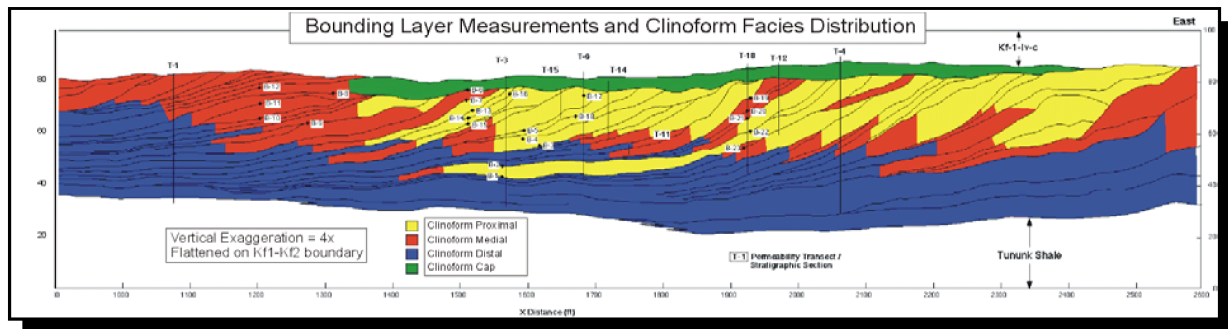


# FERRON SANDSTONE STRATIGRAPHIC CROSS SECTIONS, IVIE CREEK AREA, EMERY COUNTY, UTAH

by

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OPEN-FILE REPORT 390  
UTAH GEOLOGICAL SURVEY  
a division of  
UTAH DEPARTMENT OF NATURAL RESOURCES

June 2002



**FERRON SANDSTONE  
STRATIGRAPHIC CROSS SECTIONS,  
IVIE CREEK AREA,  
EMERY COUNTY, UTAH**

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## CONTENTS

ABSTRACT .....	1
INTRODUCTION .....	2
IVIE CREEK AREA .....	3
STRATIGRAPHY .....	3
CLINIFORM FACIES .....	5
Cliniform Proximal (cp) .....	5
Cliniform Medial (cm) .....	5
Cliniform Distal (cd) .....	6
Cliniform Cap (cc) .....	6
METHODS .....	6
Measured Sections .....	6
Drill-Hole Program .....	6
ACKNOWLEDGMENTS .....	7
REFERENCES .....	7

## FIGURES

Figure 1. Location map of the Ferron Sandstone project area (outcrop belt is shaded) showing the Ivie Creek area .....	2
Figure 2. Diagrammatic cross section showing relative positions of Ferron parasequence sets ..	2
Figure 3. Data collection point locations in the Ivie Creek area, Emery County, Utah .....	4

## ABSTRACT

The Ferron Sandstone Member of Mancos Shale in east-central Utah has world-class outcrops of fluvial-dominated and wave-modified deltaic, Upper Cretaceous strata deposited along the margin of the rapidly subsiding foreland basin. Extensive vertical and lateral exposures in the Ivie Creek area, located along Interstate 70, offer an excellent opportunity for mapping and describing the architecture, geometry, and distribution of lithofacies which serve as oil and gas reservoir analogs. Lithofacies include distributary channels and mouth bars; prodelta and delta-front deposits; lower, middle, and upper shoreface; foreshore; and bayfill, lagoonal, and flood-plain deposits.

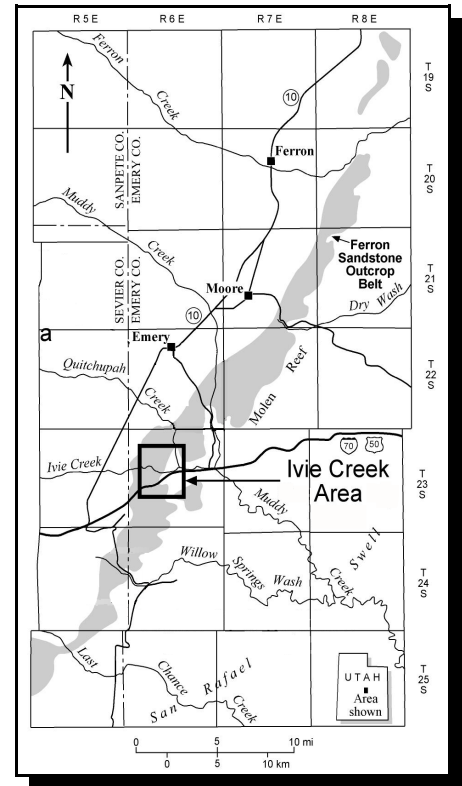
Closely spaced stratigraphic sections were measured and described to identify sedimentary structures, lithofacies, bounding surfaces, paleocurrents, and other geologic parameters. These sections were combined with drill-hole data to develop a three-dimensional view of the reservoir analogs for modeling and fluid-flow simulations. This report contains stratigraphic cross sections with graphical measured stratigraphic sections and core descriptions (including parasequences, lithofacies, and other information) from the Ivie Creek area. The Ivie Creek cross sections can be used for educational and industry training purposes, a guide for field work, additional reservoir models and simulations, facies analysis, sequence stratigraphic studies, and numerous other applications.

## INTRODUCTION

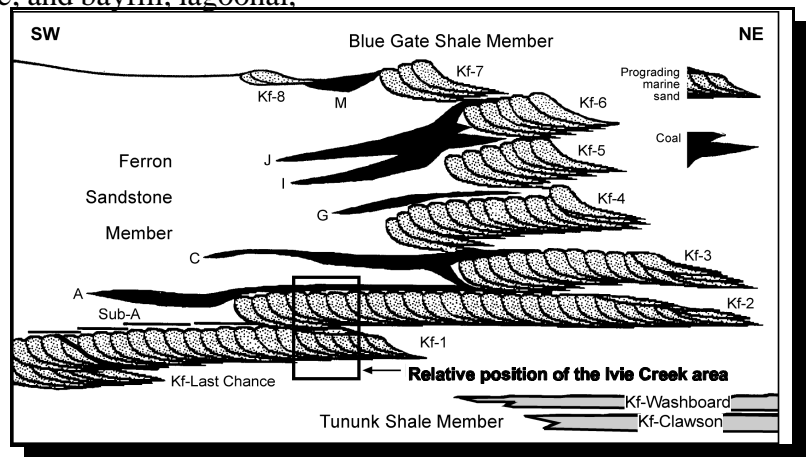
The Ferron Sandstone Member of Mancos Shale in east-central Utah has world-class outcrops (figure 1) of fluvial-dominated and wave-modified deltaic, Turonian-Coniacian-aged (Upper Cretaceous) strata deposited along the margin of the rapidly subsiding Cretaceous foreland basin. Extensive vertical and lateral exposures, in three dimensions (3-D), offer an excellent opportunity for mapping and describing the architecture, geometry, and distribution of lithofacies which serve as oil and gas reservoir analogs.

The Ferron and equivalent portions of the Frontier Formation in northern Utah and Wyoming record a pronounced and widespread regression of the Cretaceous Western Interior seaway. The Ferron consists of a series of stacked, transgressive-regressive cycles (delta-front sets) which form an eastward-thinning wedge (figure 2). These various delta-front sets define a hierarchical pattern of seaward-stepping, vertically stacked, and landward-stepping depositional geometries. This architecture indicates an initial strong supply of sediment relative to available space where sediment could accumulate, followed by near-balance, and then a relative decrease in sediment supply. Exposures contain all, or portions, of the complex lithofacies that make up Ferron deltaic deposits. Such lithofacies include distributary channels and mouth bars; prodelta and delta-front deposits; lower, middle, and upper shoreface; foreshore; and bayfill, lagoonal, and flood-plain deposits.

The Ivie Creek area was selected for detailed mapping and analysis of specific lithofacies important to reservoir production (figure 1). Closely spaced stratigraphic sections were measured and described to identify sedimentary structures, lithofacies, bounding surfaces, paleocurrents, and other geologic parameters. These sections were combined with Utah Geological Survey (UGS) drill-hole data to develop a 3-D view of the reservoir analogues for modeling and fluid-flow simulations (Chidsey, 2001).



**Figure 1. Location map of the Ferron Sandstone project area (outcrop belt is shaded) showing the Ivie Creek area.**



**Figure 2. Diagrammatic cross section showing relative positions of Ferron parasequence sets with their associated coal zones (black), and the relative position of the Ivie Creek area within the Ferron Sandstone (from Ryer, 1991; Anderson and others, 1997). The diagram has no scale.**

This report contains stratigraphic cross sections with graphical measured stratigraphic sections and core descriptions (including parasequences, lithofacies, and other information) from the Ivie Creek area. These cross sections were used to map the seaward and landward pinchouts of major units, and tie into regional correlations (sheets 1 through 5). They were also used to interpret depositional facies (sheets 6 and 7).

The Ivie Creek cross sections can be used for educational and industry training purposes, a guide for field work, additional reservoir models and simulations, facies analysis, sequence stratigraphic studies, and numerous other applications.

## **IVIE CREEK AREA**

The Ivie Creek area is located in the central part of the Ferron outcrop belt (figure 1), about 6 miles (9.7 km) south of the town of Emery, Utah, in the center of T. 23 S., R. 6 E., Salt Lake Base Line (SLBL), Emery County. The Ferron Sandstone exposures straddle Interstate 70 (I-70). A small stream, Ivie Creek, flows just north of the interstate highway, hence the name Ivie Creek area. Access to the area is excellent because of proximity to I-70. The “Ivie Creek amphitheater” is an informal name applied to a broad, curving area of cliffs north of I-70 where most of the data in this report was collected (figure 3).

## **STRATIGRAPHY**

The Ivie Creek area (figure 1) was selected to develop a detailed geological and petrophysical characterization, at well-sweep scale or smaller, of the primary reservoir lithofacies typically found in a fluvial-dominated deltaic reservoir. The Ivie Creek area contains abrupt facies changes in two regional-scale deltaic cycles or parasequence sets, the Kf-1 and Kf-2 (figure 2). Each of these deltaic cycles has differing geometries that can be characterized by sedimentologic and petrophysical parameters. These parameters are used in reservoir models and simulations for oil field development and secondary or enhanced oil recovery programs.

Kf-1 consists of fluvial-dominated delta deposits that prograde southeast to northwest across the Ivie Creek area. Progradation of this unit was parallel, or onshore, to the typical regional shoreline trend. However, in the Ivie Creek area, the Kf-1 parasequence set consists of only one parasequence, Kf-1-Ivie Creek (Iv), with two bedsets referred to here as Kf-1-Iv[a] and Kf-1-Iv[c]. The older Kf-1-Iv[a] bedset has distinctive, steeply inclined beds or clinoforms defined by bedding surfaces. We interpret the Kf-1-Iv[a] as a fluvial-dominated delta deposit, which changes from proximal to distal from east to west. These clinoform deposits accumulated on an arcuate, delta lobe which prograded into a deeper water, fully marine bay. The main delta, located to the east and northeast, created a protected embayment in the northwest part of the Ivie Creek area. The Kf-1 clinoforms represent deposition into the embayment fed by river channels from the southeast. The Kf-1 clinoforms were the primary focus of the reservoir modeling and simulation study in Chidsey (2001).

