TECTONIC AND SEDIMENTATIONAL EVOLUTION OF CENTRAL NORTH AMERICA AND THE CONTROL OF ECONOMIC DEPOSITS

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The economic resources of an area, whether oil, gas, metallic, non-metallic or otherwise, will be found where there has been the right combination, for the given type of deposit, in both space and time, of physical-chemical relationships and tectonic activity. This necessitates knowing the "habitats" or the environments in which a given type of deposit can occur and then to locate areas which possess these environments. The environment is generated through the proper relationships of formations which in turn reflect the paleogeographic conditions under which the formations formed, whether they be sedimentary, igneous or metamorphic, and the sequence of diastrophic events, whether tectonic fracturing, folding, or rejuvenation of old zones of weakness, or whether epirogenic uplift with its resulting erosion and solution or down warping with non-deposition or deposition of varying rock facies. The fundamental controlling factor is to have the proper historical relationship of these events.

Therefore, to find the economic deposit - to evaluate an area as to its mineral potentialities - necessitates (1) knowing the "habitat" of the given type of deposit and (2) having a thorough understanding of all aspects of the paleogeology and paleogeography of the area.

The segment of the North American continent selected for a study of its tectonic and sedimentational evolution and the relationship of the origin, formation and concentration of economic deposits to this evolutionary development, covers the broad region from Minnesota to central Montana and from Nebraska to southern Canada. This region embraces (1) the exposed margin of the Canadian Shield, (2) the broad Williston Basin which is a gently deformed portion of the sediment covered Canadian Shield or "continental platform," (3) the structural basins bordering the mountains of eastern Montana and northern Wyoming, which represent more strongly deformed portions of the western margin of the "continental platform," and (4) the eastern margin of the now deformed Beltian, Paleozoic and Mesozoic Cordilleran geosynclines. The studies were extended locally into other areas such as central Utah where certain specific additional information was desired on Cordilleran patterns of deformation.

Pre-Cambrian deformations broke the western margin of the continental platform into a system of crustal blocks bounded by fractures or zones of weakness. Some of the zones and fractures extended well across the platform. Other zones of pre-Cambrian weakness developed in the Canadian Shield area and extended westward under the present sedimentary cover. These old zones of weakness in many cases controlled post-Cambrian deformations through movements along the old zones. The reflection of the movement in the basement blocks into the overlying sediments is exhibited as individual, en echelon or other systems of faults and folds. The pattern and type of deformation depend upon the direction and intensity of the forces and their resolution by the various blocks. In other cases, fresh zones of deformation developed apparently unrelated to older zones of weakness. Some of the later zones

may be entirely confined to the post-basement sedimentary section or confined to portions of the section and show no reflection in the basement. Vulcanism was also influenced by the development and pattern of the zones of weakness.

Since the relationship in time as well as in space is of fundamental importance in locating economic deposits and in controlling distribution of sediments and other rocks, a careful analysis of each structure was made to determine (1) the age of origin, (2) the periods during which later movements took place along the structural trend, (3) the correlation of trend directions and patterns of deformation during each period, (4) the intersections of trend directions and (5) the relationship of each trend direction and its period of formation to the lithology and rock distribution.

The sedimentational history is one of a western geosynclinal facies changing eastward into shelf and marginal facies as the seas overlapped eastward across a "continental platform" which extended continuously eastward until it merged with the Shield landmass. Through Cambrian and Ordovician time there was progressive eastward encroachment of the seas across the pre-Cambrian basement complex. Variations in the land and sea pattern result from differing sea connections and areas of warping. However, there was a general withdrawal of the seas from the region during Silurian time, followed by the re-establishment of marginal and epeiric seas during the Devonian and Mississippian periods. Pennsylvanian and Permian seas were restricted in the area. From the beginning of the Mesozoic era there was again a progressive eastward overlap of sediments until by middle Upper Cretaceous time sediments were being deposited over much of Minnesota. Local unconformities interrupt the Paleozoic and Mesozoic sedimentary cycles, and facies changes mark variations in sedimentary environments.

During Paleocene and post-Paleocene time the relic Cannonball sea was filled and during most of Eocene and Oligocene time fluvial and lacustrine deposits were laid down. After a period of near "stillstand" during the Miocene and Pliocene regional elevation began, leading to extensive erosion and the partial re-excavation of the basin fillings. Pleistocene time brought renewed fluvial, lacustrine and glacial deposition and renewed erosion.

In the area covered by these studies, folded, faulted and compaction types of structural oil traps are present as well as stratigraphic traps resulting from changes of facies, porosity, truncation and reefs. Production has been found in several of these structural and stratigraphic types and studies indicate certain areas where particular types of traps are more likely to be present than others; similarly, studies indicate certain areas where special sedimentary environments probably existed or where there was a particular tectonic history. A fair evaluation of the oil possibilities of a particular area will depend upon the complete analysis and interpretation of (1) the nature of the trap-types present, (2) the local stratigraphic variations, (3) the sedimentational environments indicated, and (4) the regional and local tectonic histories.

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