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Coincidence of N. 50°–58° W. Trends in Geologic Mapping, Magnetic and Gravity Anomalies, and Lineaments in the Northern Paradox Basin, Utah and Colorado

By Jules D. Friedman

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FIGURES

Previous attempts to explain the coincidence and near-coincidence of structural, geophysical and lineament trends in the region of salt-cored anticlines in the Paradox Basin (fig. 1) relied heavily on concepts of propagation of older (Precambrian) structural patterns through a thick sequence of Paleozoic and Mesozoic sedimentary rocks (including the salt units of the Paradox Formation). Propagation of fault patterns by reactivation of Precambrian structures has been widely suggested to explain both northwest- and northeast-trending fault systems (Case and others, 1963; Case and Joesting, 1973; Shoemaker and others, 1978; Friedman and others, 1994).

The presence of salt units within the Paradox Formation has provided the basis for a major objection to this concept. The incompetent salt units, most likely, would not effectively transmit stress from the lower strata into overlying beds.

Here, I attempt to explain the coincidence of some structural trends in the sedimentary strata overlying the Paradox Formation by means of a passive form of structural control exerted by block faulting of the Precambrian basement and resulting differential concentration and solution of salt in the northern part of the Paradox Basin. This model does not depend on the transmission of stress by incompetent salt units to explain the reiteration at the surface of older structural patterns. Rather, it credits this effect to deformation due to the differential thickness of salt controlled by the reactivation of earlier structures.

Several types of linear features in this area show strongly correlated azimuthal trends toward the northwest (fig. 2). Lineaments in both the gravity and magnetic-field data have peak distributions at N. 55° W., and major throughgoing lineaments have a sharp defined peak at N. 50° W. These peaks also coincide with the N. 50°–58° W. peak distribution of geologically mapped faults. Because the magnetic field represents the orientation of Precambrian basement discontinuities, the congruence or coincidence of magnetic trends with