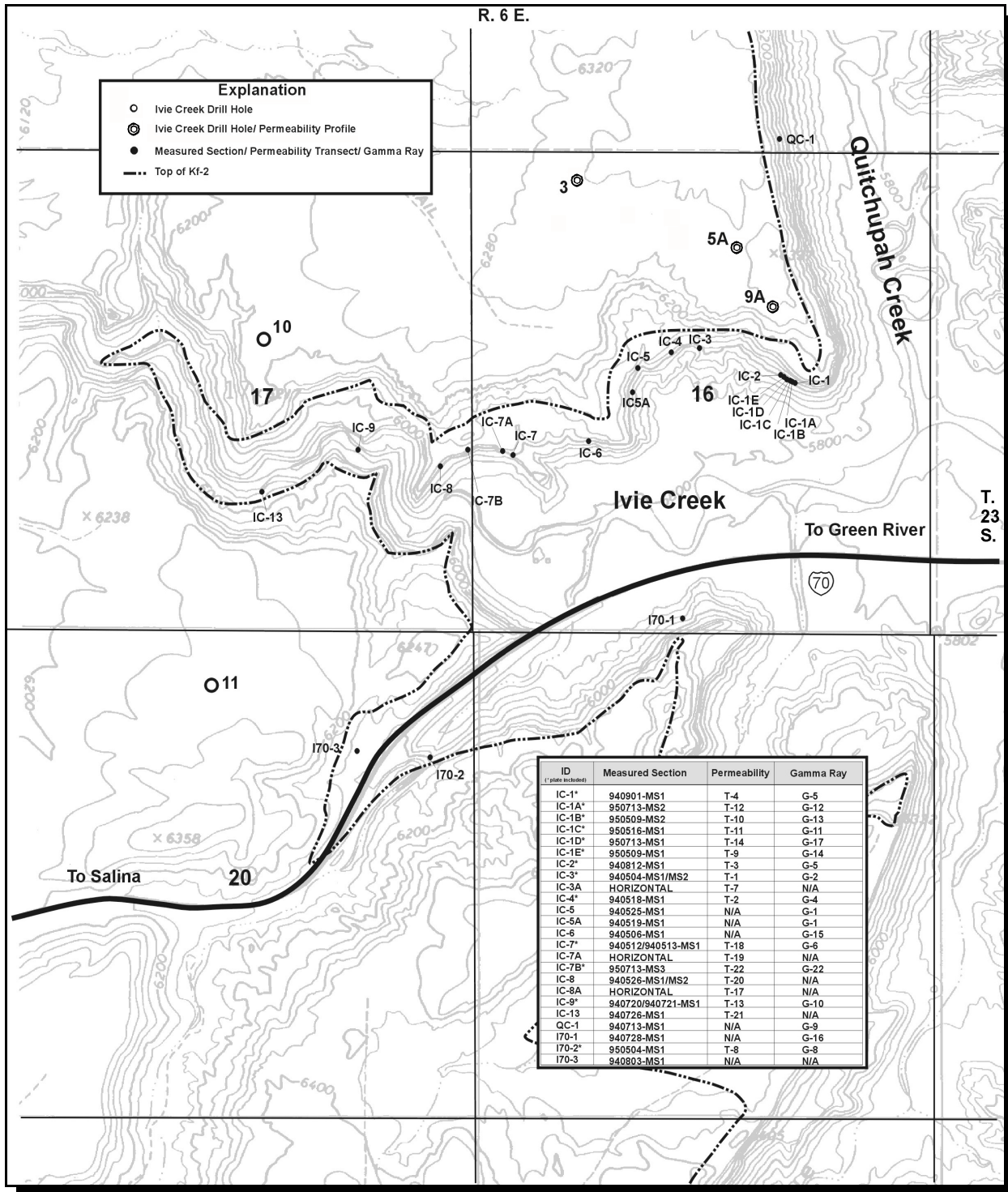


Figure 3. Data collection point locations in the Ivie Creek area, Emery County, Utah.

Kf-2 is represented by wave-modified deltaic deposits that generally coarsen east to west, and consist of shoreface and distributary complex facies. These relatively clean, sand-rich deposits accumulated along a local north-south shoreline trend defined by a landward pinchout of marine shoreface facies, as opposed to the more common regional northwest-southeast shoreline trend recognized in other Ferron cycles above and below Kf-2. In the western part of the Ivie Creek area, east- to northeast-flowing distributary channels deposited large amounts of sand in north-south-trending distributary-mouth bars. Shallow- to moderate-depth marine conditions existed in the eastern part of the area.

## **CLINIFORM FACIES**

The cliniforms change characteristics from the shallower water, more proximal (near the shoreline) locations to the deeper water, more distal locations. Four cliniform facies are designated within the Kf-1-Iv[a] bedset: cliniform proximal (cp), cliniform medial (cm), cliniform distal (cd), and cliniform cap (cc) (sheet 6). Cliniform facies were based on grain size (sheet 7), sedimentary structures (sheet 7), bedding thickness, inclination angle, and stratigraphic position. Facies cp, cm, and cd are assigned to cliniforms only, and facies cc is a bounding facies above the cliniforms (Anderson and others, 1997; Chidsey, 1997).

### **Cliniform Proximal (cp)**

Facies cp is sandstone, mostly fine to medium grained. The chief sedimentary structure is low-angle cross-stratification with minor horizontal and trough cross-stratification and rare hummocky bedding. The facies is dominantly thick to medium bedded, well to moderately indurated, with permeabilities ranging from 2 to 600 millidarcies (md) and a mean of about 10 md. The inclination of bed boundaries is generally greater than 10E. This facies is interpreted to be the highest energy, and most proximal to the sediment supply. The steep inclinations are interpreted to represent deposition into a relatively localized deep portion of an open bay environment. The dominance of low-angle cross-stratification, along with inclinations within the bed or cliniforms in an up-depositional dip direction, indicates the influence of on-shore wave energy.

### **Cliniform Medial (cm)**

Facies cm is dominantly sandstone with about 5 percent shale. The sandstone is primarily fine grained with slightly more fine- to very fine-sized grains than fine- to medium-sized grains. Horizontal beds dominate with some rippled, trough, and low-angle cross-stratified beds. Bed thicknesses range from laminated to very thick, but most are medium. The beds are generally well to moderately indurated, but are occasionally noted as friable. The permeability values range from non-detectable to 100 md with the mean about 3 md. Inclination on the cliniform boundaries is between 2° and 10E. The facies is generally transitional between facies cliniform proximal and distal. Cliniform medial is occasionally present at the erosional truncation, or off-lapping boundary, of the cliniforms, with no visible connection to facies cliniform proximal.

## **Clinoform Distal (cd)**

Facies cd is sandstone (sometimes silty) and about 10 percent shale. The sandstone grain size is dominantly fine to very fine grained, with considerable variation. Sedimentary structures in this facies are chiefly horizontal laminations and ripples in medium to thin beds. Induration of the beds ranges from well cemented to friable. Average facies permeability is just at the detection limit of 2 md, but ranges up to 80 md. This facies is gradational with facies cm and represents the deepest water and lowest energy deposition within the clinoform. It can be traced distally into prodelta to offshore facies.

## **Clinoform Cap (cc)**

Facies cc is sandstone, generally very fine to fine grained. The beds are horizontal, with some trough and low-angle cross-stratification in thick to medium beds. Burrowing is rare. The sandstone is mostly well indurated, with permeabilities ranging from non-detectable to 100 md and a mean of about 2 md. Clinoform cap facies are present stratigraphically above the subcycle line (truncated clinoforms), where the line is near the top of the parasequence and bed boundaries show little to no inclination. This facies is interpreted to represent an eroded and reworked delta top.

## **METHODS**

### **Measured Sections**

Measured stratigraphic section locations were chosen to develop a general geologic characterization of the Ivie Creek area. Each section was located on photomosaic coverage and plotted on a topographic map. Sections were measured using a Jacob's staff or by directly measuring a unit's thickness with a tape on the mostly vertical outcrops. Description of the individual units in the measured sections included the following information: (1) primary and secondary lithologies, composition, color, and grain size of the rocks; (2) size, shape, and degree of induration of the beds; (3) sedimentary structures, biologic structures (trace fossils), and fossils in the rocks; and (4) bounding surfaces and depositional environment of the unit. Sections were correlated to interpret stratigraphy, lithofacies, depositional environment, and to define reservoir components.

### **Drill-Hole Program**

The drill holes in the Ivie Creek area were located 200 to 1,200 feet (60-265 m) downdip from the Ferron outcrop to provide data for a 3-D morphologic interpretation of individual lithofacies, and to capture the various lithologic changes in the Kf-1 and Kf-2 parasequence sets (figure 3). The drill holes were permitted, drilled, logged, and plugged. Where hole conditions allowed, drill holes were logged with sonic, density, neutron, focused resistivity, spectral gamma ray, and dipmeter tools. Cuttings were described and tied to existing well data from the area to pick unit

tops and core points. A total of 586 feet (179 m) of core were recovered and described from the Kf-1 and Kf-2 parasequence sets. Descriptions of the cored sections followed the same format as the stratigraphic sections. Measured stratigraphic sections and drill holes were correlated to interpret the stratigraphy and lithofacies.

