Salt Basins of Bresse and Valence, France

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ABSTRACT

Several basins of Oligocene evaporites, including important thicknesses of salt, have been discovered in recent years in France as a result of geophysical studies followed by petroleum exploration drilling.

Certain of these basins are unusual for the thickness of the bedded salt and the purity of these deposits. Thicknesses are in excess of 3,000 feet in the Bressian basin and more than 2,000 feet in the Valencian basin. Throughout the entire thickness the salts of these basins show effects of post-depositional solution.

The basins of Bresse and Valence, recently discovered, have remarkably similar evaporite stratigraphy. Both constitute important reserves for the chemical and salt extraction industry.

The Oligocene period, in France, was an epoch of very arid climate which permitted the simultaneous formation of the several basins as deep trenches located near and blocked by the chains of mountains in the process of the Alpine orogeny.

INTRODUCTION

The Tertiary Basins

The eastern and southern half of France includes several deep narrow Tertiary basins. Some of these were first mapped by geophysics and then were confirmed by petroleum exploration wells in recent years.

In order, from north to south, these are: (See Fig. 1.)

ALSACE, where the thick saline section contains large quantities of potash salts which are presently being exploited.

BRESSE, where the salt is separated into two principal beds, between which there is a less pure zone containing clay and anhydrites.

LIMAGNE, where the presence of salt is known but the studies are as yet insufficient to permit knowledge of the structure and thickness.

VALENCE, where the salt is also separated into two principal beds with an intervening impure zone containing clays, carbonates, and anhydrite.

PROVENCE (Manosque), where the salt is less well developed, of less thickness and the Oligocene age is debatable because of the tectonic complexity of the basin.