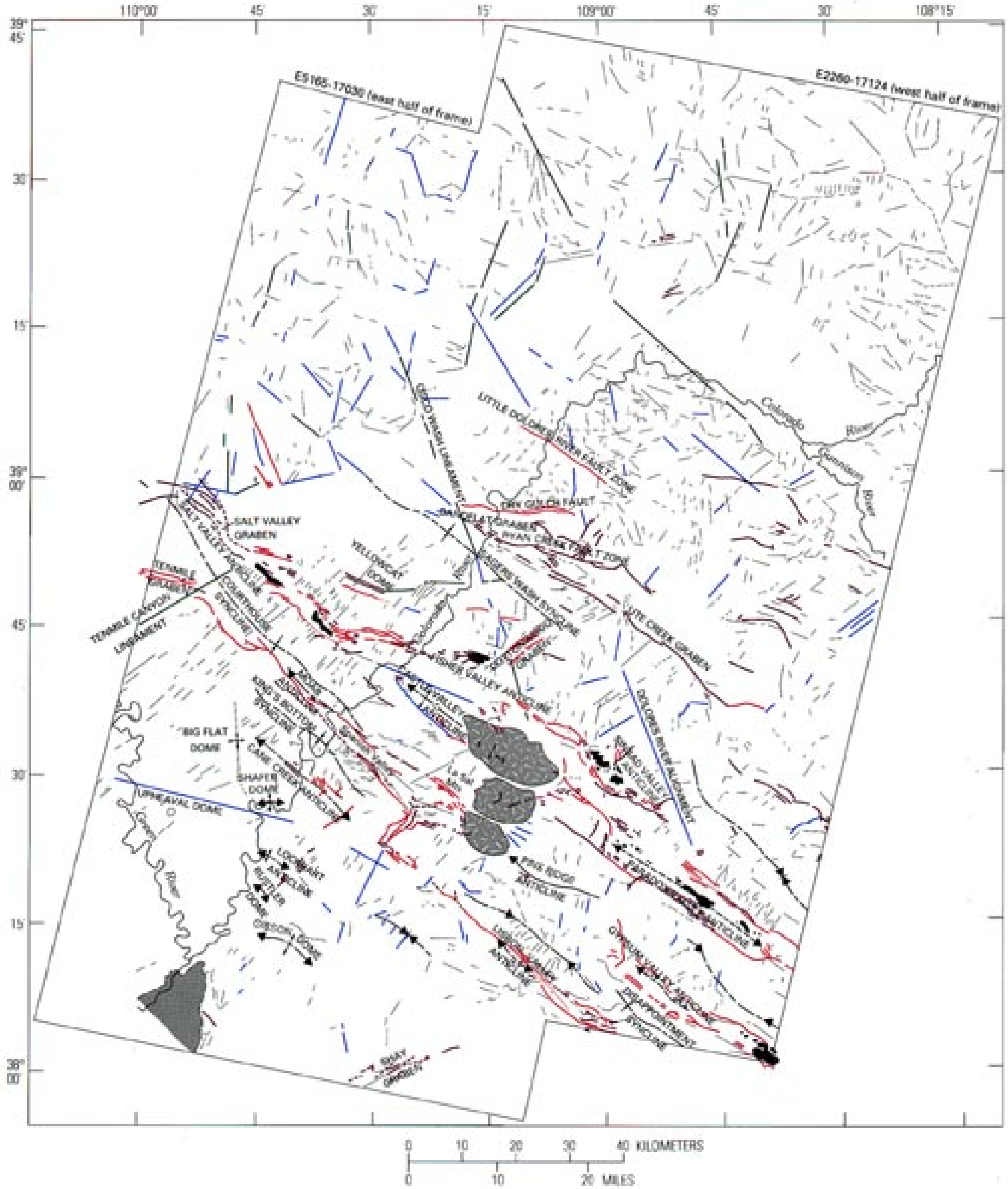
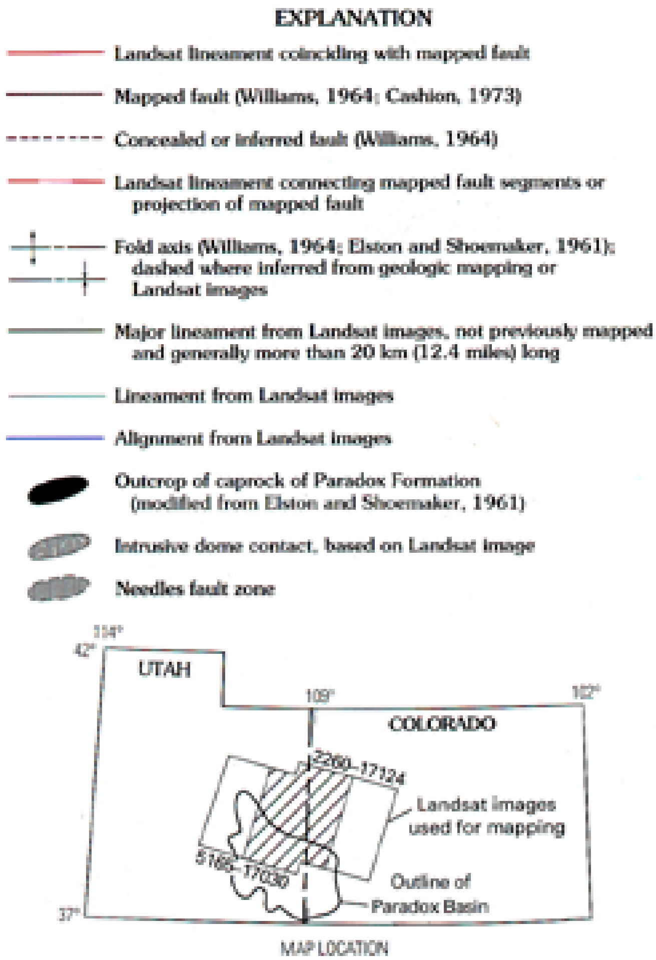


