Fold Relationships Within Evaporites of the Cane Creek Anticline, Utah

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ABSTRACT

At the Cane Creek mine in southeastern Utah, Texas Gulf Sulphur Company mines potash from the Paradox Member of the Pennsylvanian Hermosa Formation. The potash bed consists of regular alternations of sylvinite (sylvite + halite) layers 1 to 6 inches thick and anhydrite laminae less than 1/8 inch thick. The ore is overlain by about 40 feet of shaly dolomite-anhydrite and is underlain by about 140 feet of salt.

Locally, the shaly dolomite-anhydrite bed and the potash bed have been deformed into folds having a wavelength between 100 and 400 feet and an amplitude from 20 to over 100 feet. The anhydrite laminae in the sylvinite and salt beds below contain smaller folds which are related to the folds in the overlying dolomite-anhydrite. The minor folds have a uniform sense of asymmetry, their limbs are attenuated and broken, and the intensity of the folding in the sylvinite and salt increases downward from the dolomite-anhydrite. The most severe minor folding occurs where the overlying dolomite-anhydrite is itself folded.

Early in the history of sedimentation of the Paradox Member, a compressive stress buckled the anhydrite laminae in the sylvinite and halite. As burial and deformation proceeded, the early buckles were modified by passive flow. Ultimately the anhydrite-dolomite bed was folded, the compression in the cores of the resultant anticlines causing severe folding and minor faulting in the anhydrite laminae in the sylvinite and halite below.

INTRODUCTION

In late 1964, Texas Gulf Sulphur Company began mining potash on the Cane Creek anticline in southeastern Utah. Shortly after mining began, the Company found that numerous smaller folds existed on the major anticlinal structure.

As development work exposed more of the potash bed, it became apparent that several types and styles of folding were present. A special study was undertaken during the summer of 1967 to try to determine if these smaller folds were related to each other and to the Cane Creek anticline. This paper presents the results of the investigation.

The authors thank Texas Gulf Sulphur Company for permission to publish the results of their study. Special thanks are also due Messrs. George R. Grandbouche, Robert J. Hite, and Philip A. Van Alstine. Messrs. Grandbouche and Hite prepared detailed stratigraphic sections of the potash bed, upon which the numbering system for individual sylvinite layers (sylvite + halite) and anhydrite laminae is based. Mr. Van Alstine prepared the structure contour maps drawn on the base of the marker bed overlying the potash horizon. His maps served as a point of departure for the present study.

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GENERAL GEOLOGY

The Cane Creek anticline is one of many anticlines in the Paradox basin of southeastern Utah and southwestern Colorado (Fig. 1). At the surface, the crest of the anticline trends about N.60°W., and the limbs dip between 5 and 10 degrees. The oldest rocks exposed at the surface on the eroded crest are limestones of the Upper Member of the Hermosa Formation of Pennsylvanian age. The top of the salt of the underlying Paradox Member occurs at a depth of about 2000 feet below the crest of the anticline. The base of the salt rests on the Lower Member of the Hermosa Formation at a depth of about 7000 feet, as shown on the generalized stratigraphic section in Figure 2.

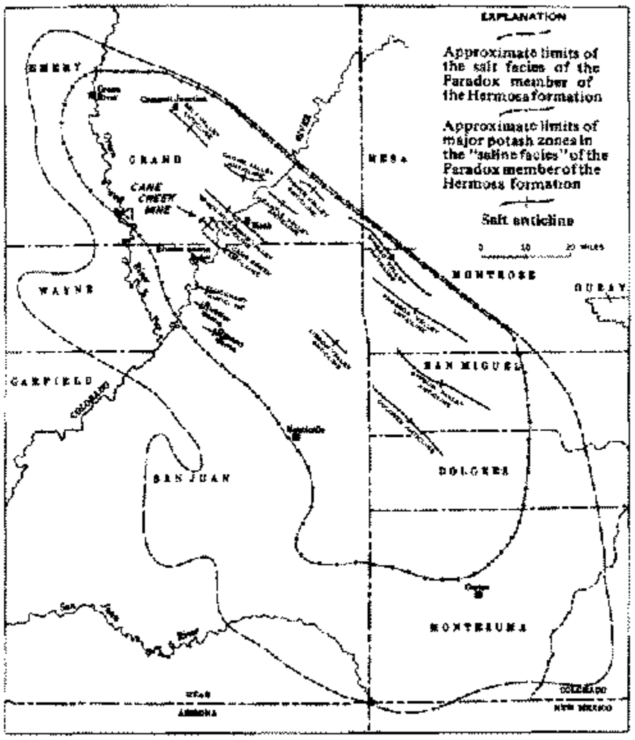

Figure 1. Location map of the Cane Creek anticline, modified from Hite (1961).

