacent grid points. The current effort is attempting to develop a strategy that both reduces computational error and smoothes the numerical noise introduced by the error. A smoothing algorithm has been developed that reduces noise but that preserves key properties of the solution, notably local force balance and boundary conditions. Work continues on the finite element stress solver; the elastic module is coded and being tested. A viscoelastic module is currently being developed. Debugging and testing should be completed in the next month. The sediment input module is complete. Lateral data interpolation (X and Y directions) for subsidence, sedimentation rate, and mineralogy is completed and will soon be completed for input sediment texture in the next month. Implementation of a fracture model has begun. This model includes propagation, extension and healing history of the fractures.

**3. Data analysis and database:** All petrographic data for the MWX site have been entered into the Excel database. Thermal histories for sixteen sites (Sandia National Labs and the U.S.G.S.) have been developed from published burial histories. Data are being evaluated to determine if calculated thermal histories appropriately match temperature gradient maps and vitrinite reflectance data. Thermal conductivity data for ten different rock types at the MWX site have been collected and will be used to calibrate the relation between texture and mineralogy with thermal conductivity. A database manager has been chosen for a trial period, to determine if it suits the needs of the project. Work is progressing on an interface that will make the use of CIRF.B* codes easier. This interface is approximately half-finished.

**4. Organic reactions and multi-phase flow:** The strategy developed for aqueous fludi-gas (biphase) flow has been implemented and added to the three-dimensional pressure solver. Work has begun on solving mass balance and chemistry of the gas-water system. In particular, a code is being developed to determine the gas saturation. Ths initial program will intially allow only water and gas to occupy the gas phase.

**5. Grid optimization:** The grid optimization technique for a two-dimensional grid with regular boundaries has been completed. The technique has been generalized for problems with irregular boundaries and work continues on coding and testing.

### World Geoscience:

Approval of the fly-over contract between ARI and World Geoscience has been granted by DOE. Final contract signature will occur by September 15. Flight commencement is planned for early-mid October 1994.

## B. Geologic assessment of the Piceance Basin (Advanced Resources International)

Research effort continued on creation of a new structural map of the southeastern Piceance Basin to update the earlier work of Johnson (1983). This new map contains updated structural data obtained during the past ten years of exploration and development drilling. This map area expands the Parachute-Rulison area to better define regional trends. In addition, it serves to fully delineate the NW-trends in the eastern basin. A copy of the final map is attached (Figure 1).

Detailed mapping of the southwest Piceance Basin (Debeque area) in Plateau and Shire Gulch fields is underway to extend the results of the preceding map to the entire southern basin. This region serves as a contrast to the Parachute-Rulison area because publically-available and industry data indicate the reservoirs in Plateau and Shire Gulch are not fractured. The strong relationship between production trends and linears suggests, however, that fracturing may exert a significant control on subsurface permeability and producibility of these reservoirs. Given the low matrix permeability of sandstone reservoirs in the southwest basin, it seems necessary for

some amount of fracture permeability to be present in these fields to permit economic production.

In contrast to the eastern basin, the subsurface structure in the southwest basin trends nearly E/W instead of the WNW and NW-trends observed along the eastern half of the basin. An interpretation of high-altitude, false-color infrared photos has been made to determine the relationship between production and structural trends with interpreted linear features. Figure 2 is a map overlaying production from Shire Gulch field with interpreted linear features. On this figure, mapped NW-trending surface faults are also shown. This map shows that there is an excellent correspondence between surface-mapped fracture and fault trends and zones of enhanced production. At present, it is uncertain whether all mapped linear features represent structural (i.e. enhanced permeability zones) features. Field work in this area scheduled for mid-October will fully resolve the nature of these features.

Geochemical data from throughout the Piceance Basin have been purchased at reasonable rates from commercial sources to verify the gas-centered basin hydrocarbon model proposed in the AAPG poster session. Work in progress continues to assess the significance of regional trends for various geochemical species.

Production, well completion and drilling information from Grand Valley field have been collected in order to evaluate how production trends from Parachute-Rulison area extrapolate into this area. Work in progress is generating maps of the relationship between subsurface structure and production trends. This information, in what is thought to be another fractured reservoir, will allow us to contrast the differences between production in the overpressured zone (Rulison field), from the transitional areas (Parachute field), to the normally-pressured zone (Grand Valley field). This transition is also accompanied by slight changes in structural intensity that may or may not correspond to production variability.

Well test and production data from Parachute and Rulison fields have been analyzed to determine the effectiveness (measured by drainage efficiency) of hydraulic stimulations used by the various operators in the two fields. Work in progress is attempting to delineate the reason for the variable effectiveness of the stimulations and the controlling geologic influences. The results of this will be part of the annual report to be submitted next month.

