

Depositional Settings, Correlation, and Age of Carboniferous Rocks in the Western Brooks Range, Alaska

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Abstract

The Kuna Formation (Lisburne Group) in northwest Alaska hosts the Red Dog and other Zn-Pb-Ag massive sulfide deposits in the Red Dog district. New studies of the sedimentology and paleontology of the Lisburne Group constrain the setting, age, and thermal history of these deposits. In the western and west-central Brooks Range, the Lisburne Group includes both deep- and shallow-water sedimentary facies and local volcanic rocks that are exposed in a series of thrust sheets or allochthons. Deep-water facies in the Red Dog area (i.e., the Kuna Formation and related rocks) are found chiefly in the Endicott Mountains and structurally higher Picnic Creek allochthons. In the Red Dog plate of the Endicott Mountains allochthon, the Kuna consists of at least 122 m of thinly interbedded calcareous shale, calcareous spiculite, and bioclastic supportstone (Kivalina unit) overlain by 30 to 240 m of siliceous shale, mudstone, calcareous radiolarite, and calcareous lithic turbidite (Ikalukrok unit). The Ikalukrok unit in the Red Dog plate hosts all massive sulfide deposits in the area. It is notably carbonaceous, is generally finely laminated, and contains siliceous sponge spicules and radiolarians. The Kuna Formation in the Key Creek plate of the Endicott Mountains allochthon (60–110 m) resembles the Ikalukrok unit but is unmineralized and has thinner carbonate layers that are mainly organic-rich dolostone. Correlative strata in the Picnic Creek allochthon include less shale and mudstone and more carbonate (mostly calcareous spiculite). Conodonts and radiolarians indicate an age range of Osagean to early Chesterian (late Early to Late Mississippian) for the Kuna in the Red Dog area. Sedimentologic, faunal, and geochemical data imply that most of the Kuna formed in slope and basin settings characterized by anoxic or dysoxic bottom water and by local high productivity.

Shallow-water facies of the Lisburne Group in the Red Dog area are present locally in the Endicott Mountains allochthon and throughout the Kelly River allochthon and consist of the Utukok and Kogruk Formations. The Utukok Formation is an impure limestone with disseminated and interbedded noncarbonate mud and quartz-rich silt and sand. Clean carbonate predominates in the overlying Kogruk Formation but has been widely altered to dolostone and chert. Deep-water strata, similar to that in the Kuna Formation, overlie and grade laterally into shallow-water rocks in the Endicott Mountains allochthon and compose the uppermost Lisburne in the Kelly River allochthon. The Utukok Formation is mainly Osagean but its base is Kinderhookian (early Early Mississippian) in the highest plates of the Kelly River allochthon. The Kogruk Formation is mostly Meramecian but partly Osagean and early Chesterian in some areas. We interpret inner to middle platform settings for most of the Utukok and Kogruk Formations. Deep-water, locally phosphatic facies of the uppermost Lisburne Group formed during a platform-drowning event of regional extent that began in the late Meramecian.

In the Howard Pass area, ~120 to 250 km to the east, the Lisburne Group includes an array of shallow- and deep-water facies that correspond well in age and general depositional environment to those in the Red Dog area but differ in some details. Deep-water strata are generally thinner, include less carbonate, and formed in settings that were deeper and/or had less detrital input. Shallow-water deposits are less extensive, contain less quartz silt and sand, and formed chiefly in middle and outer platform settings.

Paleogeographic reconstructions imply that carbonate platforms flanked the Kuna basin to the north and south in the west but flourished chiefly north of the basin in the east. These platforms provided carbonate and perhaps some siliciclastic detritus to the basin; siliciclastic detritus could also have come from older strata underlying the platforms and/or from the Endicott delta to the north. Carbonate turbidite deposition in the Kuna basin occurred chiefly during middle Osagean and late Meramecian-early Chesterian times and ceased when adjacent platforms drowned. A combination of local and eustatic factors probably controlled the timing of

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detrital input to the basin and the demise of the adjoining carbonate platforms. Platform inundation is roughly coeval with the onset of barite precipitation and sulfide mineralization, implying that regional extension was a significant component of all three events. High productivity, locally thick calcareous turbidite fill, and proximity to restricted, shallow-water carbonate platform environments are aspects of the Kuna basin that appear to have been important in forming the giant Red Dog deposits.

Conodont color alteration indices of the Lisburne Group in the Red Dog area and much of the Howard Pass area are mostly 2.5 to 3.5 and indicate temperatures of 110° to 200°C. Such temperatures are typically produced by burial depths of 3,500 to 5,500 m. Because Pennsylvanian-Cretaceous strata above the Lisburne Group are less than 1,500 m thick, tectonic burial and/or an elevated geothermal gradient are needed to explain the conodont color alteration index data.