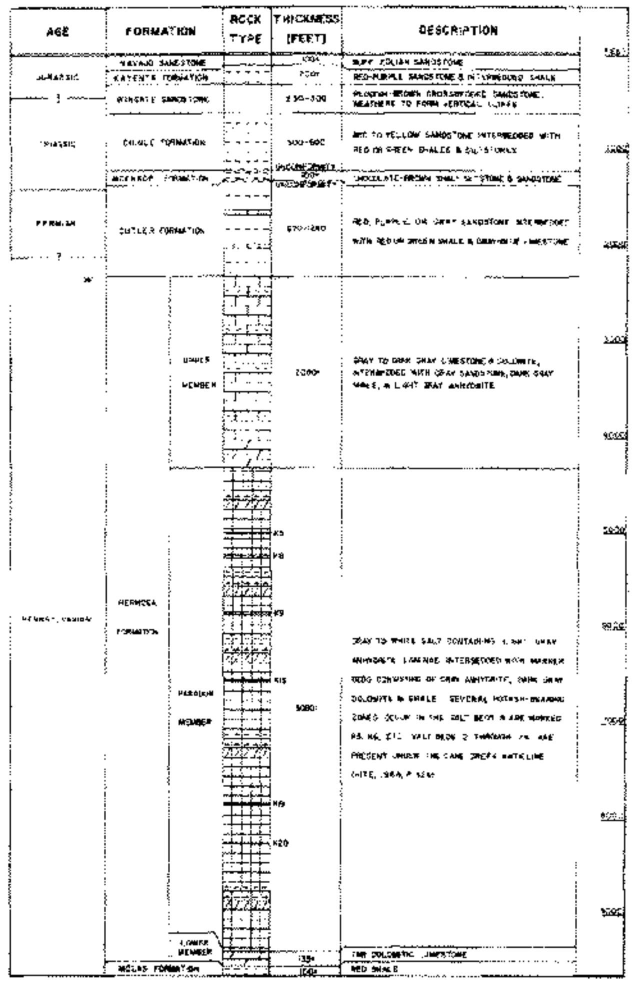

Figure 2. Generalized stratigraphic section of the Cane Creek area, modified from Davidson and Kerr (1968).

The Paradox Member is about 5000 feet thick in the Cane Creek anticline. Regionally, the member contains 29 or more distinct salt beds, separated from each other by marker beds consisting of variable combinations of anhydrite, shale, mudstone, siltstone, and dolomite.

Hite (1960) assigned a number to each salt bed, starting with 1 at the top. The marker beds between salt beds have been referred to informally as "clastics," to differentiate them from the salt beds. Many of the beds referred to as clastics actually consist mainly of anhydrite and dolomite, so the term "clastic" is often a misnomer. Vertical gradations from anhydrite and dolomite to shale, mudstone, and siltstone are common, making it difficult to assign a suitable name to these marker beds (Hite, 1960). To overcome this difficulty, Hite (1968, personal communication) suggested that these beds be referred to simply as "marker beds."

The stratigraphic nomenclature used in this report incorporates Hite's numbering system for salt beds and also assigns numbers to the marker beds underlying the various salt beds. Hite (1960) found that potassium salts occur in at least 18 of the 29 salt beds, usually near the tops of the salt beds. These potash-bearing zones are numbered the same as the salt bed in which they occur, but are prefixed with "K." "S" is used as an abbreviation for salt (halite rock) and "M" for marker beds. The numbering system we have chosen for the various beds in the Paradox Member is shown in Figure 3.

In the Cane Creek area, Salt 1 is absent. Either it was not deposited or was deposited and later dissolved away. The potash zone presently being mined is K5, near the top of Salt 5. Marker bed M4, consisting mainly of anhydrite, dolomite, and shale is about 40 feet thick and lies above K5. A stratigraphic section of the beds of interest in the Cane Creek area is shown in Figure 4.

The potash mine is served by two shafts sunk on the northeast flank of Cane Creek anticline, shown schematically in Figure 5. The shafts are bottomed in the Upper Hermosa limestone, about 30 feet above the Paradox salt, which in this location is Salt 2. Inclined entries were driven down from No. 1 shaft to intersect the K5 potash zone at a distance of 3000 feet from the shaft.

STRATIGRAPHY OF THE K5 ORE ZONE

During initial mining, the potash bed underground appeared to consist of a monotonous sequence of sylvinite layers from 1 to 6 inches thick separated by thin anhydrite laminae less than 1/8 inch thick. Studies of the ore showed a readily identifiable micro-stratigraphy throughout the mine to which a numbering system was applied. The sylvinite layers were given even numbers and the anhydrite laminae--called "bands" by the miners--were given odd numbers.

A particularly prominent anhydrite band about seven feet below the Marker bed M4 was arbitrarily assigned the number 99. The numbering scheme for the bands is largely the work of Grandbouche and Hite, and is shown in Figure 6. The anhydrite band that has been most useful to the miners and most easily recognized is the 139 band. Above 65 band the ore is partially recrystallized so that bedding is difficult to discern. A disconformity separates the top of the ore from an overlying thin salt bed. The contact between the thin salt bed and marker bed M4 is also a disconformity.

BED	SYMBOL	REMARKS
Salt 1	S1	
Marker bed 1	M1	
Salt 2	S2	
Marker bed 2	M2	
Salt 3	S3	
Marker bed 3	M3	
Salt 4	S4	INTERVAL STUDIED
Marker bed 4	M4	
Potash bed 5	K5	Potash bed being mined at Cane Creek Mine
Salt 5	S5	
Marker bed 5	M5	
Potash bed 6	K6	
Salt 6	S6	
Marker bed 6	M6	
Salt 7	S7	
Marker bed 7	M7	
Salt 8	S8	
Marker bed 8	M8	
Potash bed 9	K9	
Salt 9	S9	
Marker bed 9	M9	
Salt 10	S10	
Marker bed 10	M10	"A" marker of local usage
Salt 11	S11	
Marker bed 11	M11	
Salt 12	S12	
Marker bed 12	M12	
Potash bed 13	K13	
Salt 13	S13	
Marker bed 13	M13	"B" marker of local usage
Salt 14	S14	
Marker bed 14	M14	
Salt 15	S15	
Marker bed 15	M15	"Black Oil" zone of local usage
Potash bed 16	K16	
Salt 16	S16	
Marker bed 16	M16	
Salt 17	S17	
Marker bed 17	M17	
Potash bed 18	K18	
Salt 18	S18	
Marker bed 18	M18	
Potash bed 19	K19	
Salt 19	S19	
Marker bed 19	M19	"C" marker of local usage
Potash bed 20	K20	
Salt 20	S20	
Marker bed 20	M20	
Potash bed 21	K21	
Salt 21	S21	
Marker bed 21	M21	"Cane Creek" marker of local usage
Potash bed 22	K22	
Salt 22	S22	
Marker bed 22	M22	
Salt 23	S23	
Marker bed 23	M23	
Salt 24	S24	
Marker bed 24	M24	
Salt 25	S25	
Marker bed 25	M25	
Salt 26	S26	
Marker bed 26	M26	
Salt 27	S27	
Marker bed 27	M27	"D" marker of local usage
Salt 28	S28	
Marker bed 28	M28	
Salt 29	S29	
Marker bed 29	M29	

Figure 3. Nomenclature used in this report for beds in the Paradox Member of the Hermosa Formation.