Figure 1 (above and facing page). Tectonic features of the northern part of the Paradox Basin, southeastern Utah and southwestern Colorado. Landsat multispectral scanner images 5165–17030 and 2260–17124 were used to map some lineaments and alignments. From Friedman and others (1994, fig. 2).



geologically mapped structures is strong evidence for basement control of mapped faults. It further suggests that the Precambrian crystalline basement has been involved in pre-Laramide, Laramide, and post-Laramide tectonic episodes. The northwest alignment of the salt anticlines of the Paradox Basin suggests that the crystalline basement, already block-faulted in the late Paleozoic, may have been further deformed during Laramide compression. It is possible, but less likely, that northwest-trending, parallel antiforms and synforms were then formed in the Precambrian crystalline rocks and that the synforms provided the locus for enhanced thickening of the deep-seated keels of the salt anticlinal cores (Friedman and others, 1994).

I suggest here that a multistage process controlled the azimuth and position of fault blocks in the Precambrian basement. The steep and relatively continuous magnetic and gravity gradients along the subsurface Uncompahgre Fault Zone, which underlies the northeastern boundary of the Paradox Basin, suggest that this zone marks a fundamental boundary within the Precambrian basement. This boundary, here termed the proto-Uncompahgre tectonic line (Cashion and others, 1990), has been the site of recurrent thrusting (Frahme and Vaughn, 1983). Movement along this zone may have been the earliest discernible event in the multistage process culminating in the tectonic development of parallel fault blocks in the Precambrian basement.

Stone (1977) placed the first recognizable tectonic activity along the proto-Uncompahgre line of structural weakness in late Precambrian time. The resulting faults, bounding the proto-Uncompahgre uplift, probably determined the trend of the deep-seated northwest-striking faults bounding blocks in the Precambrian basement rocks. The structural position of the basement blocks in turn controlled the positions and northwest trends of the major salt-cored anticlines of the Paradox Basin (Witkind, 1991; Friedman and others, 1994).

The coincidence of azimuthal trends in magnetic data, gravity data, surface faults, and lineaments (longer than 20 km) is the result of a threefold sequence of structural and tectonic events: (1) basement block faulting (as reflected in the magnetic field), (2) parallel alignment of the thick keels of salt-cored anticlines along the downdropped fault blocks (as reflected in the gravity field), and (3) listric and extensional faulting as a result of differentially greater salt solution and subsidence of clastic-rock units overlying the thicker salt keels of the anticlines, parallel to basement fault-block margins (Doelling, 1985). The resulting faults and folds are mapped at the surface, where they make up part of a northwest-trending lineament system. Many of the northwest-trending lineaments and extensional faults (fig. 3), and some shorter ones trending northeast, terminate approximately at the zero isolith of subsurface salt of the Paradox Formation. This coincidence is hardly fortuitous.

The emplacement of the laccolith complex and domal uplift of the La Sal Mountains and several other laccolith complexes at intersections of some of the major northwest and northeast lineaments of the Paradox Basin is of special tectonic significance. The La Sal, Henry, and Abajo Mountains laccolith complexes, among others, may have been intruded at nodes of a northwest-northeast lineament grid. Recent studies indicate a mantle source for the laccolith magmas (Friedman and others, 1994), and this finding suggests faulting down to the depth of the crust and the deep-seated nature of the N. 40°–60° W. and N. 40°–50° E. discontinuities.