**C. Remote Sensing Interpretation**

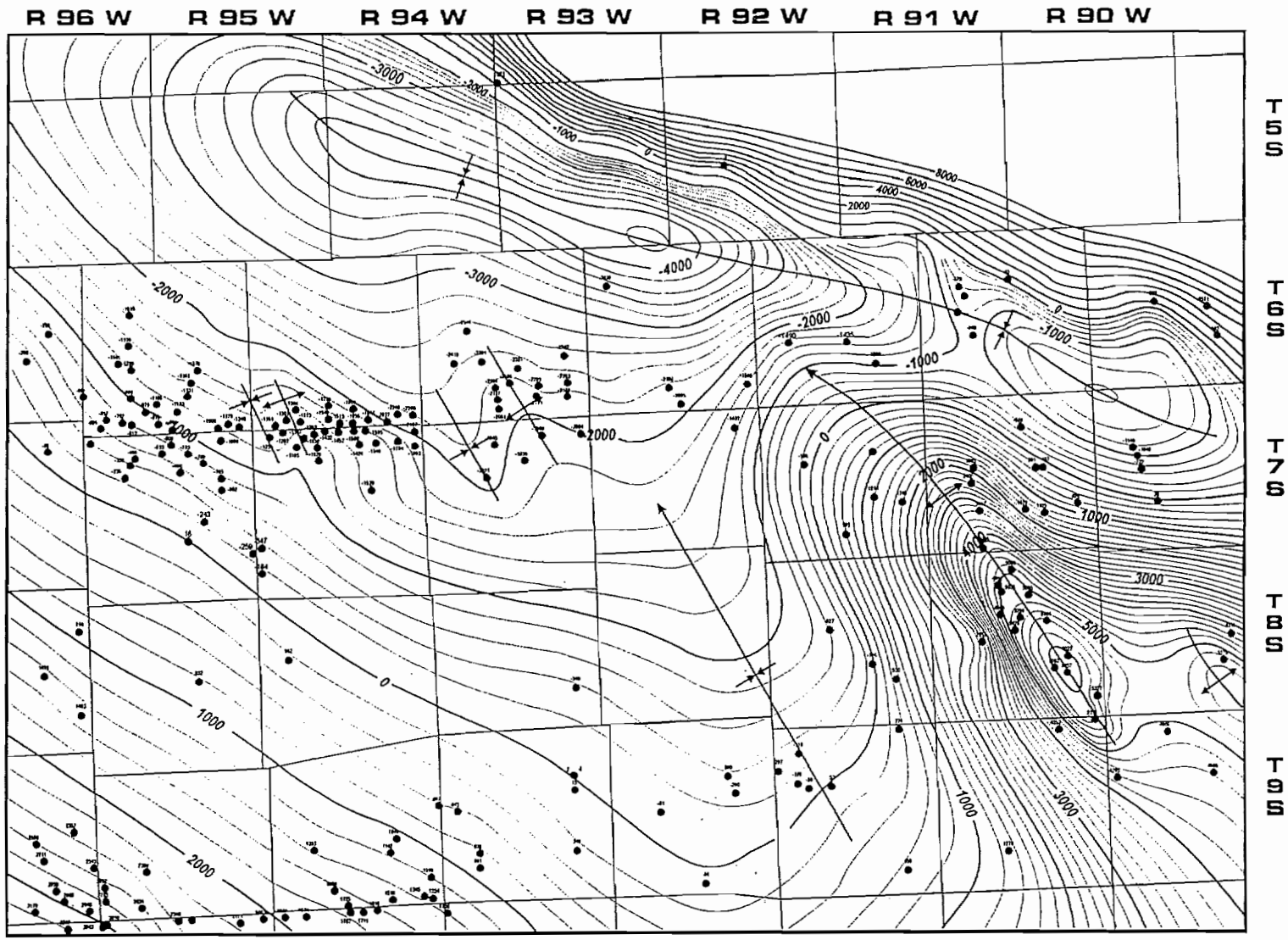
Interpretation of detailed TM imagery from throughout the basin has been completed. It is anticipated that all digitizing and subsequent work will be complete by mid-October. Once these interpreted linear features have been digitized, statistical interpretation of their orientations can commmence. Field checking of these interpreted linears will be performed in mid-October.

**OPEN ITEMS:** None

SUMMARY STATUS AND FORECAST

All initial phases of the project are now fully operative. Subcontract work is proceeding as planned after the initial delays involved in subcontract approval. Geologic assessment of the basin is proceeding on schedule and significant progress has been made towards addressing many of the critical problems in basin understanding.