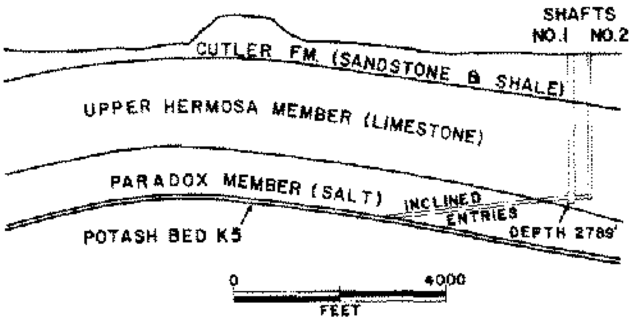

Figure 4. Stratigraphy of upper part of Paradox Member in the Cane Creek Area.

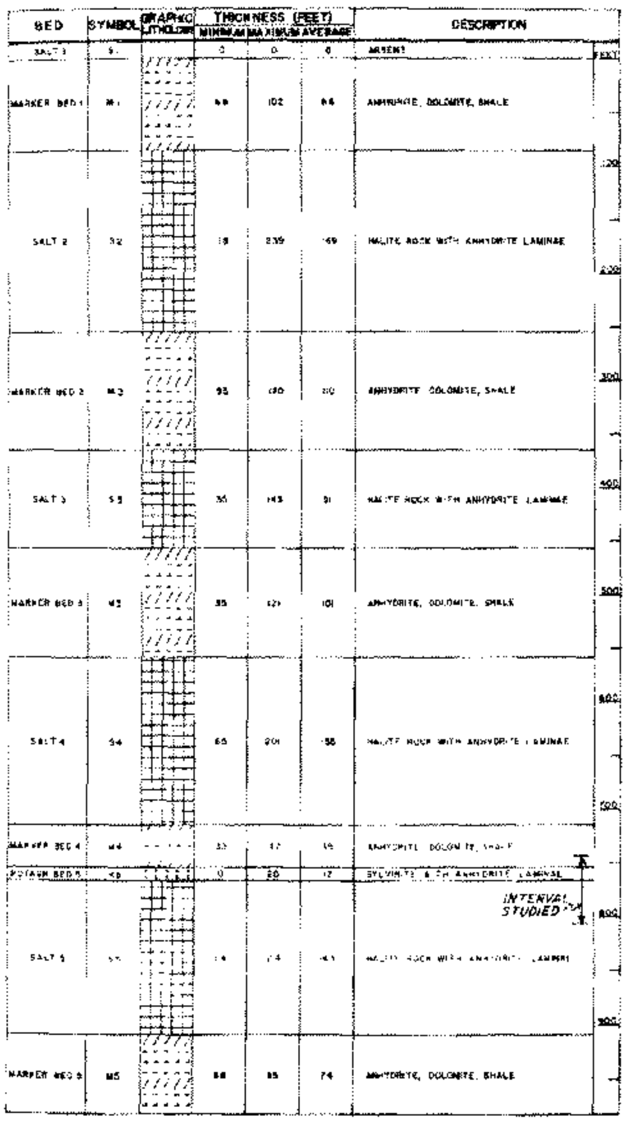

Figure 5. Schematic cross section through the Cane Creek anticline (looking northwest).

