DEVONIAN AND CARBONIFEROUS CARBONATE PLATFORM FACIES IN THE BOLSHOI KARATAN, SOUTHERN KAZAKSTAN: OUTCROP ANALOGS FOR COEVAL CARBONATE OIL AND GAS FIELDS IN THE NORTH CASPIAN BASIN

Cook, H. E.[1]; Zhemchuzhnikov, V. G.[2]; Zempolich, W. G.[3]; Lehmann, P. J.[4]; Alexeiev, D. V.[5]; Zhaimina, V. Ya[2];and Zorin, A. YE.[2]
[1] *USGS, Menla Park, CA USA*
[2] *JSCE, Almaty Kazakhstan;*
[3] *Mobil, Dallas, TX USA;*
[4] *Exxon, Houston, TX USA*
[5] *Russian Academy of Sciences, Moscow, Russia*

The Bolshoi Karatau carbonates of southern Kazakstan record development of a 4,500 m. Thick platform which evolved close to the North Caspian Basin of western Kazakstan during the Late Devonian and Carboniferous (Cook et al, 1994). Carbonate facies in the Bolshoi Karatau mountains of southern Kazakstan provide outcrop analogs for coeval reservoirs in supergiant oil and gas fields in the North Caspian Basin (Fig. 1). The carbonate platforms in the Bolshoi Karatau and the North Caspian Basin are similar in several important ways. First, both the Bolshoi Karatau and the Tengiz oil field carbonate platforms were initiated in the Upper Devonian and ended in the Bashkirian, a span of about 50-55 my (Fig. 3; Lisovsky et al., 1992). Second, the stratigraphic thickness of the Bolshoi Karatau and the Tengiz oil field is similar (Fig. 2). Third, the proven oil reserves in Tengiz occur in the Visean through Bashkirian and these strata are well exposed in the Bolshoi Karatau (Figs. 2,3).

The seaward margin of the Bolshoi Karatau carbonate platform was probably structurally controlled by the rifted edges of a passive continental margin. The overall geometry of the carbonate platform was controlled by thermal subsidence and local tectonics. Over a 50-55 my period of time this passive margin underwent thermal subsidence, normal faulting, and numerous sea-level fluctuations of varying amplitudes. Sedimentation rates suggest that subsidence decreased exponentially. Sediment accumulation rates ranged from 185-285 m/my during the Late Devonian, 60-100 m/my during Tournaisian, 35-50 m/my during the Visean, 15-30 m/my during the Serpukhovian, and 20-50 m/my during the Lower Bashkirian. The net result was a carbonate platform that evolved from reef and sand-shoal rimmed platforms in the Devonian to deep-water ramps and skeletal mounds in the Tournaisian to ramps with skeletal mounds and rimmed margins in the Visean, Serpukhovian, and Bashkirian (Fig. 3).

Depositional sequences, sequence boundaries, and facies were controlled by relative sea-level oscillations, sedimentation rate, climate, as well as subsidence. Relative sea-level changes were responsible for shelf-margin flooding and backstepping, multiple stacked sequence sets in shelf interiors, paleosols (Lehmann et al., 1996), extensive meteoric diagenesis (Zempolich et al., 1995), and karst and collapse breccia.