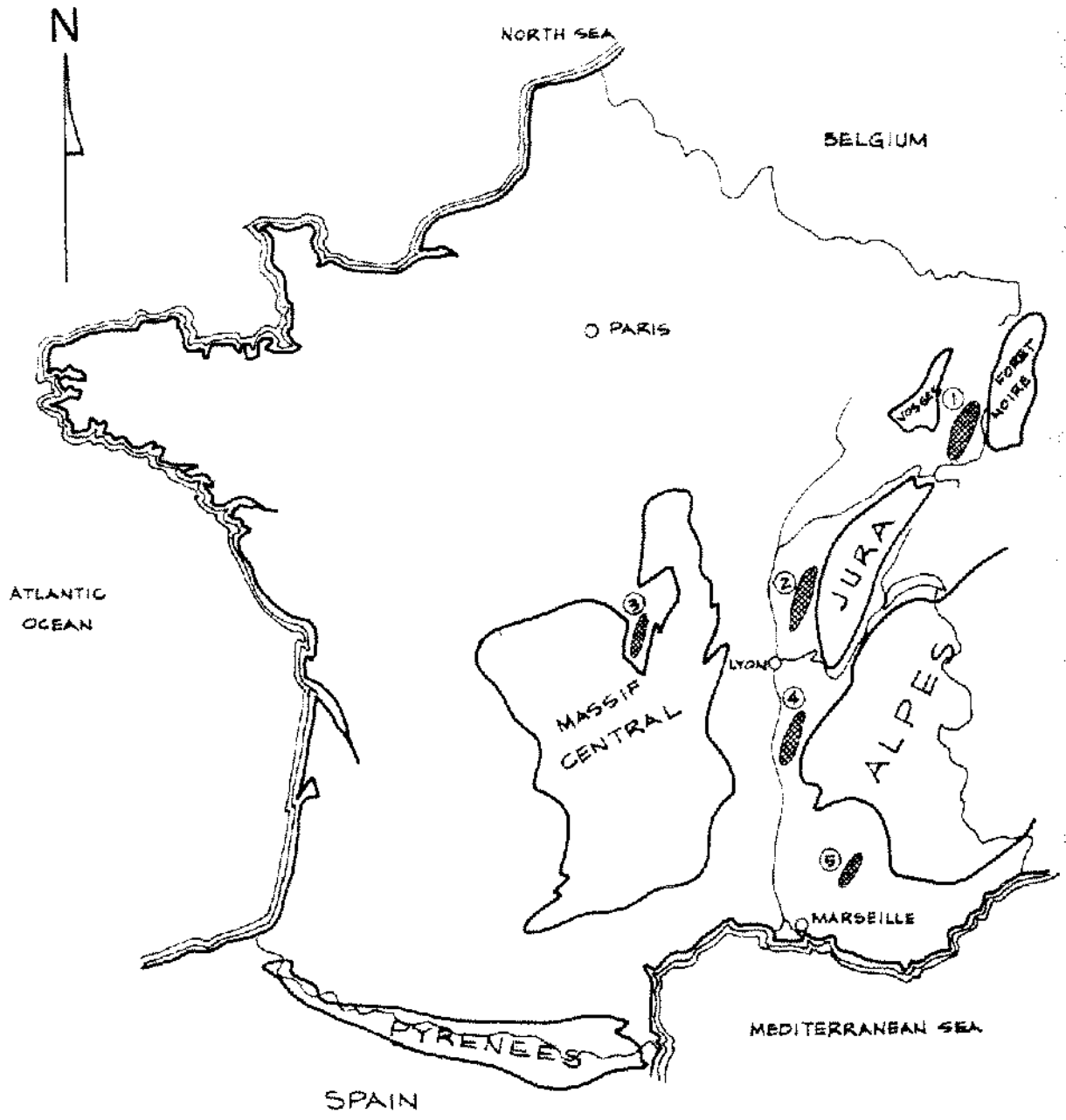

Figure 1. Location of Tertiary basins in Southeastern France.

ɔation of the Basins

All of these basins were formed during the hot part of the Tertiary, the Eocene and the Oli-ɔene, when there was in France an epoch of marine invasions with subtropical to tropical cli-ıte. Another aspect is that these basins are found on the flanks of the chains of mountains: so ıt the thrust taking place in the mountain chains had the effect of subjecting these bordering ba-ıs to intermittent subsidence. These two elements, climate and subsidence, permitted the de-sit of nearly continuous bedded evaporites. And the duration of that period was such that the cumulation of evaporite formations, in certain of the regions, exceeds 4,000 feet.

There are found within the different basins striking analogies.

First, the periphery of all of the basins are not belts or aureoles of Jurassic and Cretaceous ɔcks which would be regularly found outlining a Tertiary basin as a product of sinking and con-nuous deposition. On the contrary these boundary areas are all with the primary or secondary ıassives without transition. The Limagne and the Alsace basin resulted from the filling of a ɔench or graben between two faults: in Alsace the Vosges is to the west and the Black Forest is ɔ the east. In Limagne, the plateaux of gneiss of the Massif Central are on both sides. It is be-ieved that similar conditions will be found with further exploration in Bresse and Valence.

On the other hand, very constant physical conditions were extant. The axes of all the basins ɣithout exception are very parallel with a north northeast-south southwest orientation which is in-lependent of the strike of the alpine chains or the foliation of rocks in the older massives.

With regard to the boundary faults, these are high-angle normal faults. Thus the depres-ɜions are probably products of a period of repose of the Alpine overthrusts.

Finally, the subsidence which occurred and gave rise to the basins, together with the moun-tains in the vicinity, was followed by the evaporite period. Some investigators postulate that the downwarping was a direct consequence of the seismic thrusts which are the Alpes, the Jura, and the old Massif Central which evoked these same conditions.

In the same way, in the Quaternary the saline basins and their environs continued to undergo sinking. This was observed in the Basin of Provence where there is displacement of the axis to-ward the east as shown by Destombes (Destombes, 1964).

The Basins of Bresse and Valence

The basins of Bresse and Valence well show in particular remarkable characteristics.

They are located between two entirely different regions geologically: the folded and sub-Alpine chains of the Jura (Secondary) or the buttresses (contreforts) of the Alpes on one side and the Massif Central (Paleozoic), with its tabular Jurassic covering, on the other side.

From the geophysical point of view, all of the Tertiary terranes, in the basins are distin-guished by their low density.