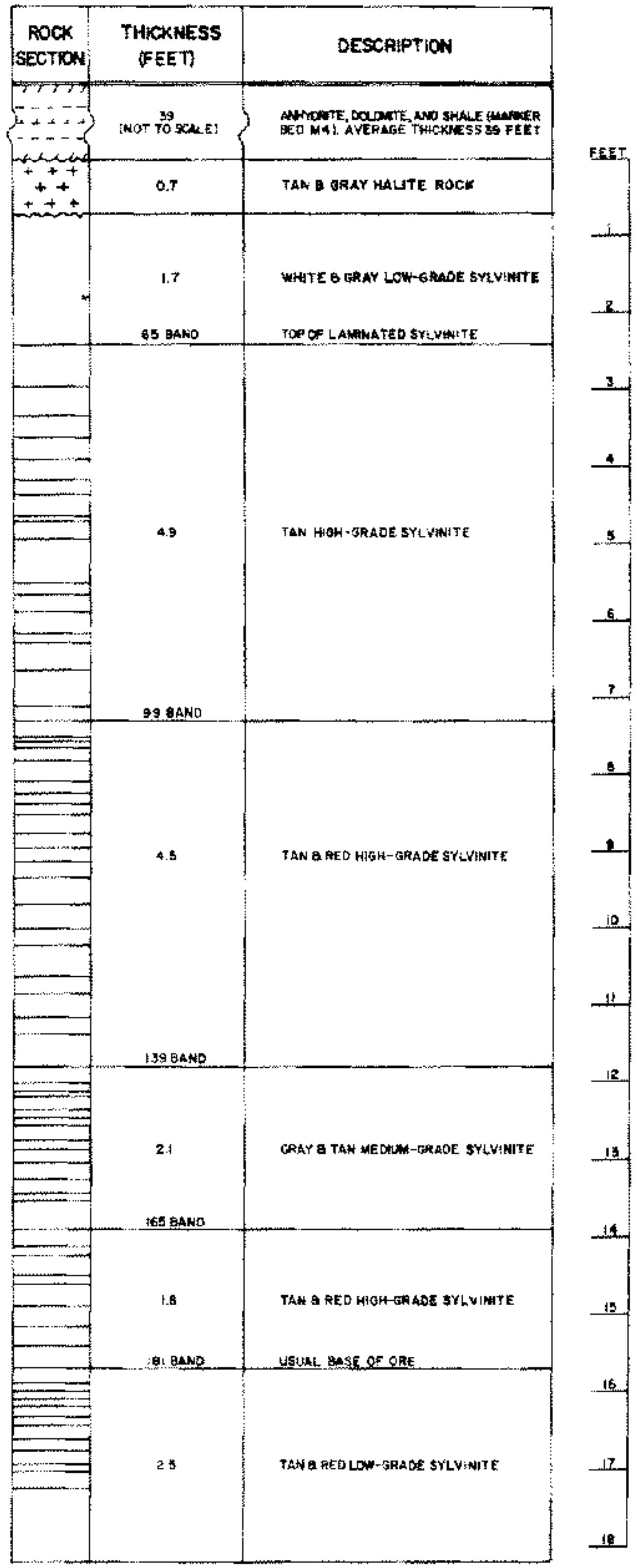

Figure 6. Stratigraphy of the K5 potash zone.

GEOLOGY OF THE FOLDED BEDS

Fold classification within the Cane Creek Anticline.

In studies of folded rock sequences, it has been found that various orders of fold sizes exist (e.g., De Sitter, 1956; Prucha, 1967, 1969). The method of determining the various orders of periodicity in a folded layer is straightforward (Ramsay, 1967, p. 354, 355) and applied to the folding within the Cane Creek anticline, produces a convenient scheme of classification of the structures.

The Cane Creek anticline, the major fold, is termed the first-order fold. In marker bed M4 are second-order folds with wavelengths up to 400 feet. They affect the ore and salt immediately below and their orientation differs from that of the first-order fold.

The anhydrite laminae within the potash bed have also been deformed into folds of even smaller wavelength, no more than several feet. These are third-order folds and, as depicted in Figure 7, are complicated by fourth-and fifth-order folds. Figure 8 shows in a diagrammatic way the various fold orders within the Cane Creek anticline.

Throughout the mine, anhydrite laminae exhibit small asymmetrical crenulations (Figs. 7, 11) which have amplitudes and wavelengths of less than 1 inch.

Characteristics of the folds in the anhydrite laminae.

Figure 10 is a plan and structure contour map of that part of the Cane Creek mine considered in this investigation. The relationship between the folds in marker bed M4 and the folds in the anhydrite laminae of K5 and S5 was studied along the section marked A-A'. Figure 11 (in pocket) is a section of the folds in the marker bed and the anhydrite laminae, and was prepared from a tracing of a series of photographs of the entire section studied.

The anhydrite laminae display certain features common to the third-, fourth-, and fifth-order folds:

(1) Each fold along the study section, even the smallest crenulation, has an identical sense of asymmetry or overturning (Figs. 7, 11).

(2) The anhydrite laminae are attenuated and broken, especially on the limbs of folds. The degree of attenuation varies along the section studied and provides information on the nature of the folding. This feature will be discussed below in greater detail.

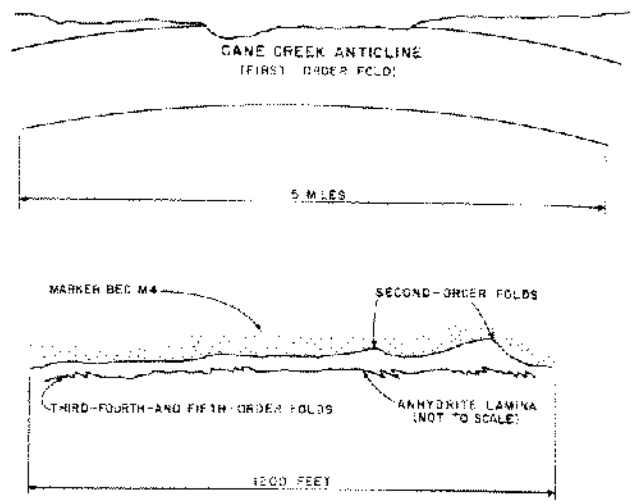

Figure 8. Fold orders in the Cane Creek anticline.

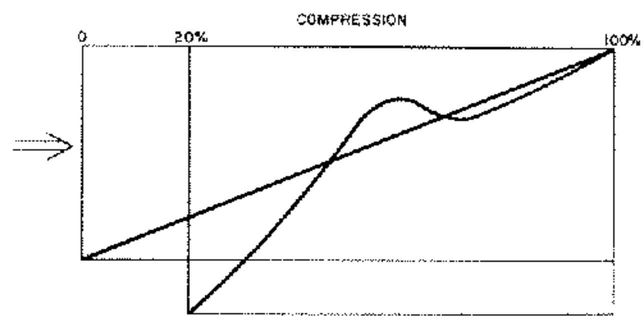

Figure 9. Diagram illustrating the shortening of a tilted layer by compression (adapted from de Sitter, 1958).

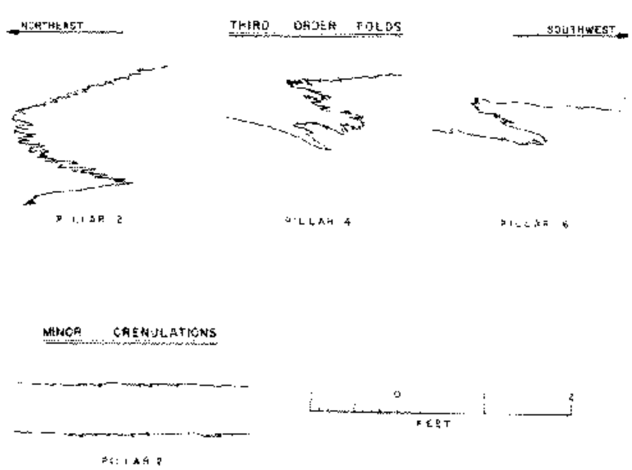

Figure 7. Folds in anhydrite laminae.

