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STRATIGRAPHIC RELATIONSHIPS OF THE SHAFER LIMESTONE, SAN JUAN COUNTY, UTAH

RICHARD B. MATTOX AND JOHN P. BRAND

The Cutler Formation, or Group, has been the subject for stratigraphic controversies since it was named by Cross and Howe for exposures of redbeds along Cutler Creek at sites near Ouray, Colorado. This sedimentary unit is composed primarily of arkosic debris derived from the Precambrian metamorphic and igneous provenance of the Uncompahgre Plateau. It parallels the western margin of the plateau, is thickest near its source area, and its arkosic and redbed phases extend approximately 50 miles southwest from the source area.

The manner in which the Cutler Formation was deposited, by streams flowing westward from the Uncompahgre Plateau, leads to the inevitable conclusion that the basal beds on the eastern margin of the basin are distinctly older than the basal beds near the western limit of deposition. The formation crosses time planes and includes the boundary between the Pennsylvanian and Permian Systems. To add additional complexity to the problem, salt anticlines were developing at the time the formation was being deposited. A thickness of 8000 feet of Cutler beds exists near Gateway, Colorado, but on a nearby salt anticline less than 2000 feet of arkosic material are present. The trend of the salt anticlines is normal to the general direction of flow that streams transporting the Cutler sediments must have followed (Fig. 1). These salt structures appear to have been a significant controlling factor in the distribution of the Cutler sediments.

A western source area may have provided sediments for units deposited west and south of the area in which the coarse, arkosic conglomerates and redbeds were developed. The combination of many factors produced the multiple facies changes that exist within the Cut-

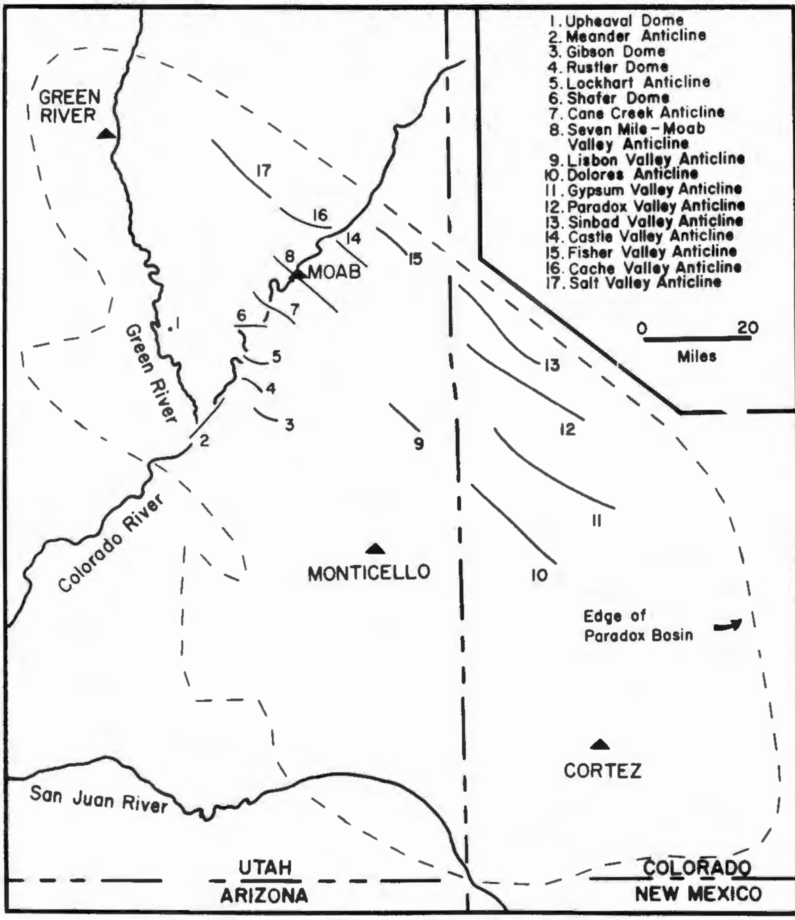

FIG. 1.—Location map showing positions and trends of the salt anticlines. The Uncompahgre Plateau lies parallel and adjacent to the northeastern margin of the basin. After Hite (1961).

ler Formation and at its outer limits where it interfingers with other stratigraphic units. In some areas variations in sedimentation were strong enough to produce four or five recognizable members, the basis used by some for calling the Cutler beds a group rather than a formation. Within the area of this investigation the beds are not divisable into distinct units and in this report will be called a formation.