The salt gives a low gravimetric response that is easily recognized. It was in a part of the survey of a gravity investigation in 1948 that M. Goguel (Goguel, 1948) announced without other physical data the probable presence of rock salt, which was confirmed by the drill-holes ten years later.

THE BASIN IN BRESSE

Among the saline basins in the east of France, that in Bresse presents a somewhat complex structure. In effect, the trench, oriented, as are the others, with the axis north northeast-south southwest, is situated randomly across Hercynian folds (Socle Premiere) which are oriented in a southwest-northeast direction. In addition it is found that the Tertiary deposits are of very vari-able thickness from one end of the basin to the other. Geophysical data (seismic) gives reasonable evidence of the presence of folds and horsts that are of substantial magnitude in the basal rocks beneath the Tertiary deposits. (See Fig. 2.)

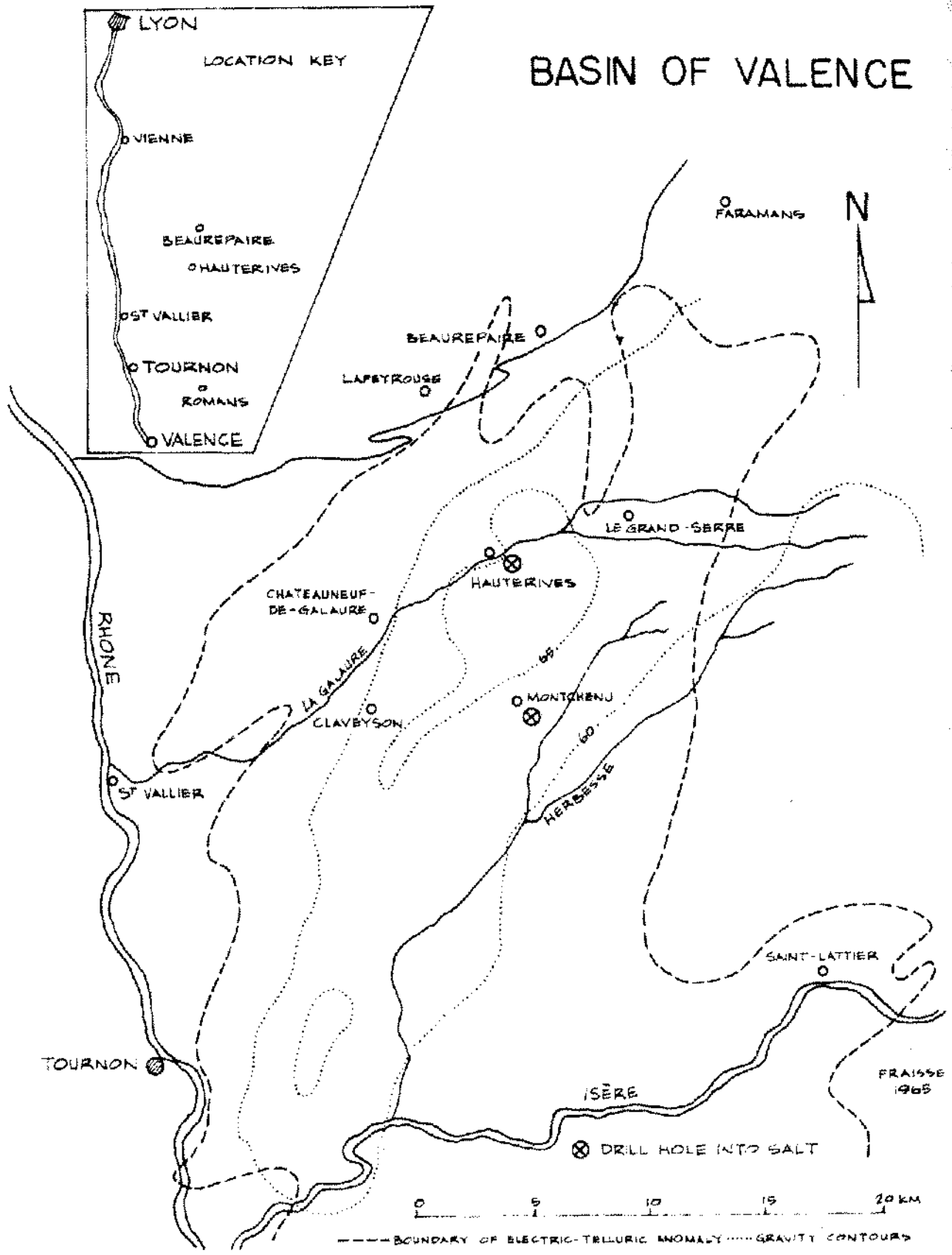

Figure 2. Basin of Valence as known from geophysical investigations and drilling.

Development of the Basin

The region of Bresse was involved in tectonic movements and erosion at the beginning of the Eocene. The mountains of the Jura, the eastern border of the basin, were strongly affected by these movements and associated erosion while the terranes of the Bresse basin itself were protected from erosion by their rapid sinking.

During the Eocene there followed a period of movements that were very important to the base of the basin. Their effect is recognized in some of the drill-holes by the fact that the younger strata discordantly overlie the lower part of the Eocene, which at some locations may have dips of 5° to 20°.

It is in the Lower Oligocene, which corresponds to the large Alpine movements, that carbonates, conglomerates, and sandy and silty shales were deposited in the lower part of the basin.

It was then that the marine invasion occurred, which started in the Middle Oligocene. The initial deposits are lagoonal. The marine deposits were commenced by varigated clays followed by evaporites. Deposition of evaporites continued to the end of the Oligocene, the depressed basin gradually being filled with deposits. Above the very thick evaporite zone deposited there was laid down the Aquitanian calcareous marl (terminal deposit of the Upper Oligocene) which contains marine fossils at its base and is fresh water at the top. This indicates that at this time period the marine environment disappeared and was replaced by a lacustrine facies.