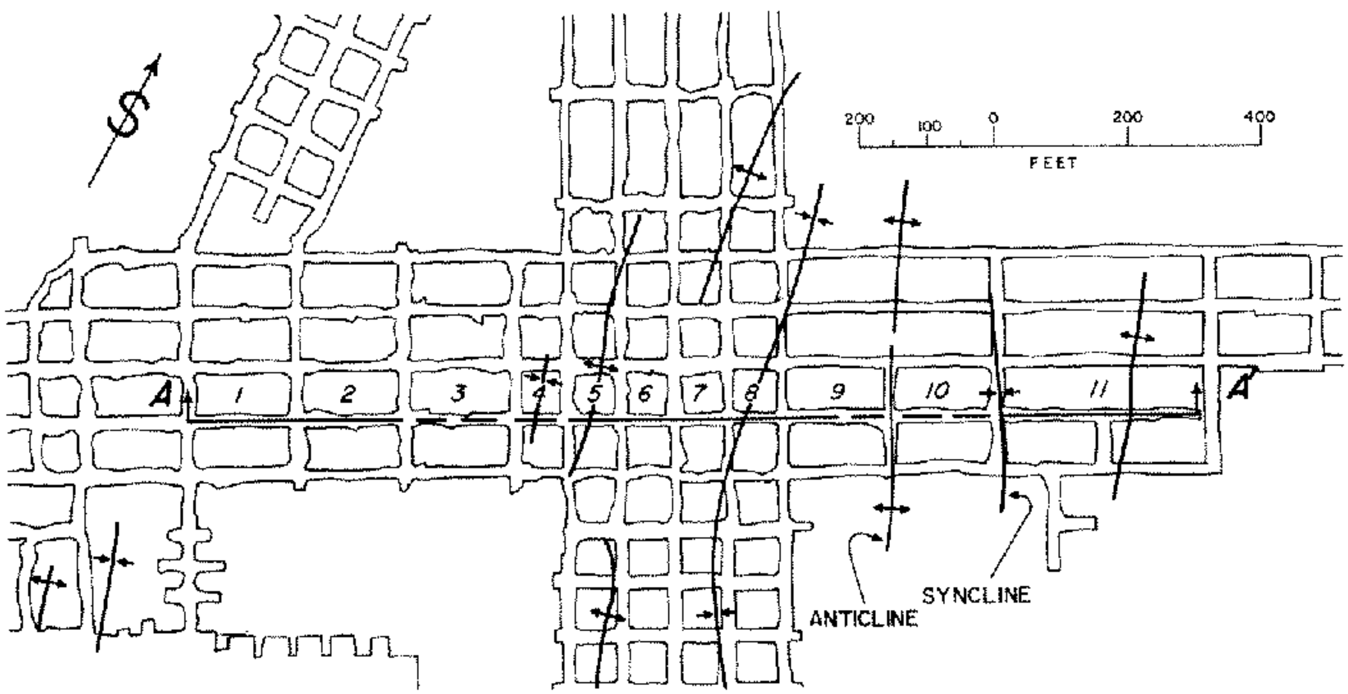

Figure 10. Location map of cross section A-A'. Pillars are numbered 1 through 11.

(3) Individual third- and fourth-order folds can be traced downward stratigraphically from anhydrite lamina to anhydrite lamina. However, the amplitude of the folds low in the potash bed and in the salt (Fig. 6) is greater than that of folds stratigraphically higher. The intensity of the folding increases downward from marker bed M4.

There is a definite relationship between the second-order folds in marker bed M4 and the third-, fourth- and fifth-order folds in the anhydrite laminae in and below the potash bed. Stated simply, where the marker bed is horizontal or gently dipping, the only manifestations of deformation in the potash horizon are the minor crenulations (Figs. 7, 11; pillar 3). Where marker bed M4 is folded or is steeply dipping, as, for example, on the inclined limb of a monocline, more severe third-order folds in the anhydrite laminae can be seen (Fig. 11; pillars 1, 9).

It has been noted above that the size and severity of the third-order folding in the anhydrite laminae increase away from marker bed M4. However, at two places on the section, large third-order folds appear high enough in the potash bed to have affected the 139 band (see Fig. 6). It is significant that these folds affect anhydrite laminae high in the potash bed only where the rock of marker bed M4 has been deformed into an anticline (Fig. 11; pillars 9, 10, 11).

The attenuated limbs of the third-order folds in the anhydrite laminae testify to the fact that slip-folding was the mechanism by which many of the minor folds in the evaporites were formed (Carey, 1962; Donath and Parker, 1964). The folds closely approximate the similar fold model (Van Hise, 1896) in which successive S surfaces (in this case S_0 or bedding) have similar profiles (Fig. 12). This fold type is well-displayed in metamorphic rocks, which at the time of deformation were in a very ductile state; and is to be expected in evaporites, rocks which display remarkable mobility.

Along the section studied, and throughout the mine workings, individual sylvinite or halite units thin towards second-order synclines and thicken towards second-order anticlines. This plastic flow of the sylvinite and halite has modified the similar-type third-order folds in the anhydrite laminae along much of the section.