Five depositional supersequences (2nd order cycles), of seismic stratigraphic scale, are recognized in the Bolshoi Karatau (Fig. 3) (Cook et al., in press; Zempolich et al., 1997, in press); 1) Supersequence #1 includes Frasnian and Famennian *Renalcis* algae-bryozoan-sponge shelf margin facies. Shelf interiors contain skeletal mud-mounds, carbonate sands, cryptalgal laminates, evaporitic laminates and a 90 m-thick regionally extensive evaporite collapse and karst breccia. Basin margins contain carbonate turbidites and megabreccia debris flow aprons. 2) Supersequence #2 is comprised of Tournaisian-Lower Visean ramps of brachiopod-crinoid biostromes and abundant tidal flat facies. Seaward ramp setting contain skeletal mud mounds and bioclastic turbidite aprons. 3) Supersequence #3 comprises Lower Visean-Upper Visean carbonates that have both skeletal mud mound and shoal-rimmed shelf margins. Skeletal mud mound margins and slopes are sponge-*Tubiphytes* (?)-algae-bryozoan bounstones and bryozoan cementstones. Deeper-water parts of these slopes contain mud mounds and turbidite aprons. Shelf interior facies consist of interbedded ooid and bioclastic sands. Shoal-rimmed platform margins are dominated by cross-bedded ooid-bioclastic sands and turbidite aprons. 4) Supersequence #4 comprises Upper Visean-Lower Bashkirian basinal carbonate turbidites and upper slope skeletal mud mounds comprised of *Donezella* algae-*Tubiphytes* (?)-sponge-bryozoan boundstone and algal rudstone. These upper slope mounds developed within a setting that was receiving abundant carbonate turbidites and debris flows. Shelf margins and shelf-interior facies consist of interbedded ooid and bioclastic sands and phylloid algae-rich sands. 5) Supersequence #5 encompasses Lower Bashkirian skeletal mud mounds that formed on slope and drowned shelf

lagoon settings. Mound facies are dominated by phylloid algae-*Donezella* algae-gastrapod-brachiopod bounstone and cementstone facies. The boundstone facies are typically interbedded with algal rudstone and possible pisoid facies. Drowned shelf-lagoon facies are comprised of lime mudstones and carbonate turbidites derived from a ooid-bearing shelf margin.

In the Bolshoi Karatau thick stacks of upward shallowing cycles of dolomitized and karsted shelf margin and shelf interior ooid-bioclastic sands form potential reservoirs whereas lower and upper slope skeletal mud mounds contain abundant marine cement and are relatively tight. Reservoir enhancement is related to early dolomitization and meteoric diagenesis. These geometric and diagenetic patterns are analogous to some reservoirs in the North Caspian Basin such as in the Karachaganak and Tengiz fields (Zempolich et al., 1995).

Bolshoi Karatau studies provide data on the heterogeneity of the reservoirs in terms of their facies, cyclicity and stacking patterns, the origins of these stacking patterns, where these reservoirs occur within the platform, and porosity enhancing conditions associated with this cyclicity. These outcrop studies should be valuable for better understanding and predicting the chareacteristics and development of North Caspian Basin oil and gas reservoirs.

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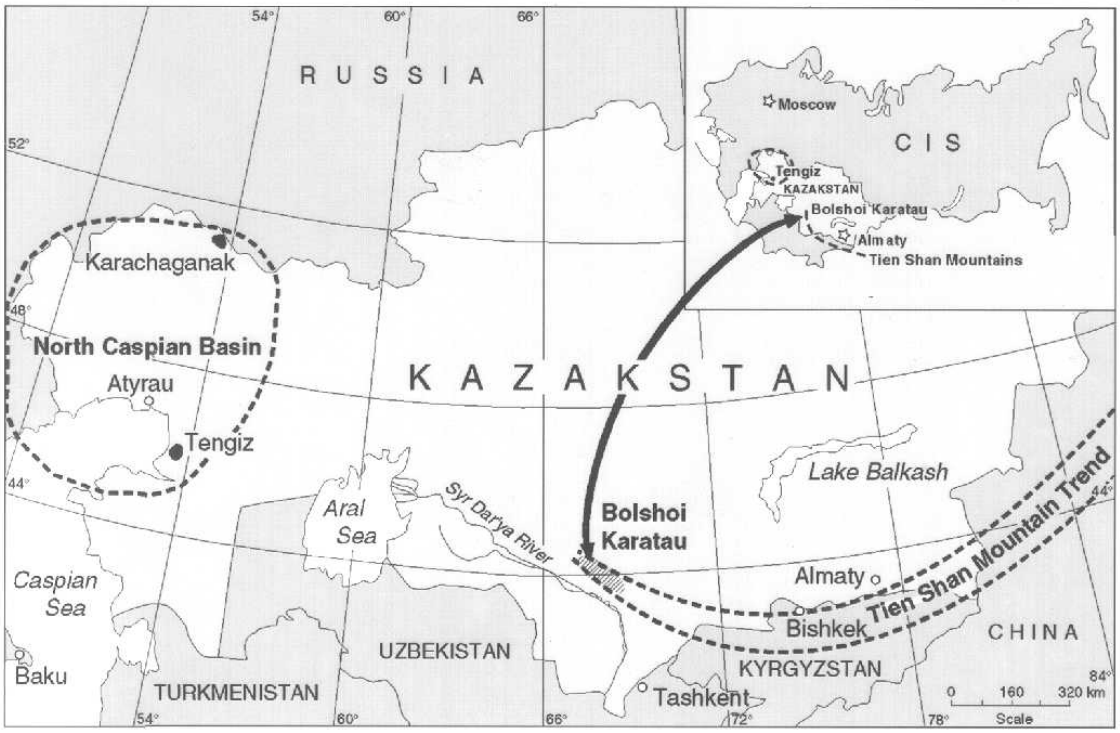