Finally above the evaporite and marine sequence are the Miocene molasse and the Pliocene fluvial clays. In the numerous valleys there are also deposits, largely terrace and channel, of glacial outwash.

Description of the Evaporite Zone

The wells effectively reliably permit, with the aid of geophysical data, the delimitation of attitude and thickness of the salt. More than a dozen drill-holes with good geophysical logs provide scattered subsurface control.

The length of the saline basin is in the vicinity of 60 kilometers and the largest transverse dimension is about 20 kilometers. There are two principal salt sections of variable thickness (Upper and Lower) at the different points of drilling. These are separated by a zone of salty clay and anhydrites (Interbed).

A section of the basin shows that the beds of salt are very elongated and lenticular, each more or less in the form of a meniscus. The progressively younger portions of the section overlap older portions and are more widespread as subsurface data are now interpreted. The information shows that after the deposits of evaporites the movements continued in such a way that the beds are thicker and depressed at the center of the basin.

The stratigraphy of the basin in Bresse is as follows:

Depth	Classification	Lithology
0- 400	Lower Pliocene	Sands, shales, and clays
400-1, 300	Miocene	Clay and silt (molasse)
1, 300-1, 700	Upper Oligocene (Aquitanian)	Calcareous marl
2, 000-3, 300	Middle Oligocene (Stampien)	Salt (Upper)
3, 300-4, 300		Clay, anhydrite and rare salt (Interbed)
4, 300-5, 700		Salt (Lower)
	Eocene	
5, 700-6, 300		Gray marls, clays, conglomerates
6, 300-	Upper Cretaceous	

Throughout cores from the basin, apparent dips in the salt beds of portions of the section, some as much as 18° to 20°, are not unusual. However such beds are typically both overlain and underlain by beds with no perceptible dip. Also distributed throughout the sequence are crystalline masses of high purity salt, recognizable from experience, as representing reprecipitated salt, deposited in solution cavities developed in the salt. There is evidence that post-depositional intense secondary solution affected the entire salt sequence, altering it from original depositional conditions. On the other hand, the pressure elongation, granulation, deformation of impurities and similar features usually indicative of diaperic deformation appear to be completely absent in cores of the basin in Bresse (Carl A. Bays, personal communication, 1965).