The attenuation of the anhydrite laminae on the limbs of third-order folds has been so severe in places as to produce incipient transposition structures—fold structures in which the fold nose has been separated completely from the remainder

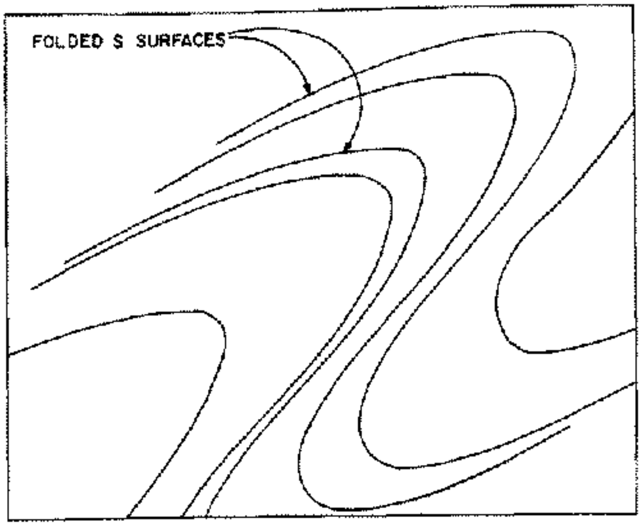

Figure 12. Geometry of idealized similar fold seen in profile.

of the structure (Knopf, 1938, p. 189,190; Whitten, 1966, pp. 81-215), e.g., pillar 6 (Fig. 11).

The third-order folds affecting the anhydrite laminae near the 139 band in the potash bed are not characterized by severe limb attenuation. The anhydrite laminae retain their continuity along limbs and in fold noses, except for some attenuation of the middle limb of a three-limb anticline-syncline structure (Fig. 11, pillar 9).

The westernmost 150 feet of pillar 11 (see Fig. 11) is in the salt below the potash. This part of the section is in the core of a large anticline in marker bed M4. At this location, the folding of the anhydrite laminae is the most severe of the entire study section, yet the attenuation so characteristic of the folds elsewhere is not present. It appears that there was not the severe plastic movement of the salt here that there was along the remainder of the study section.

ORIGIN AND DEVELOPMENT OF THE FOLDING IN THE CANE CREEK ANTICLINE

Detailed structural data indicate that the origin of the minor symmetrical and asymmetrical folds associated with larger folds is not as simple as the term "drag fold" implies. De Sitter (1956, p. 57; 1958, p. 279-280) indicated that those minor folds which occur on the flanks *and* crests of major folds could not have been produced by drag because bedding-plane slip is absent at the fold hinge during flexural-slip folding. Ramberg (1963a, p. 98; 1963b, p. 504) considers that compression plays a crucial part in the evolution of minor folds, and De Sitter (1958, p. 280, 281) suggested that asymmetrical folds would develop if the particular bed had a slight dip at the start of the compressive process (Fig. 9). Because drag was not important in the development of these minor folds, De Sitter (1958), employing a term coined by Shearman, substituted the name "parasitic folds." The term has become well-established in the literature (Whitten, 1966; Ramsay, 1967; Howard, 1968) and is used throughout this report.

The following aspects of the structures in marker bed M4, the potash and the salt require explanation:

(1) The cause of the second-order folding.

(2) The uniform sense of asymmetry in the third-order parasitic folds and crenulations.

(3) The fact that the greater the distance from marker bed M4, the more severe the deformation of the anhydrite laminae.

(4) The lack of limb attenuation in the anhydrite laminae of the halite core of the second-order anticline at the end of the study section (Fig. 11, pillar 11).

(5) The appearance of third-order folds within the potash bed where marker bed M4 has been deformed into an anticline.

There have been few detailed studies of the deformation of beds of halite or sylvinite associated with more competent dolomitic, anhydritic or clastic units. The study of a diapiric Mississippian halite and anhydrite sequence in Nova Scotia (Evans, 1967) has little relevance to the present investigation for at Cane Creek the sylvinite and halite beds of the Paradox Member have not breached the overlying competent units. The deformation of an interbedded halite and marly claystone sequence at Zipaquira, Colombia, has been studied but not yet reported (McLaughlin, 1968, written communication).

The only work which is of use for comparative purposes is that of Prucha (1967, 1969) in the Silurian salt exposed in a mine in the Firtree Point anticline in central New York. As at Cane Creek, minor second- and third-order folds complicate the major structure. The folding in the Firtree Point anticline is disharmonic through a stratigraphic interval of 700 feet, a style of folding which has been suggested for the Cane Creek structure (Hite, 1968, p. 325), but which cannot be demonstrated from within the mine workings. In both Cane Creek and Firtree Point, initial folding was controlled by the competent units, a process which is characteristic most competent/incompetent sequences illiams, 1961, p. 321, 322).

The folding of layered rock sequences has been : subject of recent theoretical and experimental /estigations, many of which are applicable to this scussion of the folding at Cane Creek. Biot 964) considered the effect of layer-parallel com- ession on a laminated medium confined between /o rigid straight boundaries. Perfect slip was as- med at the rigid wall, so that compressive flow as restricted to the multilayered structure. Biot .owed that during compression, folding of the nfined multilayer sequence would occur, and iat the folding died out at the top and bottom nfining walls (Fig. 13). In this simple model, the itial folding of the multilayer was complicated ightly by interstitial flow along the direction of ie layer, where one type of material in the lam- iated sequence was very soft in comparison with ie other. In a sequence of anhydrite laminae and ylvinite layers, the sylvinite will be considerably iore mobile than anhydrite (Lotze, 1957, p. 31-333).

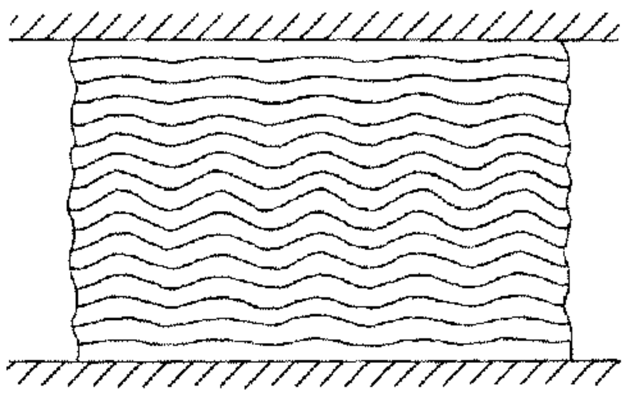

Figure 13. Internal buckling of a multilayered medium under rigid confinement (from Biot, 1964).