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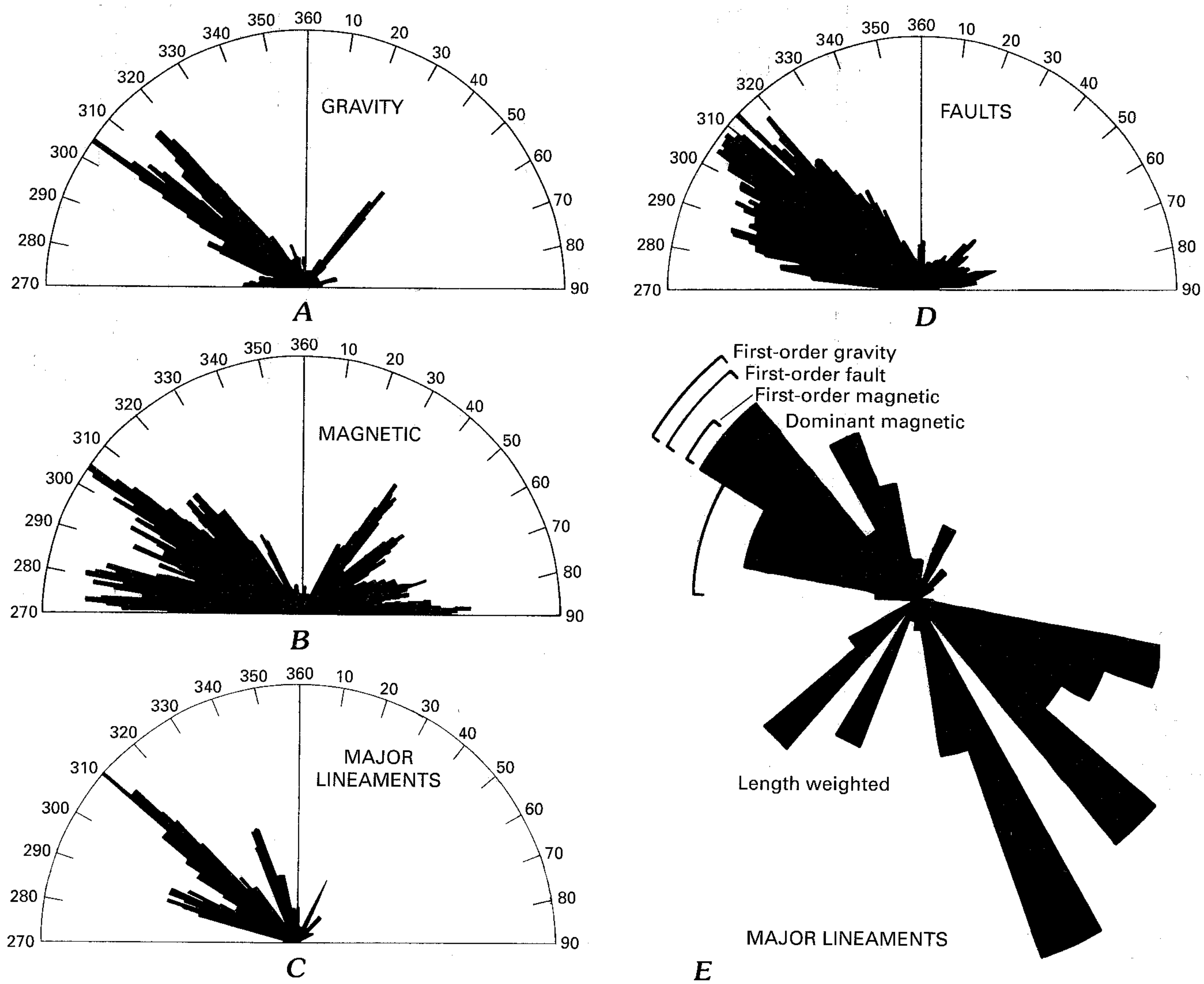

Figure 2. Rose diagrams showing frequency of azimuthal trends of linear features in the northern part of the Paradox Basin, southeastern Utah and southwestern Colorado. *A*, Gravity-field lineaments; 89 lines. *B*, Magnetic-field lineaments; 281 lines. *C*, Major lineaments (longer than 20 km) mapped from Landsat Multispectral Scanner images; 77 lines. *D*, Geologically mapped faults; 916 lines. *E*, Composite diagram showing relation of major lineaments (from diagram *C*) to gravity and magnetic lineaments (from diagrams *A* and *B*). Figures from Friedman and others (1994, figs. 9, 7, and 10).