THE BASIN OF VALENCE

This basin is the most recently discovered saline basin in France (1963). The very limited number of wells (two locations) which have been drilled do not permit giving much precise description from direct subsurface data. But the geophysical data from petroleum exploration help determine the approximate limits and general trend. (See Fig. 3.)

It is again recognized that the north northeast-south southwest orientation of the axis is suggested by the gravity data. Surface geology indicates the western border is a fault generally parallel to the axis. Finally the seismic information suggests that similarly on the eastern boundary of the basin there is also a parallel fault but this remains to be verified at present.

The history of the formation of the basin in Valence is very similar to that in Bresse. A marine invasion in the Oligocene epoch together with progressive depressing movements permitted the deposition of evaporites. The sedimentation of argillaceous materials and the cycles of evaporation with pure evaporite sedimentation are very similar to the basin in Bresse. At the end of the Oligocene the filling-up of the depression was completed by deposits of fresh-water strata as in Bresse; there were no predominantly calcareous sediments in Valence. After the Miocene, the deepening of the lakes to receive deposits of sands and muds was contemporaneous with the termination of the principal Alpine movements.

It should be noted that with the overlapping by the Miocene, and without doubt a little after that deposit, the saline beds were dissolved locally and afterward recrystallized. At the same time, they were brecciated by the later movements in such a way that the salt partly dissolved and penetrated in the form of brine, the joints and fractures in the adjacent shaly beds and was recrystallized in long crystals with a fibrous aspect and some of which have a distinctive orange color. This orange color is due to iron content of the salt which is derived by oxidation of ferrous iron present in small quantities in the greenish and grayish argillaceous beds (Carl A. Bays, personal communication, 1965).

Attitude and Thickness in the Basin of Valence

The length of the Valence basin is on the order of 45 kilometers and its greatest width is between 10 and 15 kilometers. The distribution of the iso-contours of gravity indicates that, as in Bresse, the saline deposit is in the form of a lentile, in-curved at the center toward the base.

With regard to the western border, the important fault which is found on the surface strongly limits a salt bed of substantial thickness.

It is also found, as in Bresse, the two principal beds of salt are separated by a clay-anhydrite bed with a substantial carbonate content and scarce salt with approximately the same thickness (1,000 feet).

Stratigraphic Description

The stratigraphic succession at a locality near the center of the basin is summarized on page 342.