The buckling of multilayers sandwiched be- tween straight beds was considered also by Ramberg (1963, 1964). In this case, the multilayer sequence was separated from the rigid walls by thick slabs of soft material. Although this situation is rather unrealistic geologically, it is nevertheless of interest because Ramberg showed that the folding of the multilayer preceded the folding of the confining layers, a sequence of events duplicated in the later study by Biot (1964). The wavelength of the folds that develop has been shown to be dependent on layer thickness (Fig. 14, from Currie *et al*, 1962), and the fold wavelengths in the third-order folds at Cane Creek (Fig. 7) are clearly of the right order of magnitude to fit the graph in Figure 14.

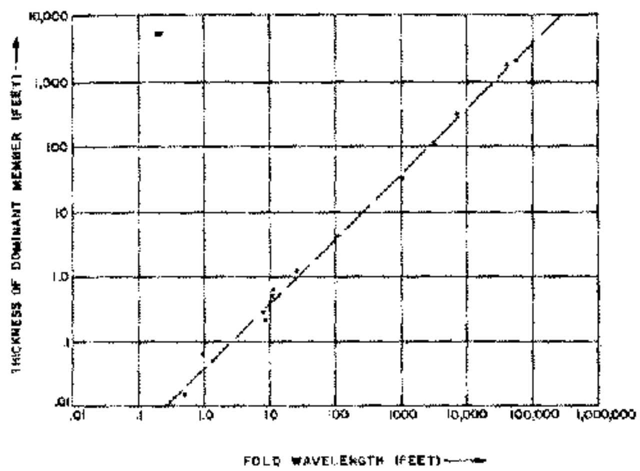

Figure 14. Log-log plot of the wavelength to thickness relationship (from Currie *et al*, 1962).

It is important to consider the circumstances under which folds of uniform asymmetry might develop. De Sitter (1958) showed that the folds in any bed which had a slight dip at the start of the compressive process would necessarily be asymmetric (Fig. 12). In a series of experiments of buckling of multilayers, Ghosh (1968) noticed that when the maximum compressive shortening was at a low angle to the layering, the folds in the multilayer developed asymmetric shapes. He demonstrated also that after initial compression had folded a multilayer, further application of the same stress produced large folds in the embedding medium. The shear strain which resulted from the growth of the large folds obliterated early small folds on the flanks of the larger structures and left the minor folds localized towards the cores of the major structures (Ghosh, 1966, 1968).

The writers are aware that none of the above theoretical or experimental work reproduces exactly the conditions pertaining during the deformation at Cane Creek. Neither experimental work, however complex, nor mathematical discussion, however free of simplifying assumptions, can hope to treat of all the variables that existed when a multilayer of thin competent and thicker incompetent units, sandwiched between strong beds, was subject to repeated and variable tectonic stresses. However, such experimental and theoretical considerations are of some use in a qualitative way in this attempt to understand the processes involved in the deformation at Cane Creek.

The formation of the Cane Creek structure has been described by Hite (1968), who based his determinations upon the drillhole data which accrued as a result of the extensive drilling in the area for potash and petroleum. The Cane Creek area was a structural low which was downwarped during salt deposition. Initial upward growth of the structure began during the later stages of salt deposition. Folding of salt beds arched the upper salt units into an anticlinal form.

The writers believe that the following sequence of events explains the structures now seen in the Cane Creek anticline. The sequence is not in conflict with the history of deformation previously interpreted from drillhole information.

The folds and crenulations in the anhydrite laminae of sylvinite (K5) were formed shortly after deposition. This is also true for minor crenulations in anhydrite laminae of Salt 5 and Salt 4. In the inclined entries from the shaft to the potash mining horizon, the eroded top of Salt 4 is exposed, and here can be seen truncated folding and truncated crenulations. It appears that a compressive stress was acting even during the deposition of the uppermost salt units.

If the foregoing discussion of theory and experiment be considered, then the third and higher order folds should vanish at the bounding marker bed M4 (Fig. 13) and the asymmetry of the folds should be the result of compression of a slightly dipping layer (De Sitter, 1958; Ghosh, 1968). This is not unreasonable, for Hite (1968) argues quite logically that the basin of accumulation was undergoing downwarping at the time when deposition of the upper salt beds was still in progress, but there is no way that one can determine the location of the axis of the trough with any accuracy.

The origin of the compressive stress that caused the folding within the evaporites of the Cane Creek anticline is perhaps beyond the scope of this report. It is pertinent, however, to mention that two possibilities exist: (1) Compression on a regional scale has been suggested by Hite (1968), who indicated that the rise of the evaporite masses complicated the early-formed compressional features. (2) If the Cane Creek depositional area was being downwarped during the accumulation of the evaporite units, then the later rise of those units would necessarily produce a shortening (compression) of individual layers within the sequence. Compressional stress in the younger layers might, therefore, be the result of upward movement of older evaporites.

Donath and Parker (1964) explained that the mechanism of fold formation was a function of rock type, the environmental conditions pertaining during deformation, and the relative ductility of each of the rocks involved. The ductility of the rocks can, of course, change with changing environmental conditions during the course of deformation. Figure 15 (from Donath, 1963) expresses neatly the qualitative relationship between fold mechanism and rock ductility.