During the first 40 years after the establishment of the Cutler Formation the beds considered in this report were regarded as being two distinct formations. The lower unit, the Rico Formation, was interpreted as being transitional between the marine Hermosa Limestone (Pennsylvanian), on which it lies, and the continental beds of the Cutler Formation that are above it. Current classifications have eliminated use of the term Rico; the entire sequence of arkosic beds are assigned to the Cutler Formation, or Group.

Baars' (1962) exhaustive treatment of the Permian System of the Colorado Plateau illustrates the problems inherent to the task of correlating the Cutler Formation and is recommended to anyone interested in a detailed discussion of the subject. Part of the difficulties stem from the fact that the arkosic beds are almost entirely nonmarine and, therefore, provide no guide fossils for positive correlation with the marine Permian (Wolfcampian) strata that have been identified in areas west and southwest of Moab (Herman and Sharp, 1956; Heylmun, 1958); studies by Vaughn (1962, 1964, 1966, 1969) of vertebrate forms from Cutler beds south and east of Shafer Dome provide evidence to support the view that the Cutler Formation is in the lower part of the Permian System. Simple correlation on the basis of facies changes is not entirely satisfactory because the Cutler Formation is a time transgressive unit. At its western margin, it probably is equivalent to the Wolfcampian carbonate beds with which it interfingers, but this does not establish the formation's age relationships in the eastern part of the basin.

Within the Moab field area, the formation is red to brown to maroon, and its texture ranges from shale to coarse conglomerate. Great ranges in thickness exist. The formation is absent in some parts of Moab Valley, but more than 1000 feet of section are present in nearby areas. The goal of our field study was to find marine fauna or other stratigraphic markers that would be of value in making local determinations of the Cutler Formation's stratigraphic position.

Within the Paradox Basin, the Colorado River is a transverse stream that has eroded a deep canyon lying at a right angle to the trend of the major salt anticlines. Excellent exposures of the Cutler Formation exist in this canyon (Fig. 2). One of the salt structures, Shafer Dome (Figs. 3 and 4), contains a marine carbonate unit at about 450 feet above the contact between the Cutler Formation and the Hermosa Limestone (Fig. 5). Because of the abundant marine fossils in this carbonate unit, it was selected as a subject for study in the hope that the fauna would provide specific evidence for establishing the stratigraphic age of the Cutler Formation in that area.

Locally, the carbonate beds are called the "Shafer limestone," but this is not an officially accepted stratigraphic term. During that period in which the Rico Formation was considered to be transitional beds

FIG. 2.—Canyon of the Colorado River at Shafer Dome, San Juan County, Utah. The Shafer limestone caps the cliffs on either side of the river.

between the Hermosa Limestone and the Cutler Formation, some local geologists regarded the Shafer limestone as being the youngest member of the Rico Formation and of possible Pennsylvanian age. The beds have a maximum thickness of 25 feet and where best developed are composed of five distinct units (listed in order from top to bottom):

5. 5 to 7 feet of porcelaneous limestone; probably nonmarine,
4. 2 to 5 feet of sandy shale and interbedded limestones approximately 2 inches thick; fossiliferous (Fig. 6),
3. 5 to 10 feet of bioturbated limestone; abundant allorismid pelecypods (Fig. 7),
2. 3 to 5 feet of arenaceous limestone containing abundant *Neospirifer*, poorly preserved productid brachiopods and gastropod steinkerns (Fig. 8),
1. 0 to 1 foot of unfossiliferous arenaceous shale.

Units 2, 3, and 4 contain approximately 78 per cent soluble materials and 22 per cent insoluble clastic grains. The clastic fraction is predominantly quartz, but visible quantities of feldspars and micas were present in all samples. The Shafer beds have not been identified in any area other than Shafer Dome and the west flank of the adjacent Cane Creek anticline. Its stratigraphic value under existing knowledge of its areal distribution is restricted to providing a more definite age assignment for the strata with which it is in conformable contact.