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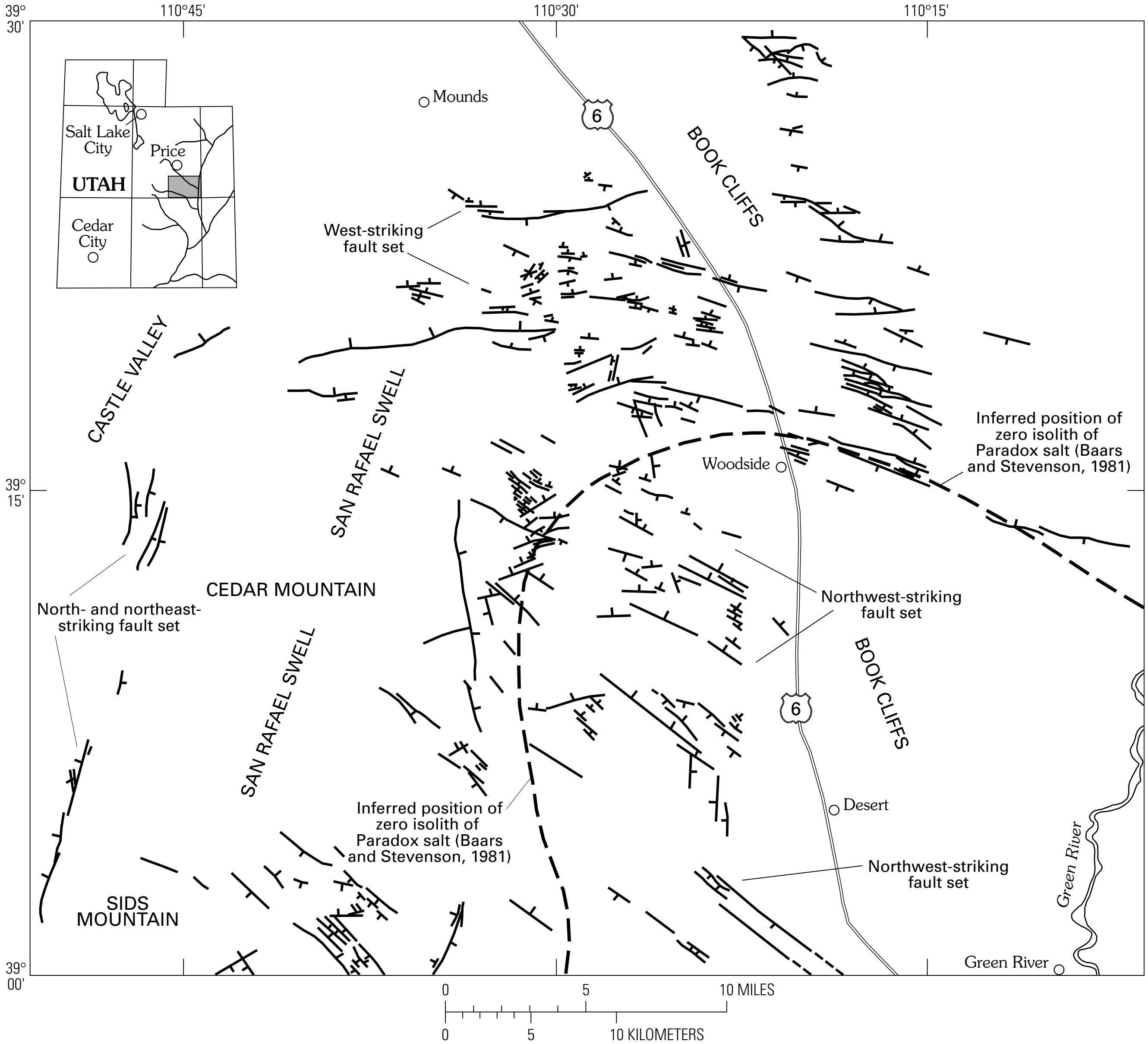

Figure 3. Distribution of known faults and fractures in the northern Paradox Basin, compared to the inferred position of the zero isolith of salt in the Paradox Formation. From Witkind (1991) and earlier sources.

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