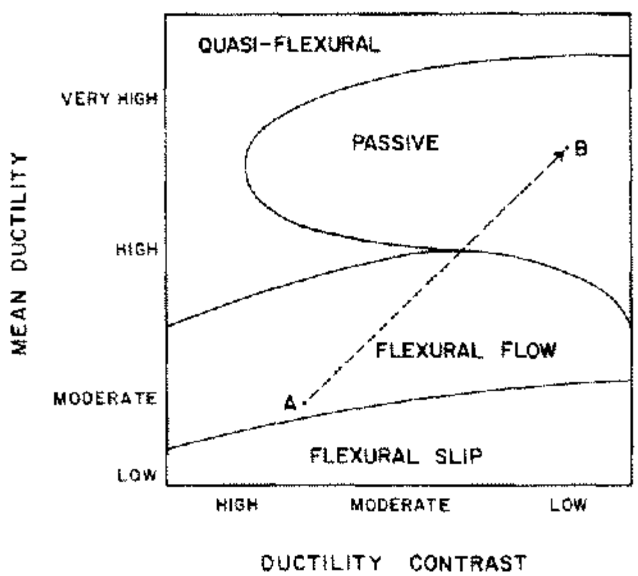

Figure 15. Fields of folding related to mean ductility and ductility contrast (from Donath, 1963).

During the early deformation at Cane Creek, there would have been little overburden above the evaporite section. Under such circumstances, the ductility contrast between anhydrite laminae and adjacent sylvinite/halite layers would be moderate to high, and the mean ductility would be low to moderate (i.e., point A on Fig. 15). Folding would be by flexural flow: the anhydrite laminae would control the shape of the folds, but there would be considerable flow within the adjacent layers of sylvinite/halite to allow these incompetent units to accomodate themselves to the developing fold form (Williams, 1961).

As the burial of the Paradox Member proceeded, the environment of deformation of the Cane Creek sequence was changed. Increasing temperature and pressure increased the ductility of the evaporite units to such a point that the mean ductility was high or very high, and the ductility contrast was low (point B on Fig. 15). The mechanism of folding of the anhydrite laminae and the sylvinite or halite layers would, under such circumstances, be passive flow (Donath, 1963; Donath and Parker, 1964); the layering or anhydrite laminae would exert no control on the deformation, and the slip folds or similar folds so abundantly displayed on the study section (Fig. 11) would be formed, as would the incipient transposition structures.

The change in environment of deformation (Fig. 15, A-B) during the development of the Cane Creek anticline provides a suitable explanation for the apparent discrepancy in the mechanical behavior of the anhydrite laminae. The laminae had to be strong enough to transmit a horizontal compressive stress to form the original buckles, yet had to be ductile enough at a later stage to permit the modification of the early folds by passive flow.

Continued compression of the developing Cane Creek anticline and movement of the salt (Hite, 1968) caused the folding of the marker bed M4. As shown by the theoretical discussion of Biot (1964), initially the potash bed and perhaps the uppermost of the salt/anhydrite sequence (Fig. 6) would not be folded. However, with the development of anticlines in marker bed M4, in the cores of which the stresses would be the greatest, the uppermost salt and the ore would become affected and would be folded by the same passive flow mechanism that modified the early-formed buckles. Simply stated, the incompetent material in the core would be squeezed by the limbs of the fold in the competent bed (see Ramberg, 1961, p. 407). The protection that marker bed M4 afforded the anhydrite laminae during the early compressional stage would no longer be sufficient to prevent the folding of the laminae in the core of the second-order anticlines. In addition, there would be movement of material towards anticlines and away from synclines, producing thickening and thinning along the section.

An indication that the stress in the core of the anticlines was very severe is provided by three small faults in the section beneath the largest of the structures studied (Fig. 11, pillar 11; Fig. 16). Odé (1960) described a process of deformation by which faulting in sedimentary rocks could have originated in response to ductile rather than brittle rock properties. A rock being deformed by flow or

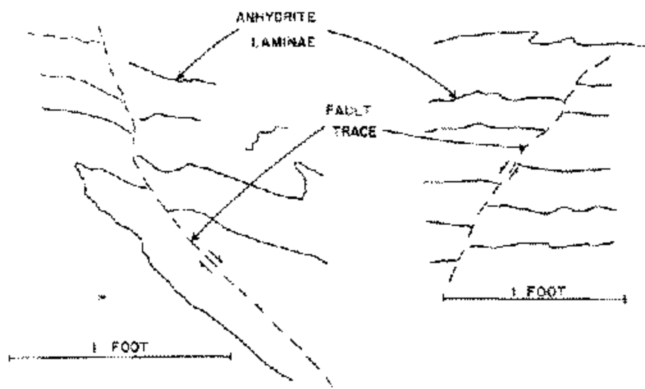

Figure 16. Ductile faults in salt below potash bed.

slip might be faulted without fracture in the ordinary sense, because macropscopically discontinuous flow, when concentrated in a narrow zone, produces a ductile fault (Odé, 1960; Williams, 1961; Donath and Parker, 1964). Faults in incompetent materials like sand and clay can be interpreted as velocity discontinuities arising during flow, for "If such a velocity discontinuity is present, it will appear that the plastic medium, after flowing for some time, has been faulted along the discontinuity." (Odé, 1960, p. 311). It has been suggested above that at the time the second-order folds in marker bed M4 were produced, the anhydrite and salt/sylvinite sequence was in a very ductile state, and was subjected to such passive flow deformation.

The sequence of events described above and summarized below is compatible with the sequence of events derived from the analysis of drillhole data (Hite, 1968) and lends credence to the idea that the development of the evaporite-cored anticlines in the Paradox Basin began at an early stage in the sedimentation of the Paradox Member.

(1) Evaporites were deposited in subsiding basin.

(2) Upward movement of early evaporite beds caused compression of later units, including those exposed in the Cane Creek workings.

(3) Initially, anhydrite laminae were strong enough to buckle as a result of the compression.

(4) As burial and deformation proceeded, the nature of the folding process changed to one of slip folding. The initial buckles were modified by passive flow.

(5) Continued compression caused folding in marker bed M4 which, in turn, caused more severe compression of incompetent material below to produce folding and minor faulting of material in cores of anticlines in M4.

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