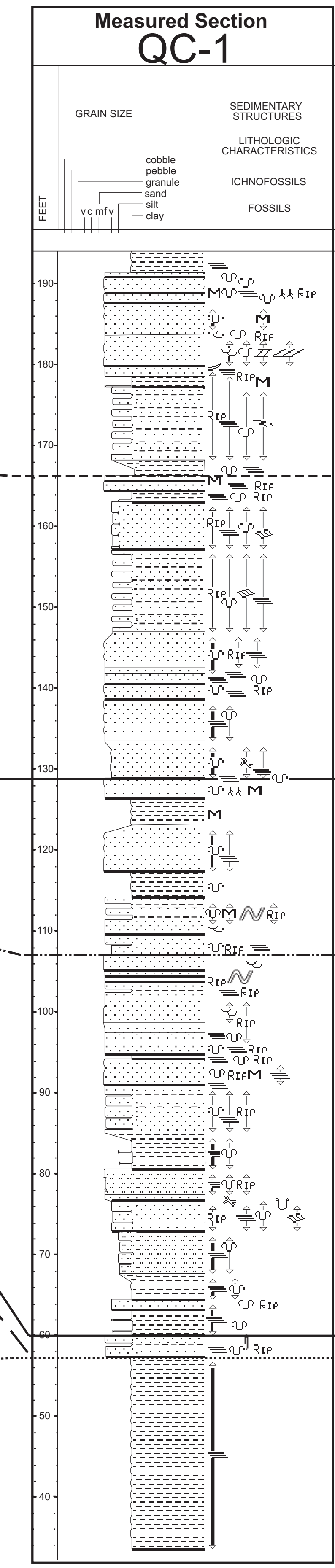
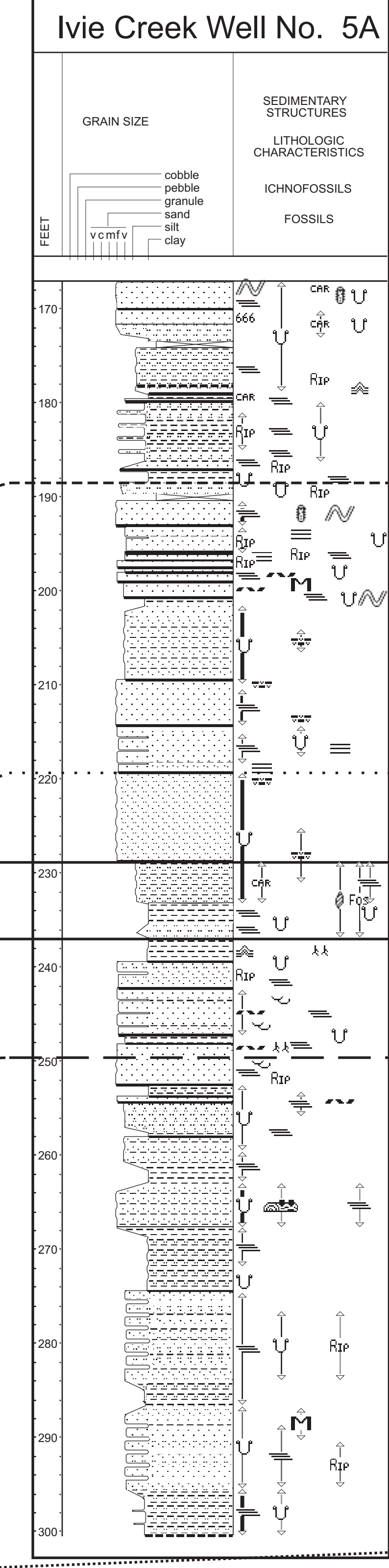
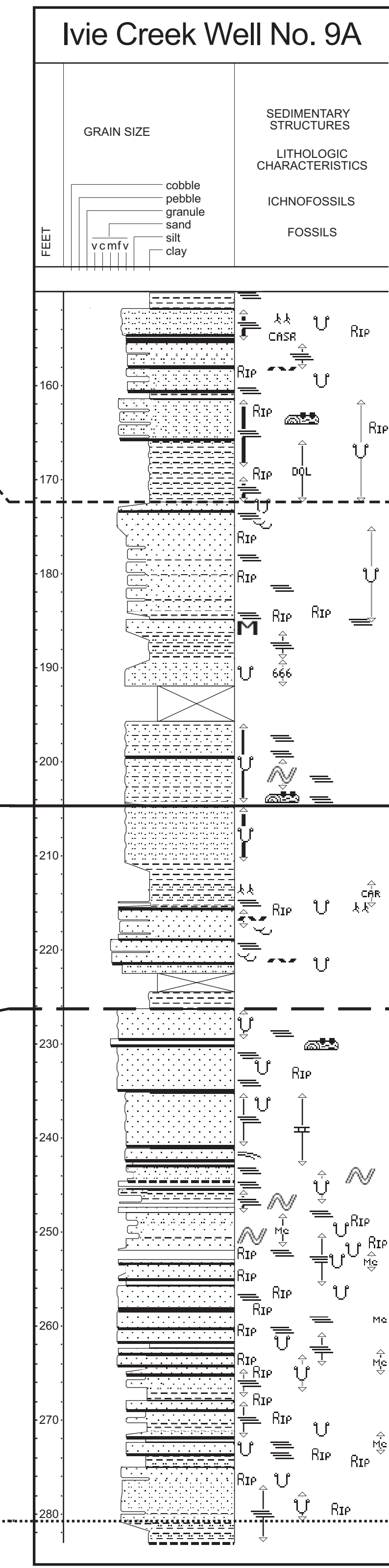
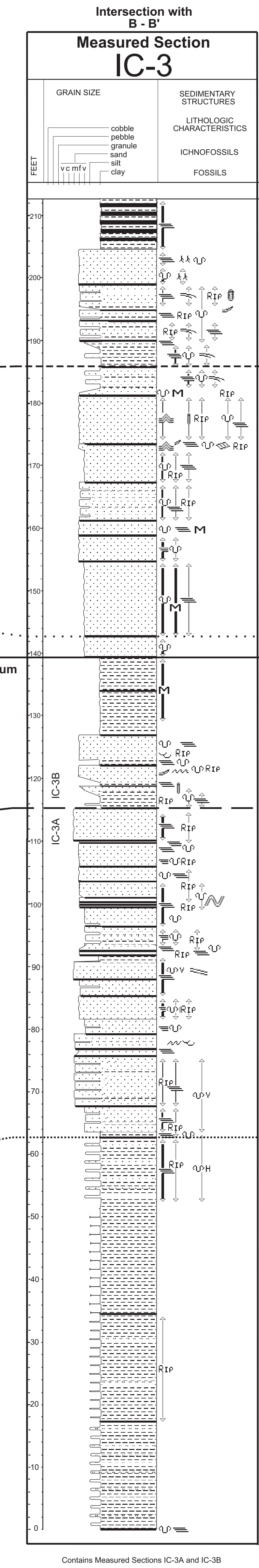
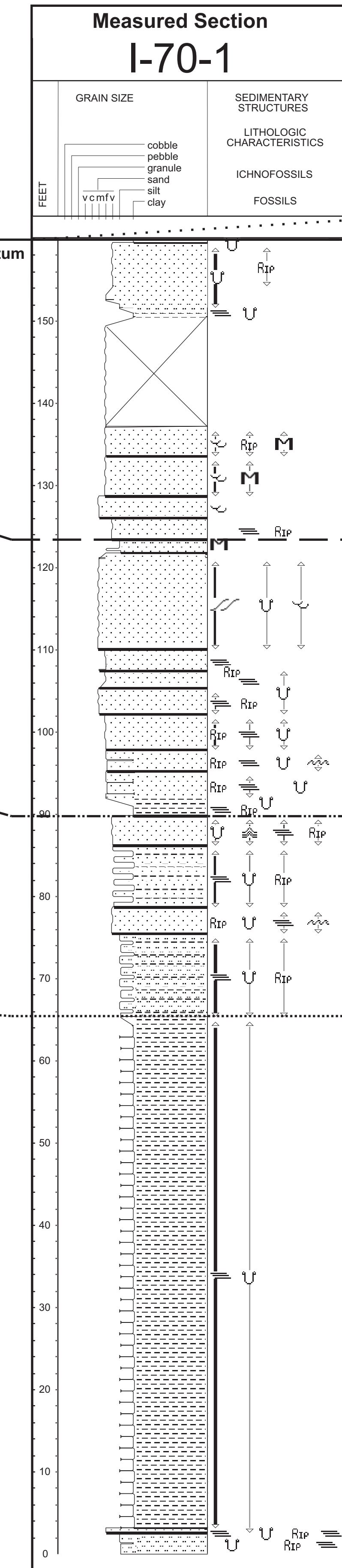
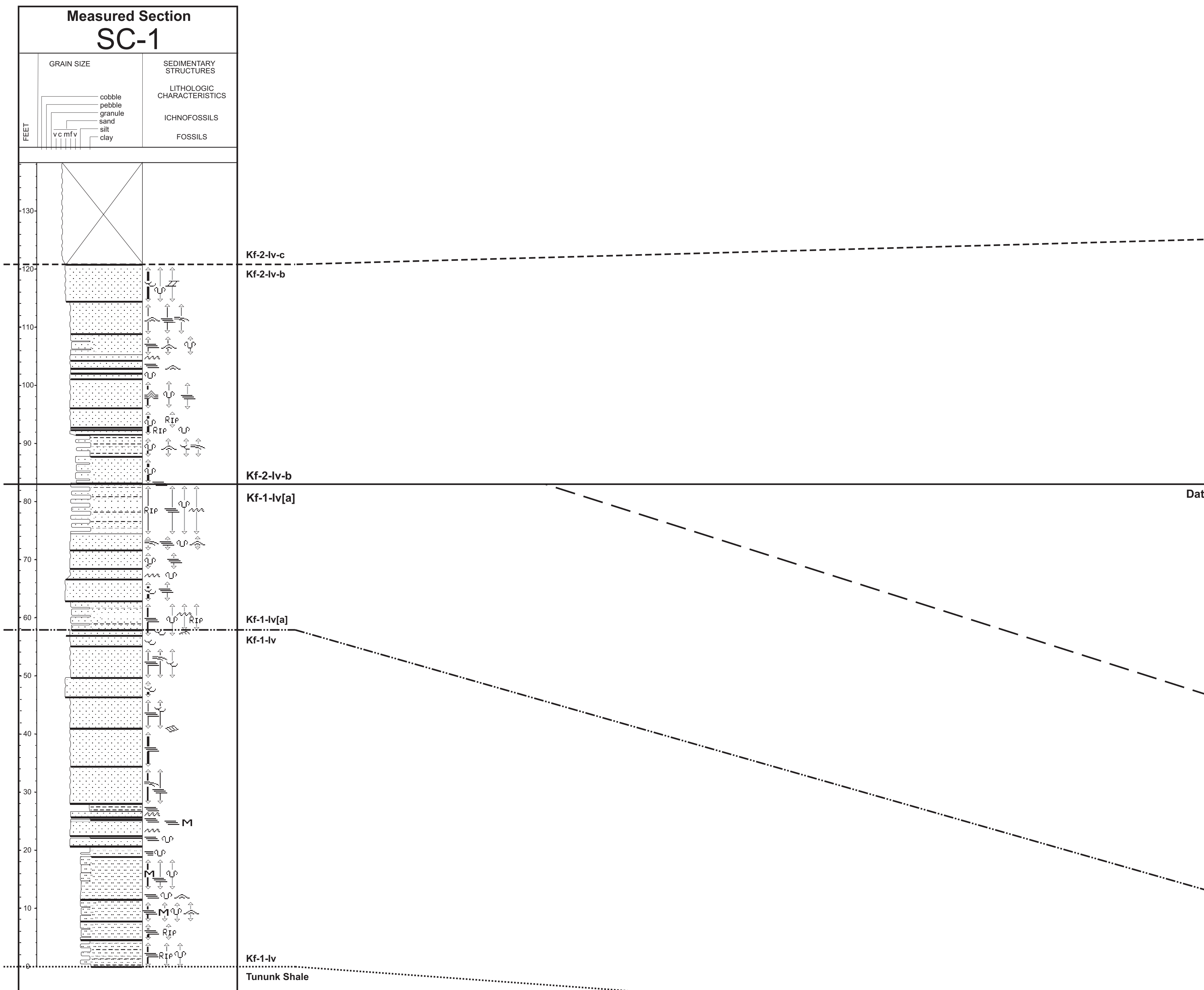
## ACKNOWLEDGMENTS

Several stratigraphic sections were measured and described by R.D. Adams (formerly with the Utah Geological Survey [UGS]). Coring operations were supervised by R.L. Bon, M.D. Laine, C.D. Morgan, S.N. Summer, and D.E. Tabet of the UGS. Cores are stored at the UGS Core Research Center, C.M. Olsen, Curator. Data entry was conducted by Janet Gillette and K.A. Waite of the UGS. This report was formatted by Cheryl Gustin of the UGS.