Figure 1. Map shows the location of the Bolshoi Karatau carbonate platform, north Caspian Basin, and the spergiant Tengiz and Karachaganak fields (modified from Cook et al., in press).

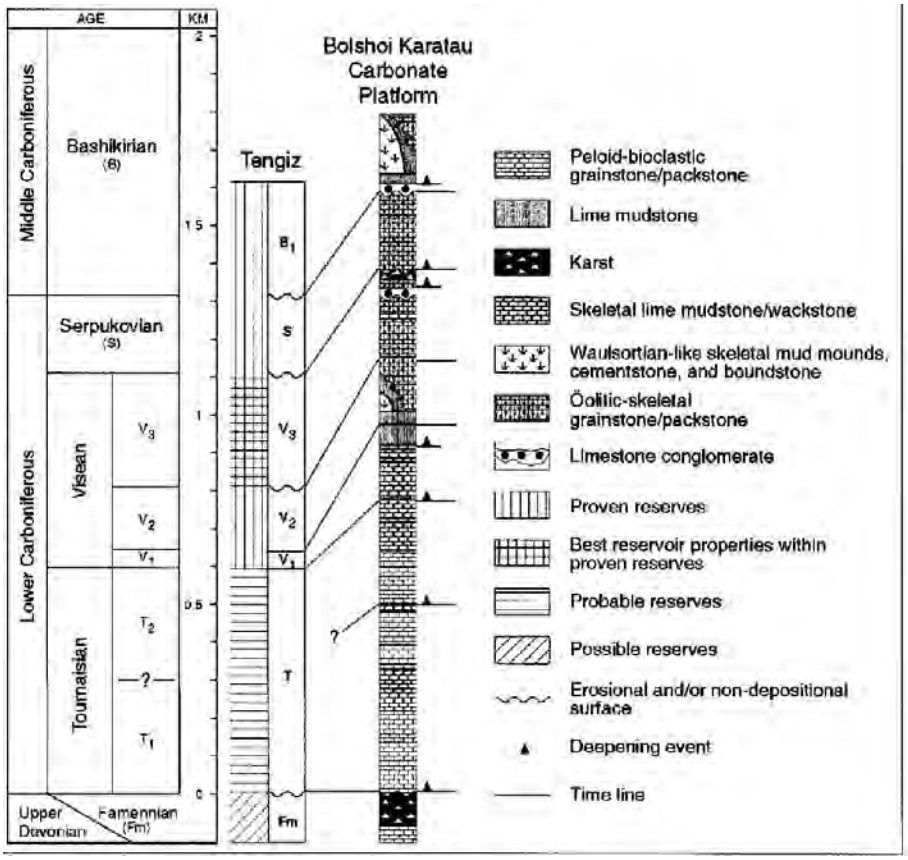

Figure 2. Stratigraphic comparison of Carboniferous carbonates in the Bolshoi Karatau and Tengiz oil fields. Columns compare thicknesses of coeval stratigraphic units, erosional and/or non-depositional horizons, and show the stratigraphic distribution of petroleum reserves in Tengiz. Tengiz data from Lisovsky et al. (1992). Location of Bolshoi Karatau section shown on Figure 3 (modified from Cook et al., in press).