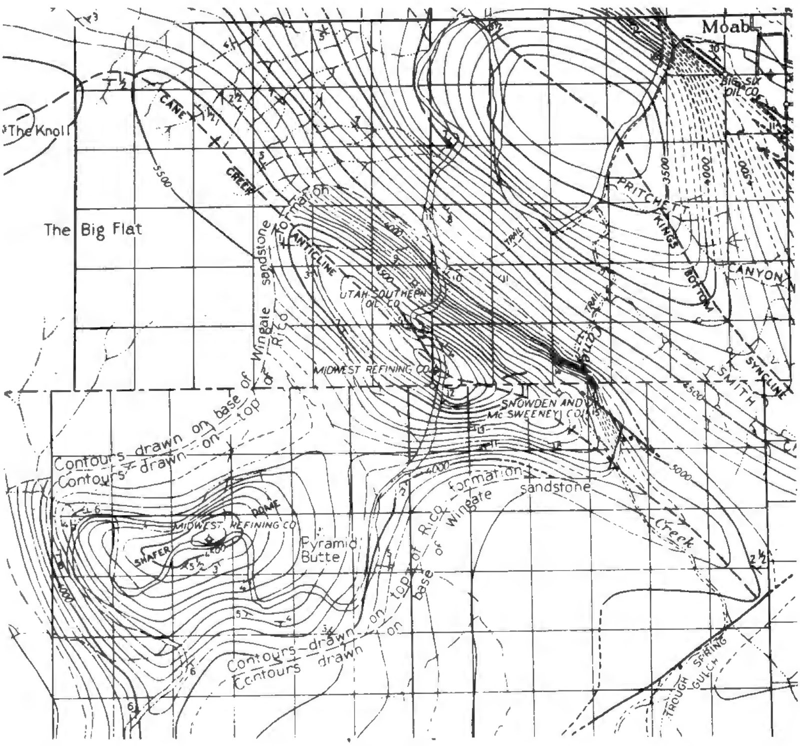

FIG. 3.—Structure contour map of Shafer Dome and the adjacent Cane Creek anticline (portion of map by Baker *et al.*, 1954). In addition, a large portion of Shafer Dome is shown on the geologic map by Hinrichs *et al.* (1967).

Baker *et al.* (1927) studied the stratigraphy of the Moab region and reported the presence of fossils in the formations exposed at Shafer Dome. Their descriptions of the sites at which collections were made are not precise, but it is believed these were on Shafer Dome and the west flank of Cane Creek anticline. Their reported faunal list follows:

> From the Hermosa formation along and near Colorado River a number of collections of fossils were made. These have been examined by Girty, who reports the following species as present in these collections and not occurring in collections made higher in the section.
>
> *Fusulina secalica, Campophyllum torquium, C. kansasense, Lophophyllum profundum, Syringopora multattenuata, Echinocrinus coloradoensis, Delocrinus* aff. *D. texanus, Erisocrinus propinquus, Cyclotrypa barberi, Thamniscus* aff. *T. guadalupensis, Rhipidomella carbonaria, Derbya crassa, Chonetes granulifer, C. geinitzianus, Productus semireticulatus, P.* aff. *P. guadalupensis, Pustula semipunctata, P.* aff. *P. porrecta, Pustula* n. sp., *Marginifera splendens, M. nebraskensis, M. wabashensis, Rhynchopora*

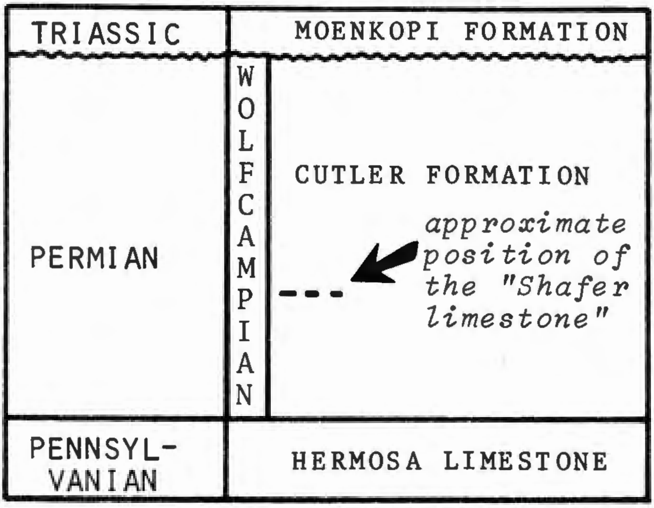

FIG 4.—Simplified stratigraphic chart showing positions of the Cutler Formation and the Shafer limestone in the area of this investigation.