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A

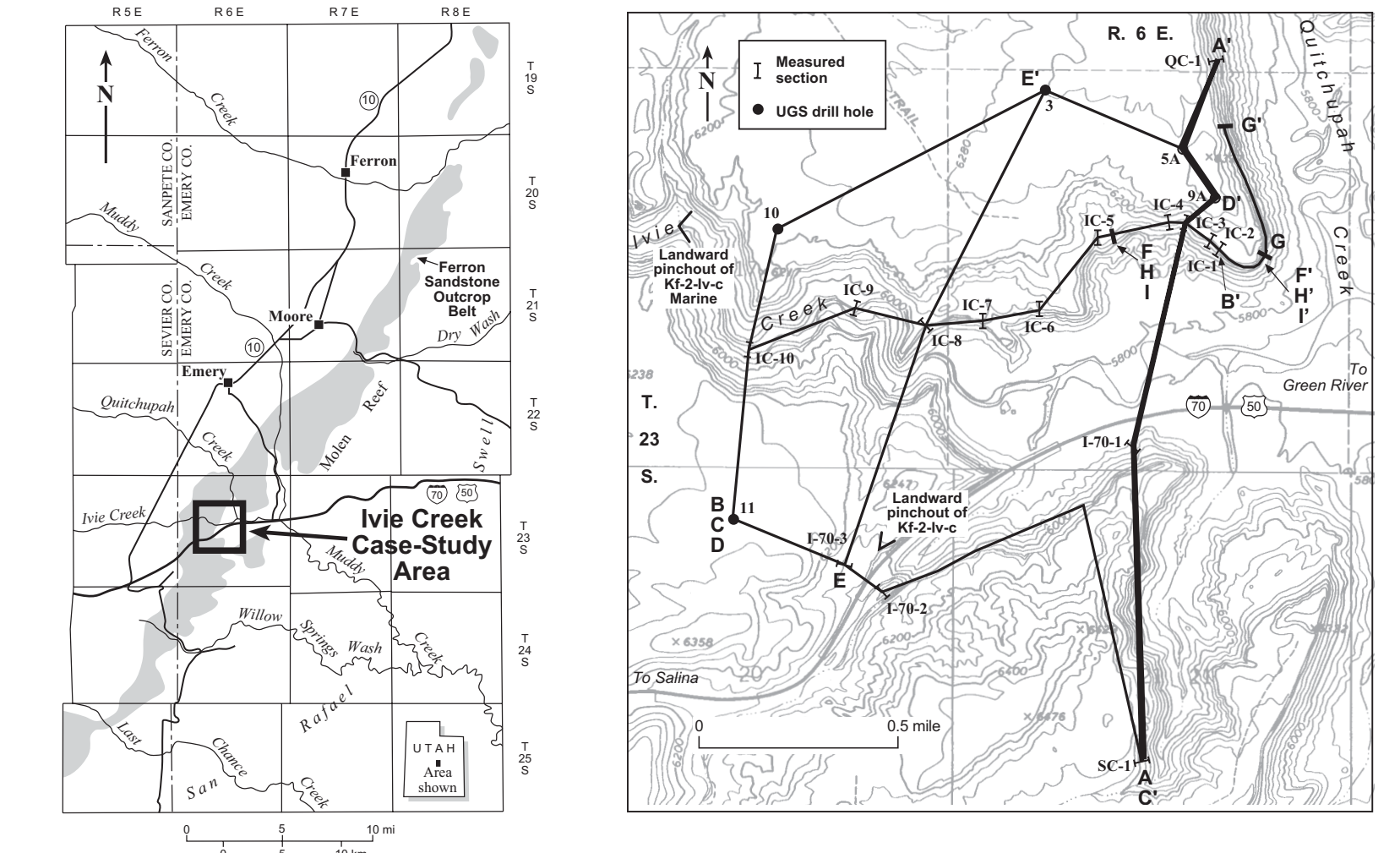


A'

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by  
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 Utah Geological Survey  
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 University of Utah

**Location of Cross Sections on Sheets 1-7**



**Explanation**

	Sandstone		Sandy Sand		Silty Sand		Sandy Silt		Silty Shale		Coal
	Shaly Sand		Shale		Sandy Shale		Silty Shale		Covered Interval		
	Sandstone		Clayey Silt		Covered Interval						
<b>CONTACTS</b>											
	Sharp		Gradational								
<b>SEDIMENTARY STRUCTURES</b>											
	Trough Cross-strat.		Flaser Bedding		Planar Tabular Bedding		Convolute Bedding		Laminae		
	Hummocky Cross-strat.		Wedge Cross-strat.		Sigmoidal Cross-strat.		Unspecified Ripples		Bedform Deformation		Climbing Symmetrical
	Massive Homogeneous		Asymmetrical Ripples		Climbing Cross-strat.		Tabular Cross-strat.		Planar Inclined		
<b>LITHOLOGIC CHARACTERISTICS</b>											
	Calcareous		Dolomitic		Micaceous		Carbonaceous		Skulllet Gran		Bony Gran
	Rip Up Clasts										
<b>ICHNOFOSSILS</b>											
	Rootlets		Ophiomorph		Thalassinoid		Teredosites		Skulllets		Unspecified Burrows
	Unspecified Vertical Burrows		Unspecified Horizontal Burrows								
<b>FOSSILS</b>											
	Unspecified Fossils		Gastropods								

--- Top of Kf-2-iv-b  
 ..... Top of Kf-2-iv-a  
 ——— Top of Kf-1-iv[c]  
 - - - Top of Kf-1-iv[a]  
 - - - - Top of Kf-1-iv  
 ..... Top of Tununk Shale

**STRATIGRAPHIC NOMENCLATURE**

Kf-1 and Kf-2 are Cretaceous Ferron Sandstone deltaic-front units. Parasequences within these successive units are designated with a geographic abbreviation for the type locality (iv for Ivie Creek and SC for Scabby Canyon) and letters for each parasequence (Kf-1-iv[a], for example).

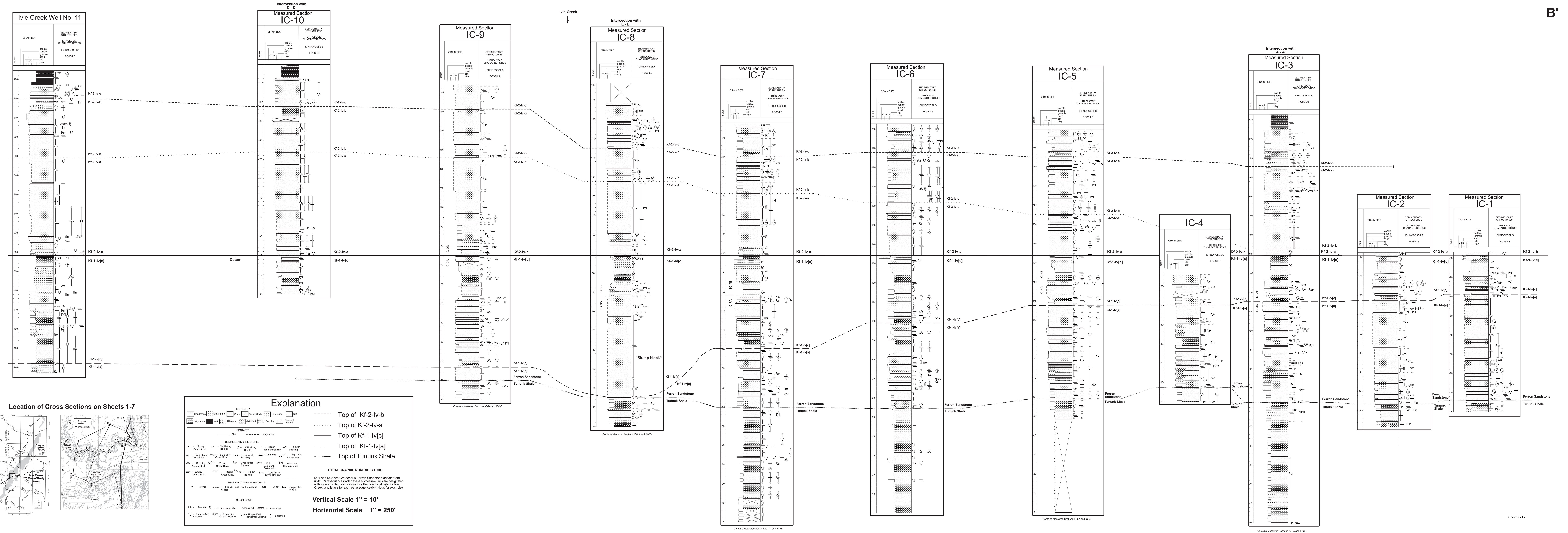
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**Horizontal Scale 1" = 250'**

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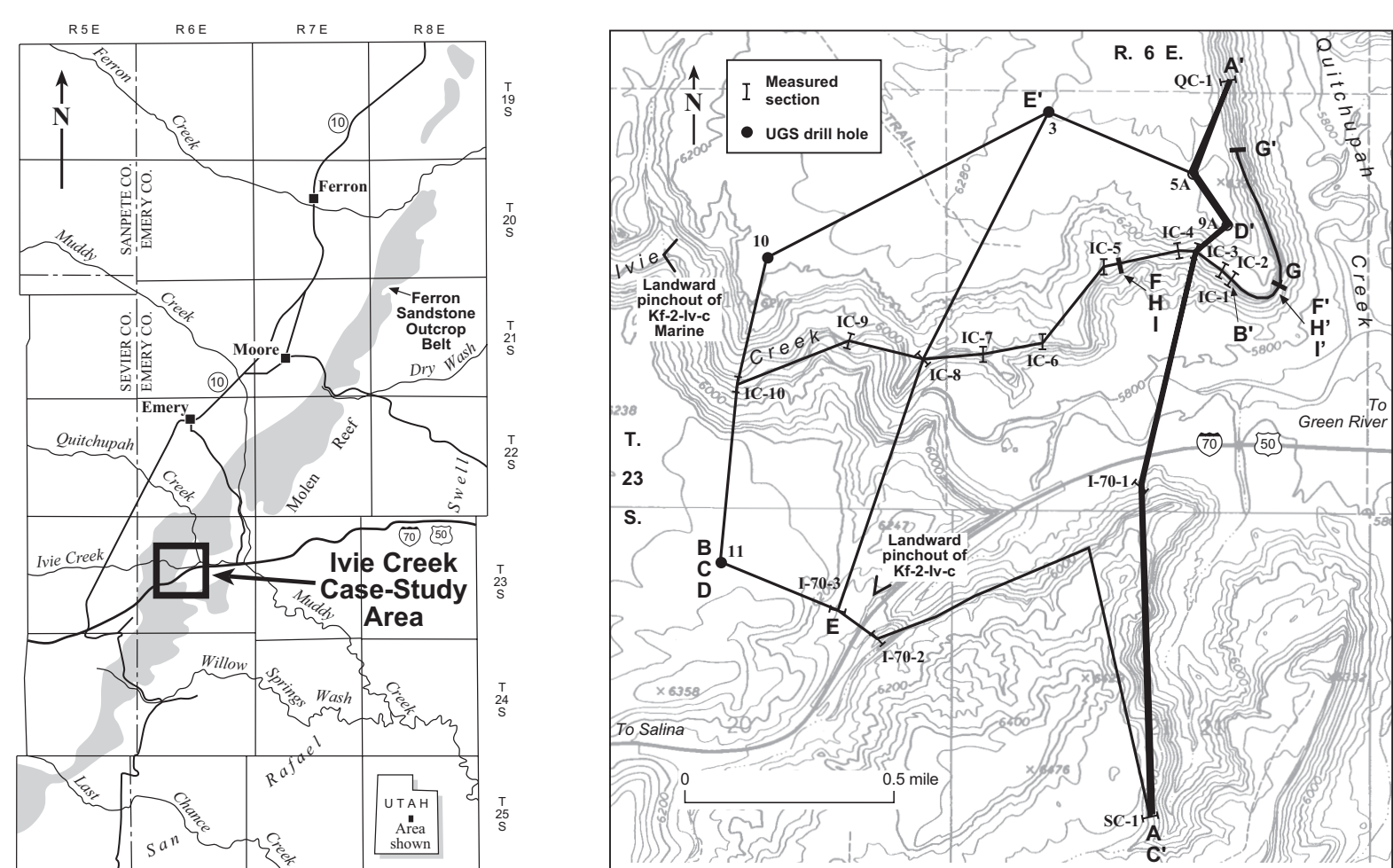
US/DOE Patent Clearance is not required prior to the publication of this document.