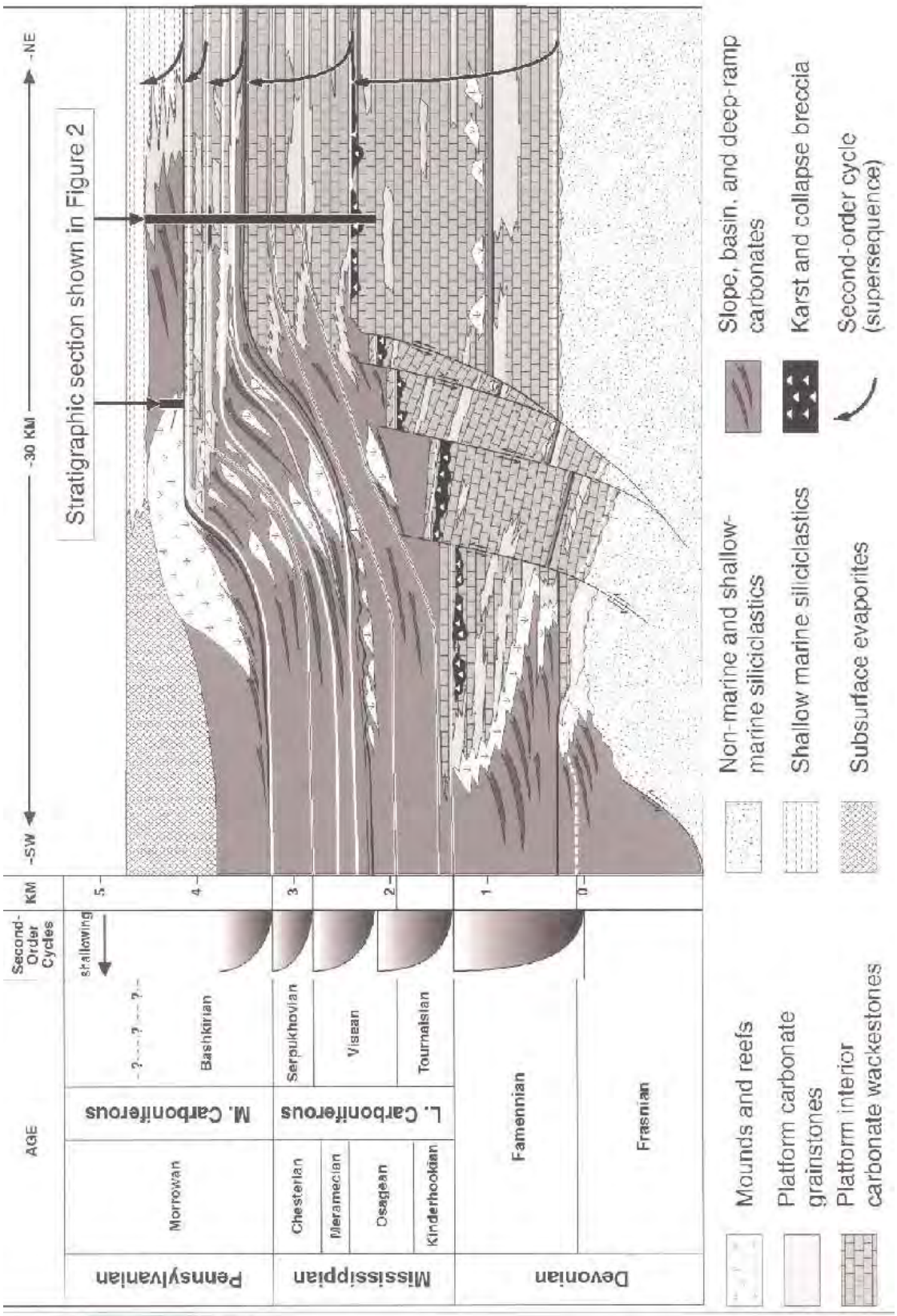

Figure 3. Depositional facies profile of the Devonian and Carboniferous carbonate platform, Bolshoi Karatau Mountains, southern Kazakstan (modified from Cook et al. İn press).