aff. *R. taylori, R. illinoisensis, Pugnoides osagensis, Dielasma* sp., *Spiriferina* aff. *S. gonionotus, Squamularia perplexa, S.* aff. *guadalupensis, Brachythyris* n. sp., *Cliothyridina orbicularis, Hustedia mormoni, Platyceras occidentale*?, *Griffithides* sp.

The fauna, in comparison with that of the overlying beds, is notable for the abundance of brachiopods and the relative scarcity of mollusks. Some species other than those named above do continue on into the Rico formation, though the aspect of the higher fauna is distinct in spite of the common species. Among these common species are:

Stenopora carbonaria, Rhombopora lepidodendrioides, Derbya bennetti, Productus cora, P. pertenuis, Pustula nebraskensis, P. symmetrica, Spirifer triplicatus, Spiriferina kentuckyensis, Composita subtilita, Edmondia gibbosa, Allerisma terminale, Pinna peracuta, Acanthopecten carboniferus, Schizostoma catiloides.

From the Rico Formation along and near Colorado River a number of collections of fossils were made. In these Girty found the following species present which do not also occur in the collections from the Hermosa formation:

Edmondia glabra, E. aspinwallensis, Chaenomya sp., *Sanguinolites costatus, S.* n. sp., *Nucula levatiformis, Yoldia* sp., *Leda arata, Parallelodon* sp., *Pleurophorus* aff. *P. subcostatus, Schizodus curtus, S. curtiformis, S. meekianus, S. compressus, S. wheeleri, Deltopecten occidentalis, Aviculipecten* n. sp., *Myalina subquadrata, M. wyomingensis, Pteria longa, Monopteria marian, M. polita, M.* n. sp., *Posidoniella*? sp., *Lima* sp., *Pseudomonotis equistriata, P. kansasensis, P. sublevis, Astartella subquadrata, Plagioglypta canna, Bellerophon crassus, Patellostium* sp., *Pharkidonotus percarinatus, P. percarinatus* var. *tricarinatus, Bucanopsis meekana, B.* aff. *B. bella, Pleurotomaria* sp., *Euconospira*? *excelsa, Naticopsis deformis, N.*

FIG. 5.—Outcrop of Unit 4, Shafer limestone, Shafer Dome, San Juan County, Utah.

(Diaphorostoma) remex, *Aclisina* sp., *Sphaerodoma hallana*, *Bulimorpha chrysalis*, *Orthoceras* sp., *Pseudorthoceras knoxense*, *Griffithides major*.

These faunas contain no elements that permit closer stratigraphic classification of the Shafer limestone than to say it is probably in the Permian System. No additional forms of stratigraphic significance were found during the field investigations related to this current study and efforts were directed toward a search for microfossils that might resolve the problem (Plates I and II). The search for fusulines was unproductive; one poorly preserved and unidentifiable specimen was recovered. The search for conodonts, on the other hand, was more rewarding, with the following being found: *Spathognathodus minutes* (Ellison), *Cavusgnathus lautus* Gunnell, unidentifiable simple cones, unidentifiable straight denticulate bars. Unfortunately the conodont fauna is composed of long ranging forms and they do not establish the stratigraphic position of the Shafer limestone. The probability that the complete conodont fauna was recovered is remote and it may be that this line of investigation will produce positive results. Additional samples will be processed in the hope that a larger fauna can be established and with it better stratigraphic control in this section.

FIG. 6.—Outcrop of Unit 3, Shafer limestone, Shafer Dome, San Juan County, Utah.