B



B'

Location of Cross Sections on Sheets 1-7



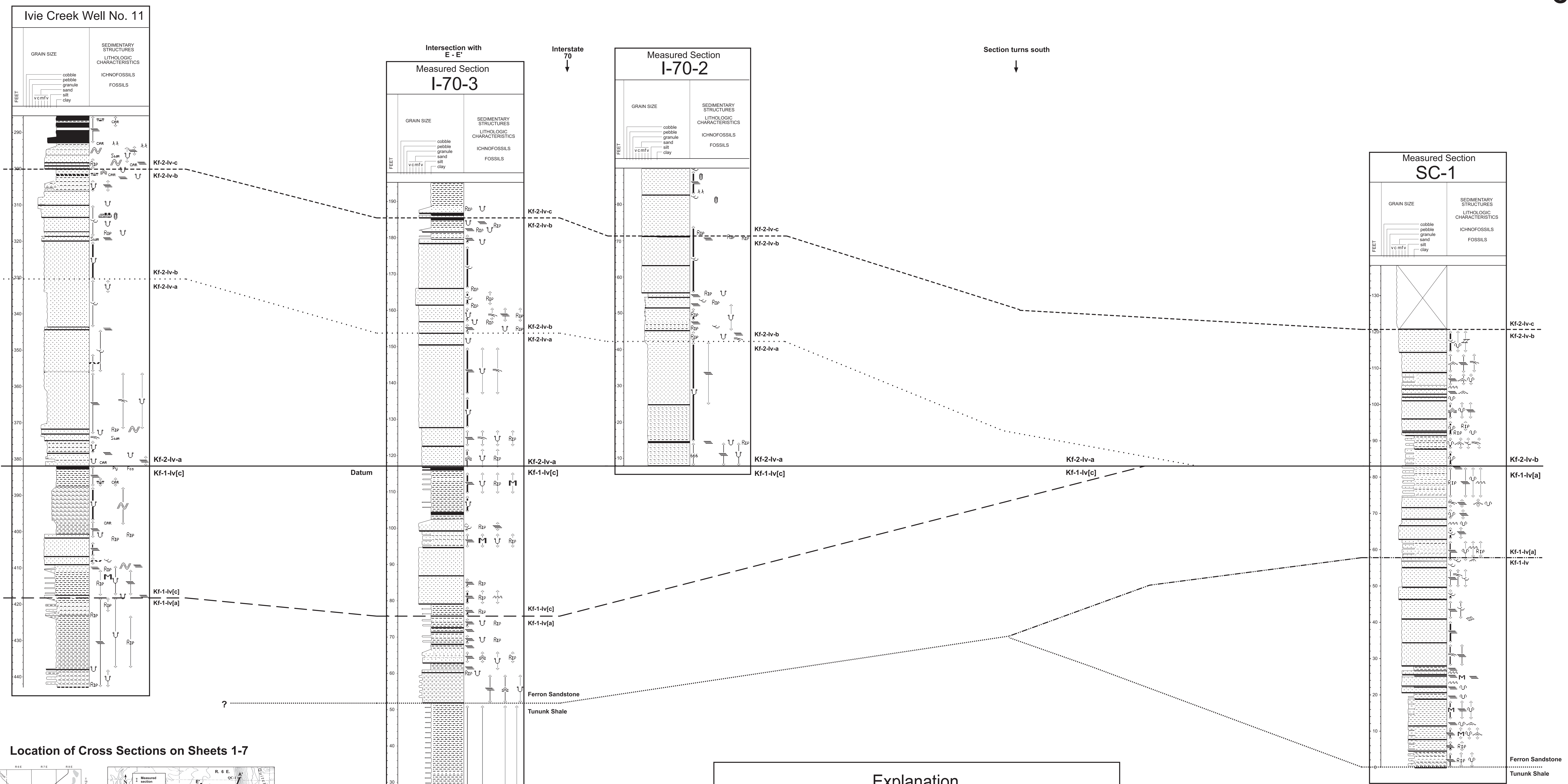
### Explanation

	Sandstone		Shaly Sand		Sandy Shale		Silty Sand		Silt
	Clay Shale		Siltstone		Mudstone		Carbonaceous Mudstone		Covered Internal
	Sharp		Gradational						
<b>SEDIMENTARY STRUCTURES</b>									
	Trough Cross-Stratification		Columnar Ripples		Planar Bedding		Flaser Bedding		
	Herringbone Cross-Stratification		Conolute Bedding		Laminar Bedding		Sigmoidal Cross-Stratification		
	Climbing Symmetrical Cross-Stratification		Wedge Cross-Stratification		Unspecified Ripples		Soft Subsoil Deformation		Massive Homogeneous
	Sandy Cross-Stratification		Tabular Cross-Stratification		Planar Cross-Stratification		Low Angle Cross-Stratification		
<b>LITHOLOGIC CHARACTERISTICS</b>									
	Pyrite		Rip Up Clay		Carbonaceous Clay		Bony Fossils		Unspecified Fossils
<b>ICHOFOSSILS</b>									
	R. A.		Optimorph		Thalassoid		Tricolpites		
	Unspecified Burrows		Unspecified Vertical Burrows		Unspecified Horizontal Burrows		Skidlines		

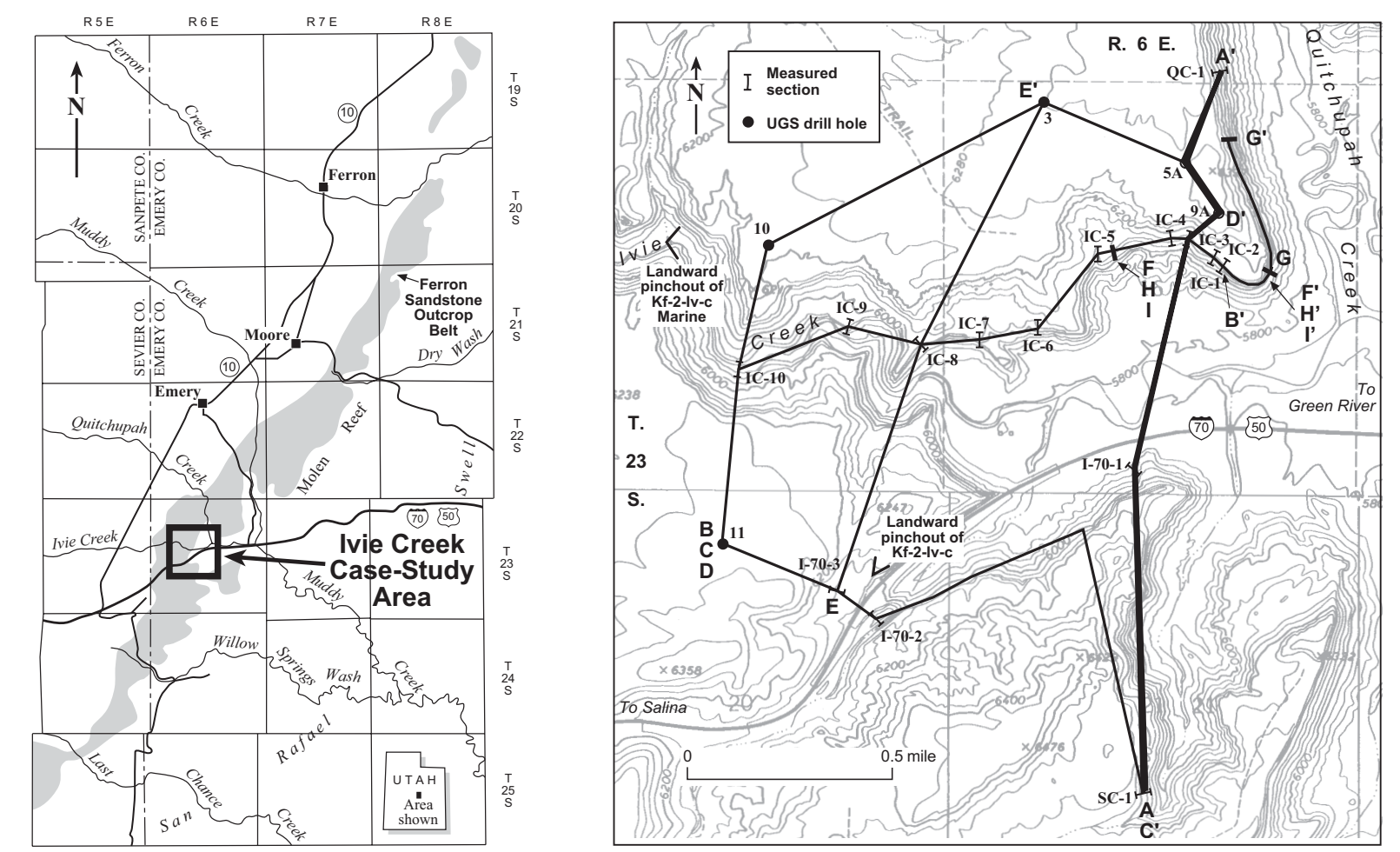
**Top of Kf-2-iv-b** (dashed line)  
**Top of Kf-2-iv-a** (dotted line)  
**Top of Kf-1-iv[c]** (solid line)  
**Top of Kf-1-iv[a]** (long dashed line)  
**Top of Tununk Shale** (short dashed line)

**STRATIGRAPHIC NOMENCLATURE**  
 Kf-1 and Kf-2 are Cretaceous Ferron Sandstone deltaic-front units. Parasequences within these successive units are designated with a geographic abbreviation for the type locality (iv for Ivie Creek) and letters for each parasequence (Kf-1-iv-a, for example).