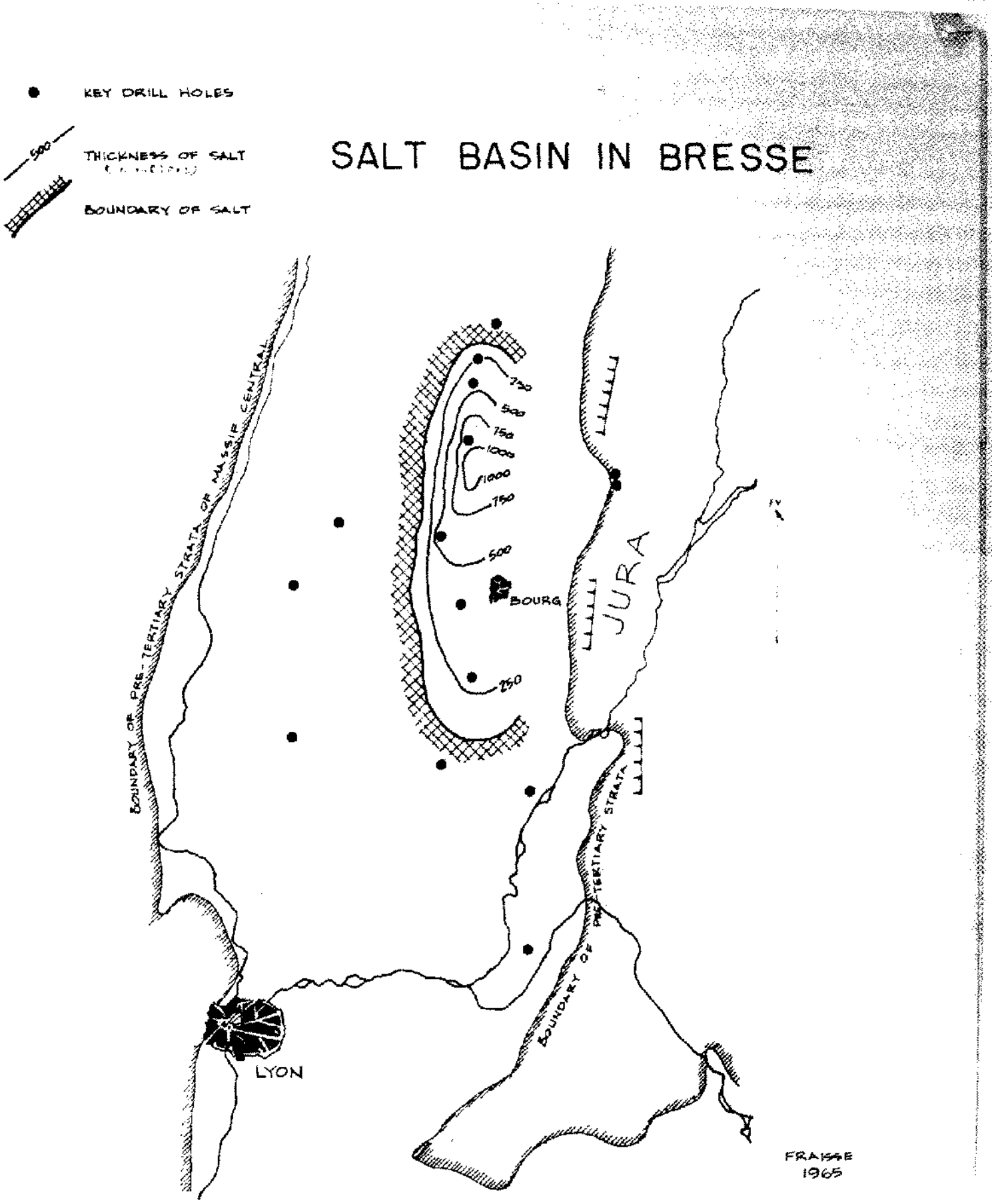

Figure 8. Delimitation of portion of Bressian basin by drill-holes.

Depth	Classification	Lithology
0- 60	Quaternary	Lacustrine clays and sands
60- 150	Upper Miocene	Molasse (fresh water)
150-1, 300	Miocene (Helvetian)	Sands and clays of marine origin
1, 300-1, 500	Upper Oligocene (Aquitanian)	Fresh-water clays
1, 500-1, 600		Marine clays
1, 600-2, 000		Varigated fresh-water sands and clays; fluvio-lacustrine
2, 000-2, 400		Carbonate and anhydrite
2, 400-3, 000		Streaked and mottled clays and silts
3, 000-3, 600	Middle Oligocene (Stampian)	Varigated clays
3, 600-4, 600	Lower Oligocene (Sannoisian)	Salt (Upper) Carbonate and anhydrite with thin salt (Interbed)
5, 000-6, 000		Salt (Lower)

CONCLUSION

The discoveries of the saline basins of Bresse and Valence have brought new information on the geology of the Tertiary of the east of France.

It is of interest to compare in these basins the parallelism of the axes of formation, the processes of evaporite deposition, the substantial thicknesses of the beds and the nearly horizontal bedding of the salt sequence.

Both basins are comparable in that the salt is present in high purity, with some interbedding of bands of clay and dolomite in the lower parts of the salt sections. The anhydrite present is in homogeneous massive beds as well as some nodules which form inclusions in the salt beds. Geophysical logs (radioactivity and laterologs) within the two basins readily correlate in pattern and there are comparable or correlative sections in both the salts and the interbed section insofar as similarity of pattern of curve is concerned.

Finally it is noted that in spite of the small number of effective drill-holes, approximate delimitation can be made with available geophysical study data and permits giving an indication of the utilizable salt resources for industry.

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