Questions can be raised concerning the relationship of the Shafer embayment to the salt anticlines that were developing at the time the "Shafer limestone" was being deposited. If the anticlines developed in an east to west progression, as proposed by Jones (1959), the site of deposition could have been a mere wrinkle on the western flank of the Cane Creek anticline during that structure's early stage of growth. The anticline would have served as a barrier to westward flowing streams, trapping most of the sediments on its eastern flank; enough clastic material to furnish the quantity found in the "Shafer limestone" could have washed over such a barrier. At the same time, growth of the Shafer Dome and salt structures that exist southwest of it would not have started, permitting the existence of a narrow channel connecting the Shafer embayment with marine waters that existed west and south of the embayment site. Subsequent erosion or burial by thick sequences of younger strata have removed the possibility of locating this channel, if one existed in the form postulated here; the rather aberrant nature of the Shafer limestone fauna does not permit productive comparisons with the normal fauna of marine units in adjacent areas.

FIG. 7.—Outcrop of Unit 2, Shafer limestone, Shafer Dome, San Juan County, Utah.

The presence of conodonts in the samples processed provides the incentive for a more exhaustive study of the Shafer limestone and the search for marine strata that may have passed unnoticed in adjacent areas where the Cutler Formation is exposed. If more abundant and definitive faunal collections can be made, the possibility exists that the order in which the salt anticlines formed could be established. This approach will be pursued in future field investigations.

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PLATE I

(All figures × 0.6)

1-2 *Linoproductus* sp.
3-4 *Juresania nebrascensis* (Owen)
5 *Juresania symmetrica* (McChesney)
6-7 *Linoproductus* sp.
8-11 *Neospirifer cameratus* (Morton)
12-13 *Composita subtilita* (Shepard)

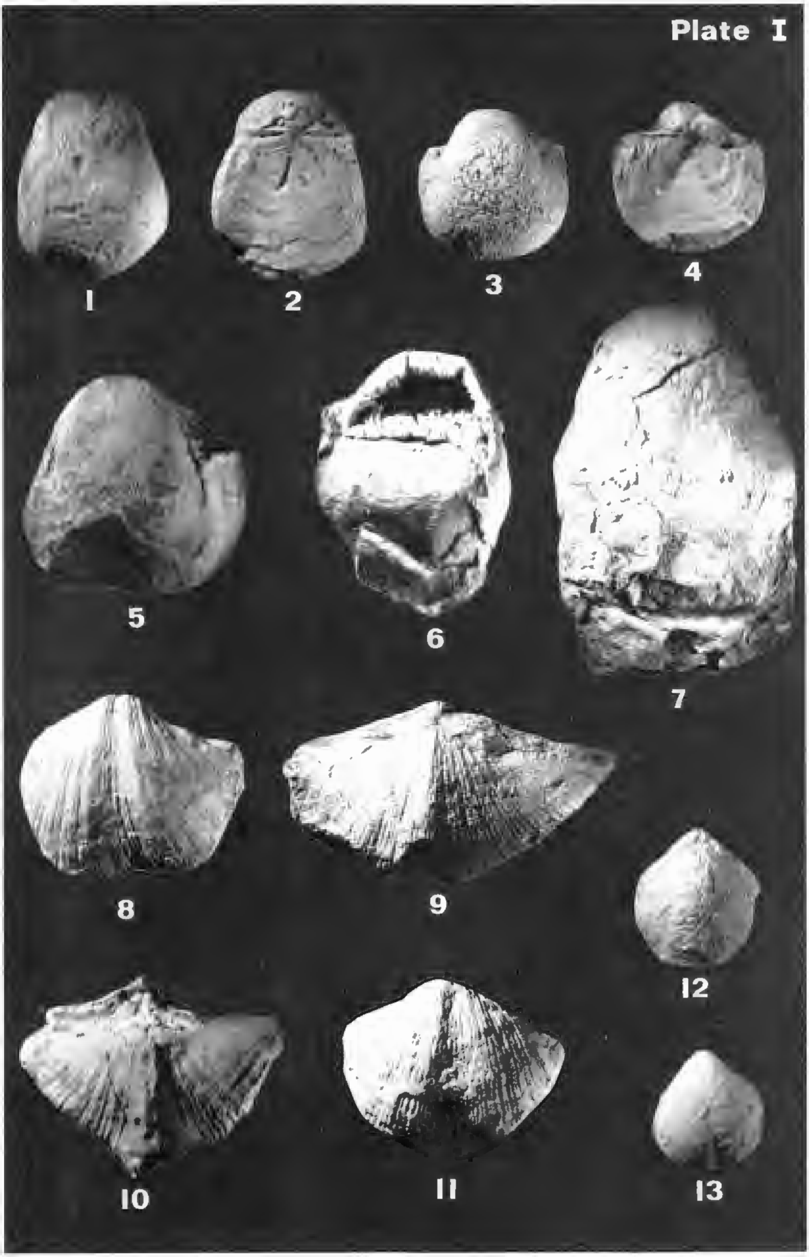
Plate I
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PLATE II