**Vertical Scale 1" = 10'**  
**Horizontal Scale 1" = 250'**



Location of Cross Sections on Sheets 1-7



### Explanation

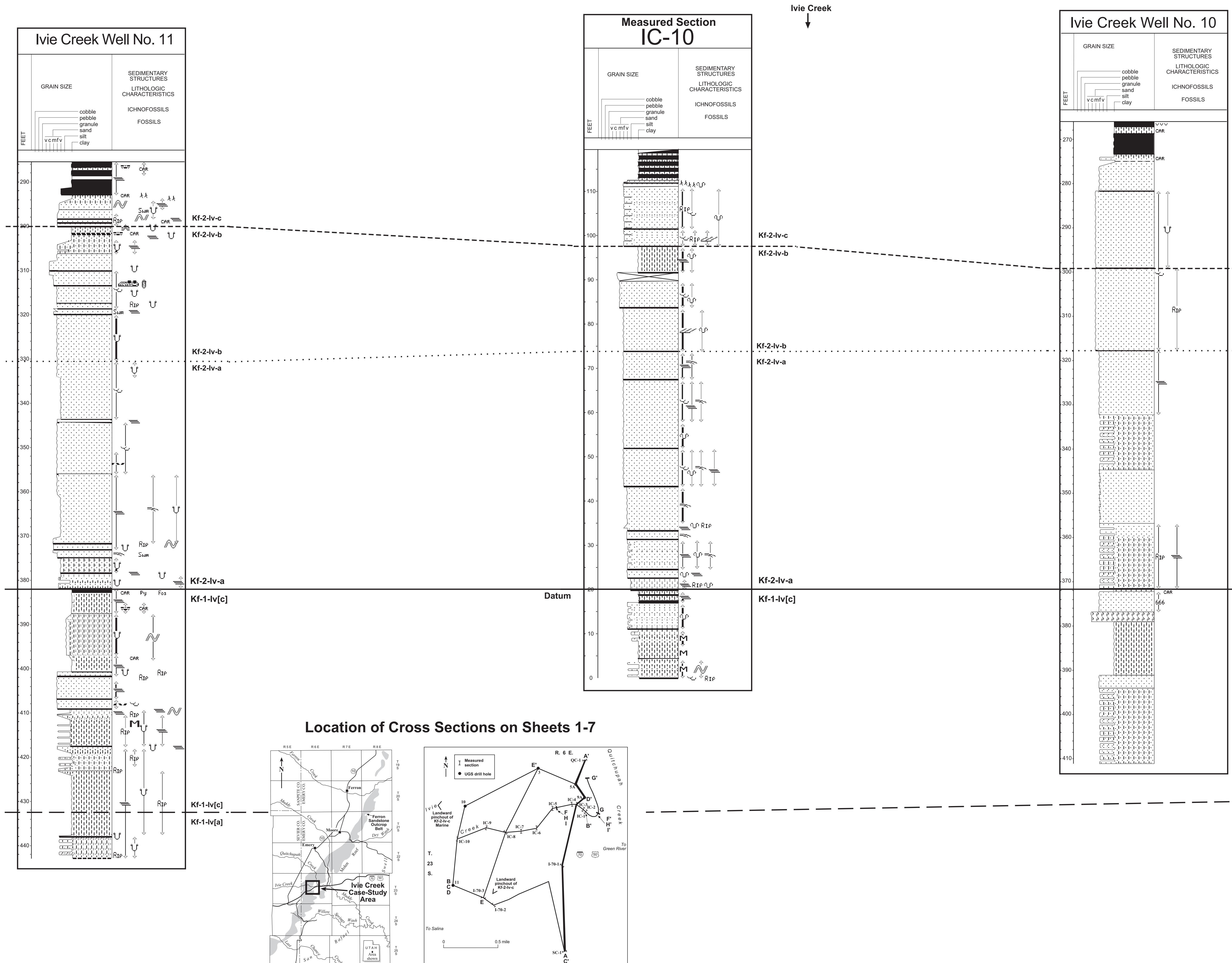
<b>CONTACTS</b>			
<b>SEDIMENTARY STRUCTURES</b>			
<b>LITHOLOGIC CHARACTERISTICS</b>			
<b>ICHOFOSSILS</b>			

**STRATIGRAPHIC NOMENCLATURE**

Kf-1 and Kf-2 are Cretaceous Ferron Sandstone deltaic-front units. Parasequences within these successive units are designated with a geographic abbreviation for the type locality (lv for Ivie Creek and SC for Scabby Canyon) and letters for each parasequence (Kf-1-iv[a], for example).

**Vertical Scale 1" = 10'**  
**Horizontal Scale 1" = 250'**

D



D'

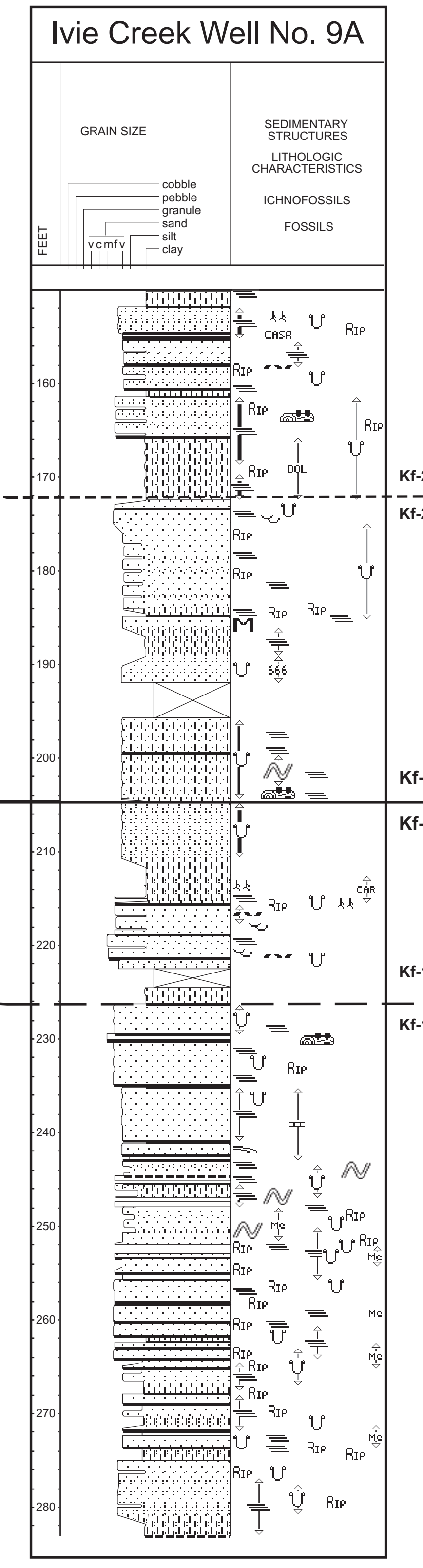
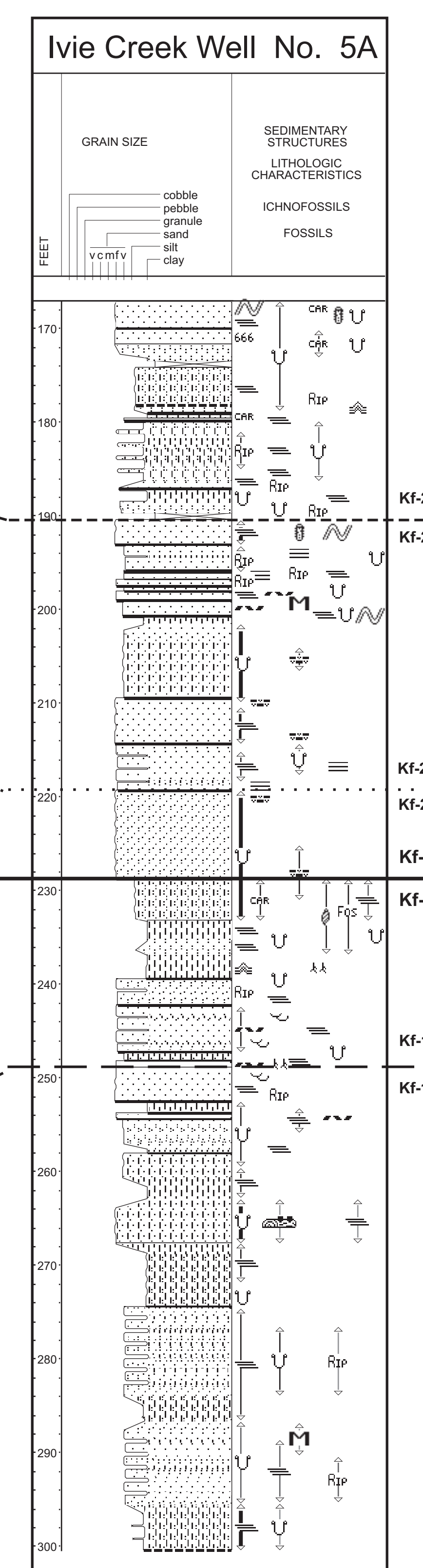
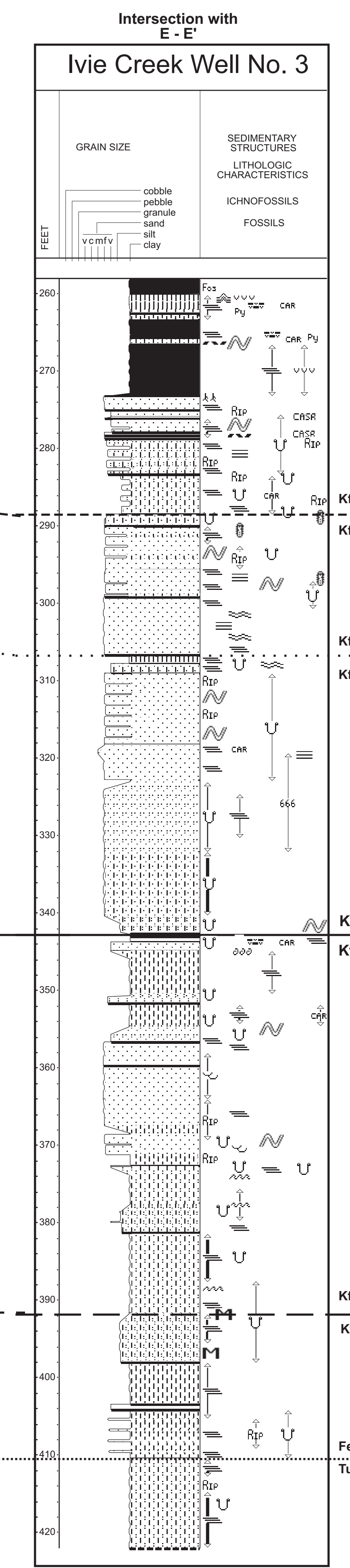
**Explanation**

----- Top of Kf-2-iv-b  
 ..... Top of Kf-2-iv-a  
 ——— Top of Kf-1-iv[c]  
 - - - Top of Kf-1-iv[a]  
 ..... Top of Tununk Shale

**STRATIGRAPHIC NOMENCLATURE**

Kf-1 and Kf-2 are Cretaceous Ferron Sandstone deltaic-front units. Parasequences within these successive units are designated with a geographic abbreviation for the type locality (iv for Ivie Creek) and letters for each parasequence (Kf-1-iv[a]), for example.