A. David Decker, Project Manager

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SOUTHEAST PICEANCE BASIN
ROLLINS STRUCTURE MAP

FIGURE 1

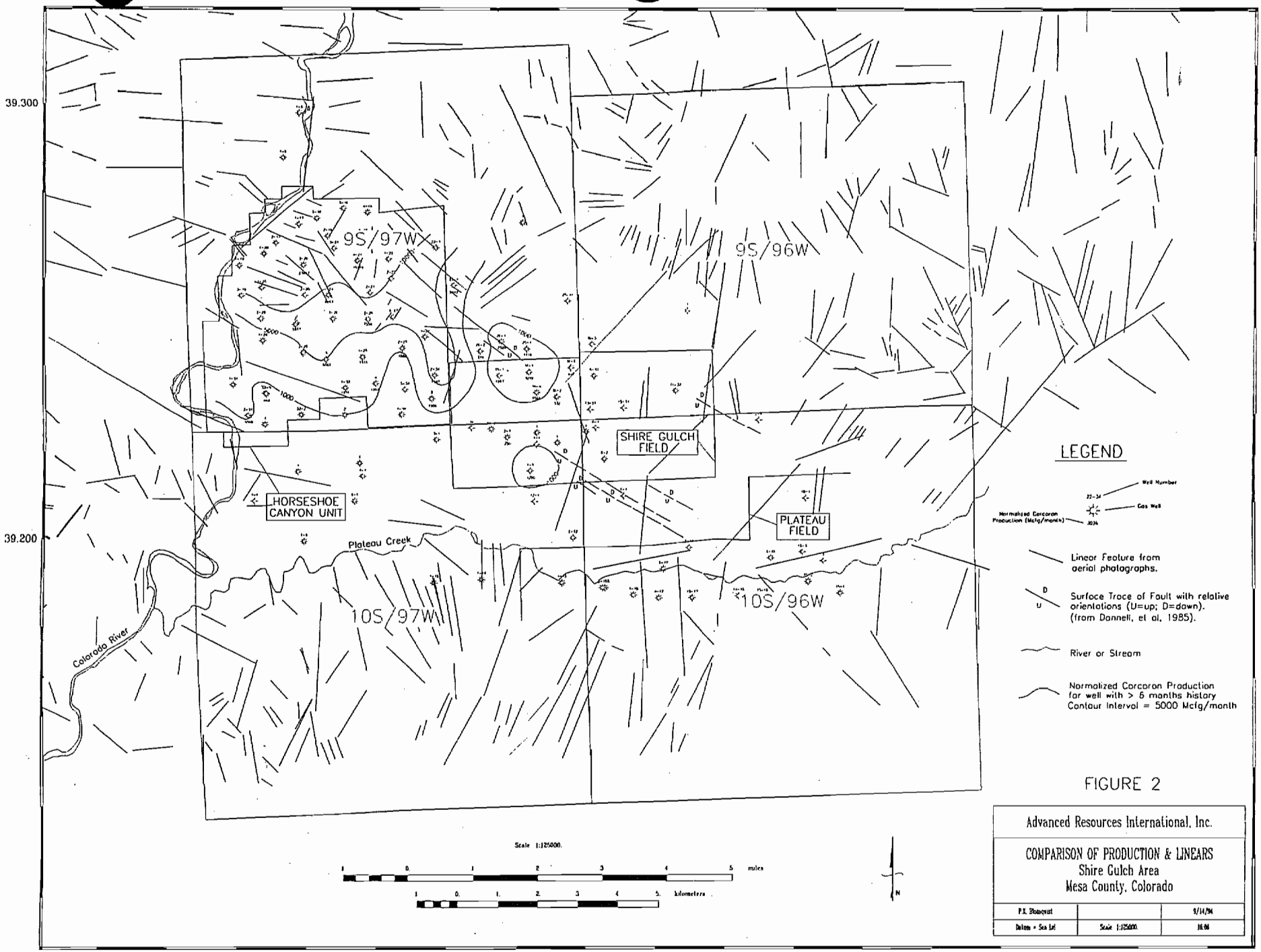


FIGURE 2

| Advanced Resources International, Inc. | | |
|---|---|---|
| COMPARISON OF PRODUCTION & LINEARS<br>Shire Gulch Area<br>Mesa County, Colorado | | |
| P.E. Branquist | | 9/14/94 |
| Datum = Sea Lvl | Scale 1:125000. | fig 06 |