(All figures $\times$ 0.6)

1 *Myalina subquadrata* Shumard
2 *Myalina* sp.
3 *Shansiella* sp.
4 *Astartella* sp.
5 *Edmondia* sp.
6-7 *Allorisma terminale* Hall
8 *Orthoceras (?)* sp.
9 *Amphiscapha catilloides* (Conrad)
10 *Bellerophon crassus* Meek and Worthen
11-12 *Euconospira* sp.

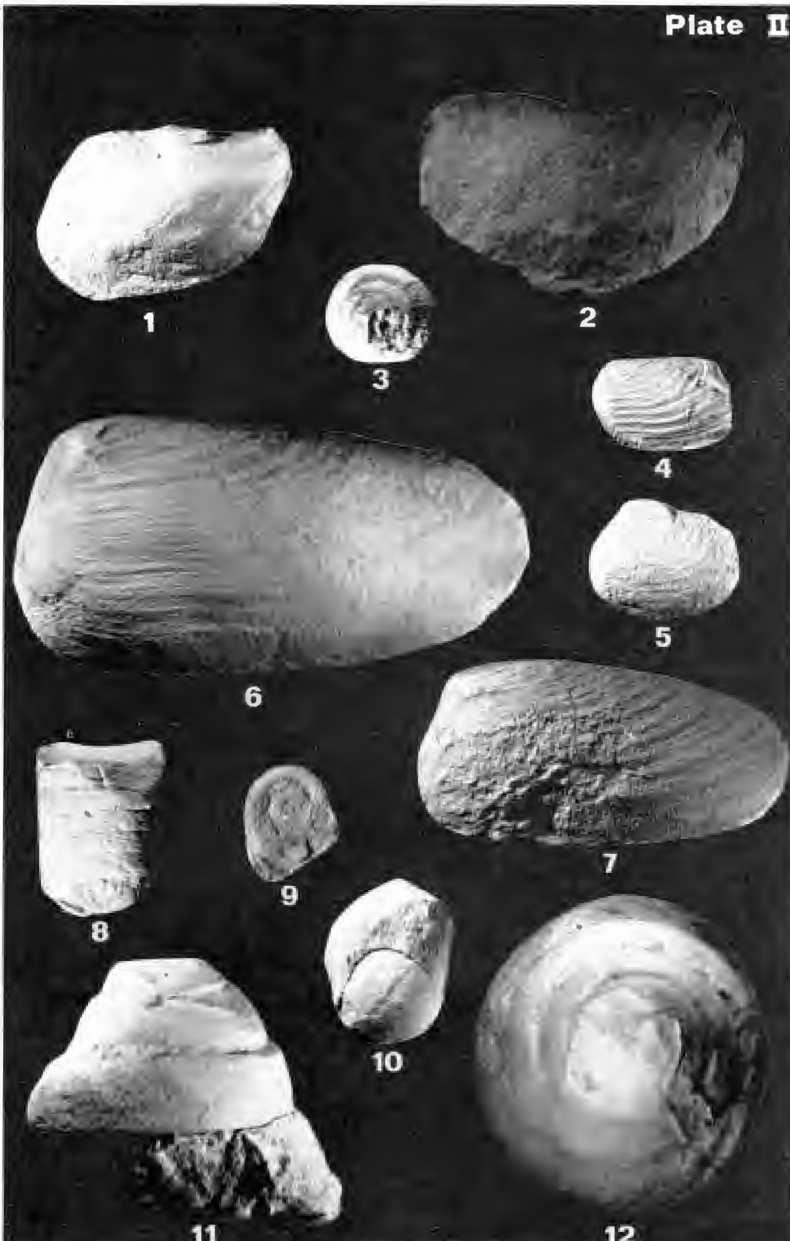
Plate II
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