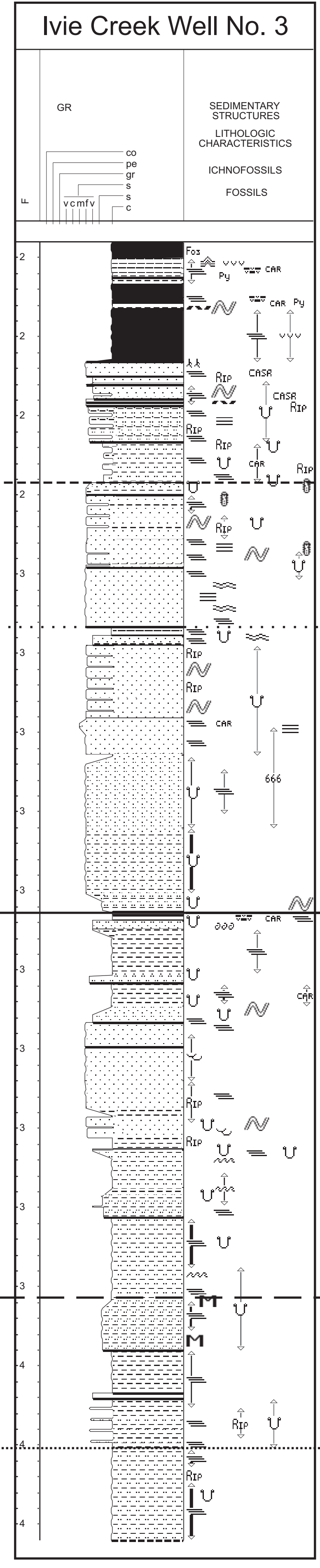
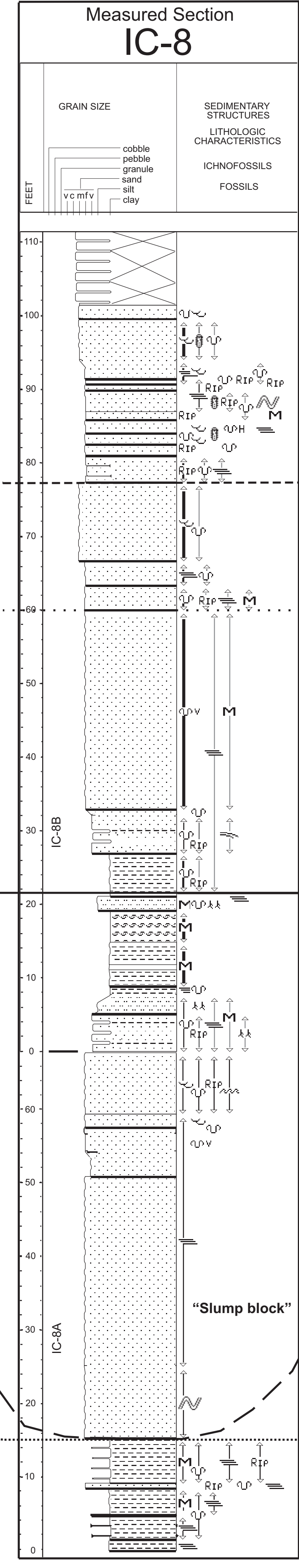
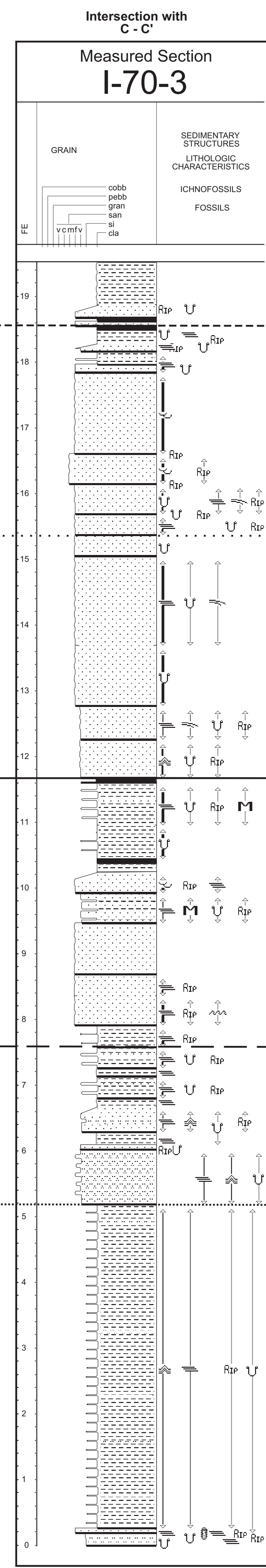
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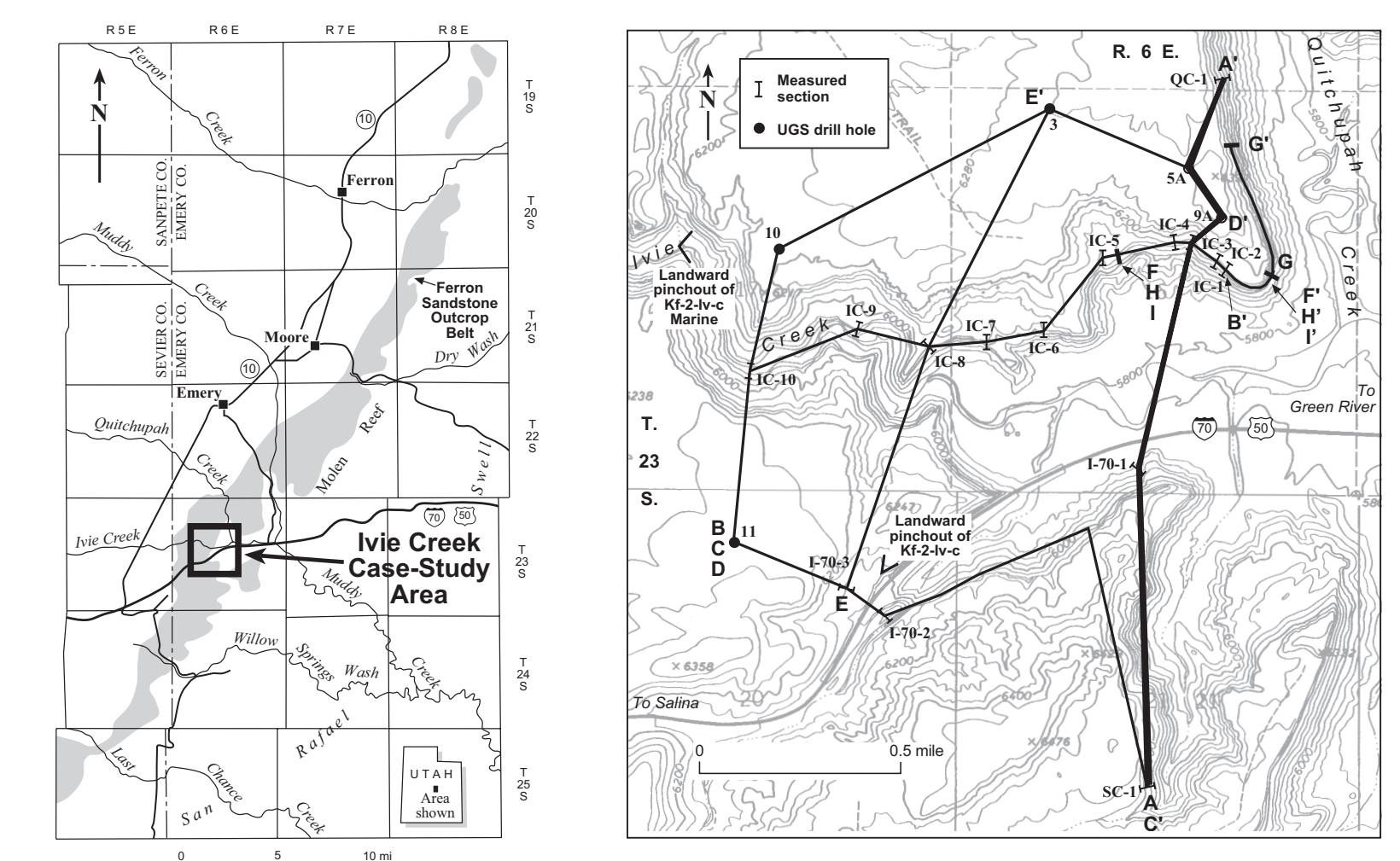
Ivie Creek

Intersection with B - B'

Intersection with D - D'



Location of Cross Sections on Sheets 1-7



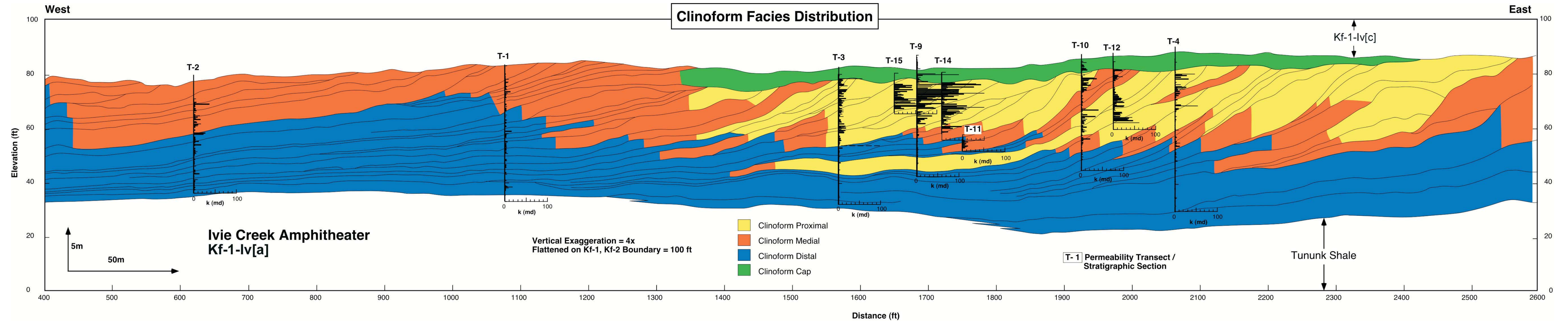
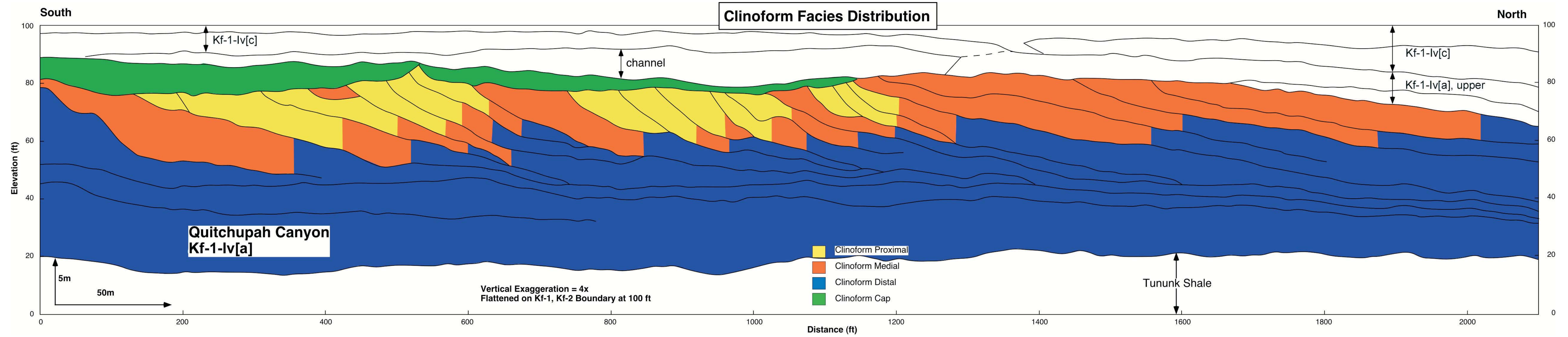
### Explanation

LITHOLOGY	
[Symbol]	Sandstone
[Symbol]	Shaly Sand
[Symbol]	Shale
[Symbol]	Sandy Shale
[Symbol]	Silty Sand
[Symbol]	Sandy Silt
[Symbol]	Silty Shale
[Symbol]	Coal
[Symbol]	Siltstone
[Symbol]	Claystone
[Symbol]	Shaly Silt
[Symbol]	Coveted Interval
[Symbol]	Coquina
CONTACTS	
[Symbol]	Sharp
[Symbol]	Gradational
SEDIMENTARY STRUCTURES	
[Symbol]	Trough Cross-Strat.
[Symbol]	Planar Tabular Bedding
[Symbol]	Hummocky Cross-Strat.
[Symbol]	Convolute Bedding
[Symbol]	Rip Up Clasts
[Symbol]	Climbing Asymmetrical Ripples
[Symbol]	Massive/Homogeneous
[Symbol]	Climbing Symmetrical Ripples
[Symbol]	Unspecified Ripples
[Symbol]	Soft Sediment Deformation
[Symbol]	Wavy Parallel Bedding
[Symbol]	Laminae
LITHOLOGIC CHARACTERISTICS	
[Symbol]	Bony
[Symbol]	Bentonite
[Symbol]	Pyrite
[Symbol]	Shell Fragments
[Symbol]	Unspecified Fossils
ICHTHOFOSSILS	
[Symbol]	Rootlets
[Symbol]	Ophiomorpha
[Symbol]	Unspecified Burrows
[Symbol]	Unspecified Vertical Burrows
[Symbol]	Unspecified Horizontal Burrows

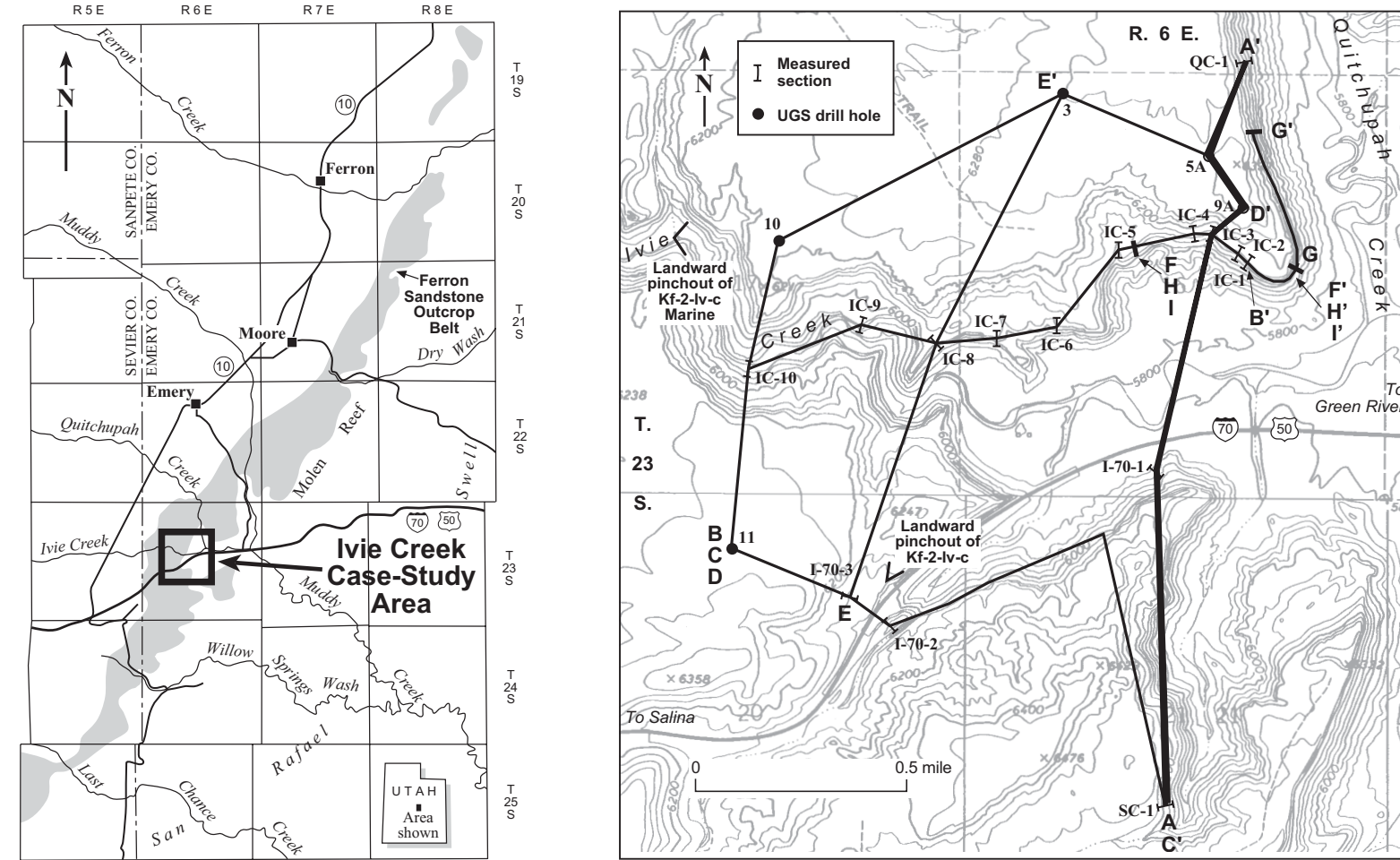
- - - - - Top of Kf-2-iv-b  
 . . . . . Top of Kf-2-iv-a  
 ——— Top of Kf-1-iv[c]  
 ——— Top of Kf-1-iv[a]  
 ..... Top of Tununk Shale

**STRATIGRAPHIC NOMENCLATURE**  
 Kf-1 and Kf-2 are Cretaceous Ferron Sandstone deltaic-front units. Parasquences within these successive units are designated with a geographic abbreviation for the type locality (Iv for Ivie Creek) and letters for each parasquence (Kf-1-iv[a], for example).

**Vertical Scale 1" = 10'**  
**Horizontal Scale 1" = 250'**

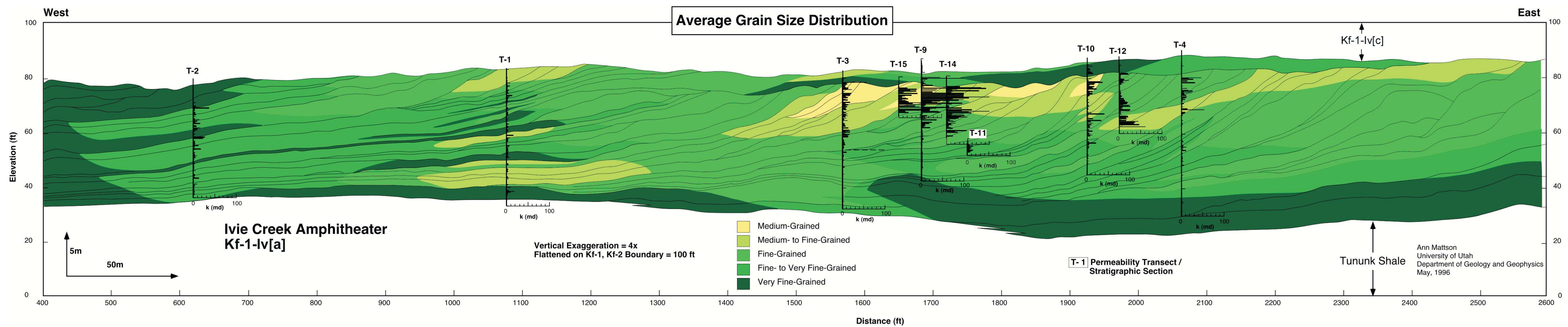
**F****F'****G****G'**

**Location of Cross Sections on Sheets 1-7**



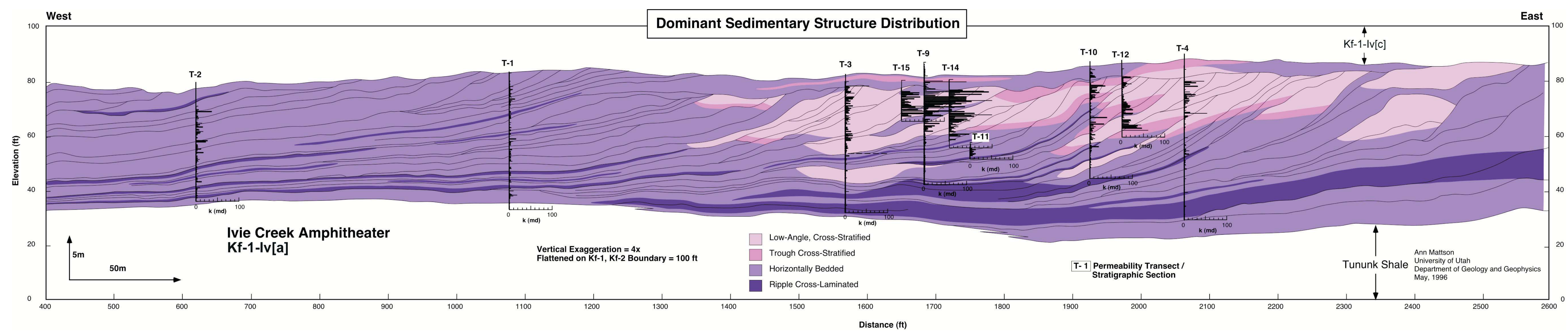
H

H'



I

I'



Location of Cross Sections on Sheets 1-7

